Original Investigation

Prevalence of Age-Related Macular Degeneration in Chinese American Adults
The Chinese American Eye Study

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IMPORTANCE Population-based prevalence estimates of age-related macular degeneration (AMD) need to be determined to assess its burden among Chinese Americans, the fastest growing racial group in the United States.

OBJECTIVE To determine the age- and sex- specific prevalence of AMD among Chinese Americans.

DESIGN The Chinese American Eye Study (CHES) was conducted in a general urban community of 10 census tracts in Monterey Park, California. A total of 4582 Chinese American adults aged 50 years or older participated in this population-based, cross-sectional study from February 16, 2010, through October 9, 2013, and underwent an interview as well as comprehensive clinical and eye examinations, including detailed retinal photography of both eyes. Fundus photographs were graded for drusen and retinal pigment epithelium abnormalities and were evaluated for AMD.

MAIN OUTCOMES AND MEASURES The prevalence of early and advanced AMD, drusen, geographic atrophy, and neovascular AMD were determined by using a modified Wisconsin Age-Related Maculopathy Grading Scale (a 6-level scale: 10, no AMD; 60, advanced AMD).

RESULTS Of the 4582 participants completing both the home survey and clinical examination, 4172 individuals (91.1%) had at least 1 gradable photograph. A total of 1526 (36.6%) participants were men, and the mean (SD) age was 61.2 (8.8) years. When examined by 10-year age groups, the prevalence of early AMD ranged from 5.8% (n = 119) in participants aged 50 to 59 years to 17.6% (n = 37) in those 80 years or older, retinal pigment epithelium abnormalities from 4.1% (n = 85) to 7.2% (n = 16), large drusen (≥125 μm) from 9.8% to 32.4%, soft drusen from 27.6% (n = 567) to 58.6% (n = 123), and soft indistinct drusen from 3.7% (n = 76) to 15.2% (n = 32). The prevalence of advanced AMD ranged from 0.2% (n = 3) in participants aged 50 to 59 years to 1.0% (n = 2) in those 80 years or older. Of the 14 cases of advanced AMD, 85.7% (95% CI, 57.2%-98.2%; n = 12) were neovascular AMD and 14.3% (95% CI, 2.0%-42.8%; n = 2) were geographic atrophy. Acute macular degeneration was more common in men (10.9% [9.3%-12.5%]; n = 166) than women (5.8% [4.9%-6.7%]; n = 154) in this cohort.

CONCLUSIONS AND RELEVANCE Data from CHES suggest that Chinese Americans have a lower prevalence of early and advanced AMD compared with non-Hispanic white individuals. The prevalence of early AMD, advanced AMD, and large drusen was higher among Chinese Americans in CHES than among the Chinese population living in urban/rural China but lower than that in urban-dwelling Taiwanese.

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Age-related macular degeneration (AMD) is one of the major causes of blindness and visual impairment in elderly residents of the United States.[1,2] Previous studies[3-5] have found AMD prevalence to vary across racial and ethnic groups within the country. One multiethnic study[3] of AMD in persons without cardiovascular disease found a higher prevalence of neovascular AMD in persons of Chinese ancestry compared with the prevalence in African American, Latino, and non-Hispanic white individuals residing in the United States. Population-based data regarding the prevalence of AMD in Chinese Americans and how the data compare with information on other racial/ethnic groups are limited.

According to the 2010 census,[6] Chinese Americans are the most populous Asian group in the United States and represent the most rapidly growing racial group in the US population based on data from 2000 to 2010.[7] Precise estimates of AMD prevalence in persons of Chinese ancestry living in the United States have not been determined. Existing estimates are based on data from selected populations developed to address nonocular outcomes and therefore may not represent Chinese Americans.[3,8]

Results from population-based studies of AMD in China[9,10] and Taiwan[11] within the past decade suggest that the prevalence of early AMD might be between 3.0% to 9.2% among Chinese and that the prevalence is higher in older populations. However, data on persons of Chinese ancestry outside the United States may not be generalizable to Chinese Americans owing to differences in environmental exposures (eg, smoking, UV exposure), dietary patterns, health care-seeking behavior, and access to health care.

Additional data to characterize the prevalence of AMD in Chinese Americans are needed to describe the burden of eye disease in this population and to guide the development of preventive screening practices and resource planning. To our knowledge, the Chinese American Eye Study (CHES) is the largest, most comprehensive population-based study of eye disease among persons of Chinese ancestry—specifically Chinese Americans aged 50 years or older—designed to allow precise estimates of AMD prevalence. This study determined the age- and sex-specific prevalence of early and advanced AMD, drusen size and type, and retinal pigment epithelium (RPE) abnormalities among Chinese Americans. Furthermore, we compare the prevalence in CHES with prevalences from population-based studies among Chinese individuals living in other countries and among other racial/ethnic groups within the United States.

Key Points

Question What is the prevalence of age-related macular degeneration (AMD) in the Chinese American Eye Study?

Findings In this population-based, cross-sectional study of Chinese American individuals, AMD prevalence ranged from 5.8% in participants aged 50 to 59 years to 17.6% in those 80 years or older, retinal pigment epithelium abnormalities from 4.1% to 7.2%, large drusen from 9.8% to 32.4%, soft drusen from 27.6% to 58.6%, and soft indistinct drusen from 3.7% to 15.2%.

Meaning The prevalence of AMD in this study is higher than that in other studies of Chinese populations living in urban and rural China but lower than in urban-dwelling Taiwanese and non-Hispanic white populations.

Methods

Study Cohort

CHES is a population-based, cross-sectional study of eye diseases in urban Chinese Americans residing in 10 census tracts in Monterey Park, California. The study area was chosen based on the communities' dense and stable population of Chinese Americans. Eligible participants were identified by a door-to-door census, followed by a screening interview to confirm eligibility, including age (≥50 years) and self-identified Chinese ancestry. Participants underwent a detailed interview at home and a comprehensive eye examination conducted in the clinic. Data were collected from February 16, 2010, through October 9, 2013. More details of the study design and sampling plan can be found elsewhere.[12] This study was reviewed and approved by the Health Sciences Institutional Review Board and the ethics committee of the University of Southern California. The participants provided written informed consent; there was no financial compensation.

Grading of Fundus Photographs for AMD

A modification of the Wisconsin Age-Related Maculopathy Grading System[13] was used to perform masked grading. In this 6-level system, 10 indicates hard drusen or small soft drusen less than 125 μm in diameter only, regardless of area of involvement, and no pigmentary abnormality (increased retinal pigment or RPE depigmentation) present (no AMD); 20 indicates hard drusen or small soft drusen less than 125 μm in diameter, regardless of area of involvement, with any pigmentary abnormality (increased retinal pigment present and/or RPE depigmentation) present or soft drusen 125 μm or more in diameter with drusen area less than 196 350 μm^2 (equivalent to a circle with a diameter of 500 μm) and no pigmentary abnormalities; 30 indicates soft drusen 125 μm or more in diameter with drusen area less than 196 350 μm^2 with any pigmentary abnormality (increased retinal pigment present and/or RPE depigmentation) present or soft drusen 125 μm or more in diameter with drusen area greater than 196 350 μm^2 with or without increased retinal pigment but no RPE depigmentation; 40 indicates soft drusen 125 μm or more in diameter with drusen area 196 350 μm^2 equivalent to a circle with a diameter of 500 μm) and RPE depigmentation present, with or without increased retinal pigment; 50 indicates the presence of pure geographic atrophy in the absence of neovascular macular degeneration; and 60 indicates the presence of neovascular macular degeneration with or without geographic atrophy (severe AMD).

Two graders at the Wisconsin Ocular Epidemiology Grading Center assessed each eye for the presence of lesions associated with AMD. Discrepancies in assessments between the 2 graders were reassessed by a senior grader (R.K.). There was

moderate to excellent intergrader agreement (weighted κ, 0.74-0.93) during the approximate 3.5 years of data collection.

Definition of AMD and Associated Lesions

Drusen

Drusen were evaluated based on their size, sharpness of the edges, and overall uniformity. Total drusen size was calculated by combining the area in each eye. Individual druse were classified as hard indistinct, hard distinct, soft distinct, or soft indistinct/reticular.

RPE Abnormalities

Photographs were graded for the presence of RPE depigmentation or increased pigmentation according to the Wisconsin Age-Related Maculopathy Grading System. Pigment abnormalities caused by non-AMD processes were excluded from analyses.

Early Age-Related Macular Degeneration

Early AMD was defined as the presence of any soft indistinct drusen or any drusen with RPE abnormalities in the absence of advanced lesions.

Advanced AMD

Advanced AMD was defined as the presence of geographic atrophy or neovascular (exudative) AMD, macular thickening, hemorrhage, and disciform scar not associated with other conditions. Geographic atrophy was characterized by 1 or more sharply defined, fairly circular patches of partial or complete depigmentation of the RPE, 125 µm or more in diameter, and with visible choroidal vessels. Signs of neovascular AMD included RPE detachment, serous detachment of the sensory retina, subretinal hemorrhage, subretinal disciform scarring, or evidence of previous AMD laser treatment.

Statistical Analysis

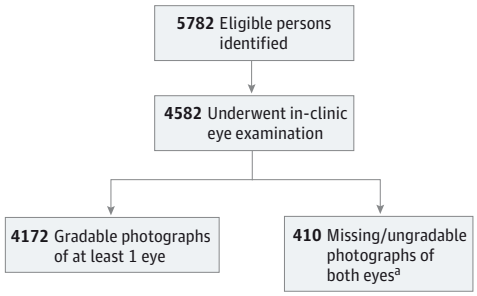
Prevalence was calculated as the ratio of the number of individuals with the condition to the total number of participants who completed the clinical examination and had gradable fundus photos. Prevalence estimates and 95% CIs were presented for the overall group and by age-specific groups. Cochran-Mantel-Haenszel χ^2 tests were used to evaluate the trends and statistical differences in prevalence by sex and age, with $P < .05$ considered significant. Age-standardized prevalence was calculated by direct age standardization using Asian population data from the 2010 US census[6] to compare prevalence across selected population-based studies. SAS, version 9.2 (SAS Institute Inc) was used to conduct statistical analysis.

Results

Study Participants

Of 5782 eligible participants, 5429 (93.9%) individuals completed the home interview and 4582 (79.2%) also completed the clinical examination. Gradable macular photographs were obtained from 4172 (91.1%) of the participants who completed the clinical examination (72.2% of the total eligible population) (**Figure**). A total of 401 participants who completed home interviews but did not undergo the clinical examination and those without at least 1 readable fundus photograph were excluded from further analyses.

Figure. Participation Flowchart from the Chinese American Eye Study



Final cohort of analysis for assessing the prevalence of age-related macular degeneration.

[a] Photographs were ungradable because of media opacities, poor camera focus, or maculopathies believed to be secondary to other conditions.

Overall, the cohort in CHES primarily included 4523 (98.7%) first-generation immigrants, with most (3149 [68.7%]) born in mainland China. A total of 1526 (36.6%) participants were men, and the mean (SD) age was 61.2 (8.8) years. CHES participants were slightly younger (50-59 years) than Chinese living in California or the United States overall (CHES, 2180 [47.6%]; United States, 1 070 337 [44.0%]) and more likely to be female (2901 [63.3%] and 1 264 944 [52.0%], respectively)[6] but slightly less likely to have 12 or more years of education (3090 [67.4%] and 1 873 090 [77.0%], respectively).

Participants in CHES clinical eye examination and nonparticipants were similar in marital status, income, health and vision insurance, and history of diabetes mellitus, cataract, and AMD. Compared with nonparticipants, the participants in the analysis cohort were more likely to be female (2901 [63.3%] vs 499 [58.8%]), slightly younger (mean age, 61.4 [9.3] vs 62.6 [11.0] years), more likely to have an education of 12 years or more (3090 [67.4%] vs 491 [57.9%]), and more likely to speak English (2695 [58.8%] vs 445 [52.5%]). These characteristics did not differ substantially in participants and nonparticipants with or without gradable photos (eTable 1 in the Supplement).

Prevalence of AMD

Early and Advanced AMD

Reported as the percentage (95% CI) of the 4172 participants, 320 persons had evidence of any AMD (7.7% [6.9%-8.5%]) (**Table 1** and eTable 2 in the Supplement). Of these, 306 persons had early AMD (7.3% [6.5%-8.1%]) and 14 had advanced AMD (0.3% [0.2%-0.5%]) (Table 1). Prevalence increased significantly with increasing age of the participants ($P < .001$, $P < .001$, and $P = .002$, respectively), and prevalence was higher in men (11.1% [9.4%-12.8%] compared with women (6.6% [5.6%-7.6%]) after adjusting for age ($P < .001$, $P < .001$, and $P = .02$, respectively). Compared with persons aged 50 to 59

Table 1. Age- and Sex-Specific Prevalence of AMD in the Chinese American Eye Study

Characteristic	No. (%)[a]								
	Early AMD			Advanced AMD			Any AMD		
	Men	Women	All	Men	Women	All	Men	Women	All
Age group, y									
50-59	71 (10.6)	48 (3.5)	119 (5.8)	1 (0.2)	2 (0.1)	3 (0.2)	72 (10.8)	50 (3.6)	122 (5.9)
60-69	47 (8.5)	57 (6.5)	104 (7.3)	4 (0.7)	0	4 (0.3)	51 (9.2)	57 (6.5)	108 (7.6)
70-79	24 (11.7)	22 (8.0)	46 (9.5)	4 (1.9)	1 (0.4)	5 (1.0)	28 (13.6)	23 (8.3)	51 (10.6)
≥80	14 (14.3)	23 (20.5)	37 (17.6)	1 (1.0)	1 (0.9)	2 (1.0)	15 (15.3)	24 (21.4)	39 (18.6)
Total [95% CI]	156 (10.2) [8.7-11.8]	150 (5.7) [4.8-6.6]	306 (7.3) [6.5-8.1]	10 (0.7) [0.3-1.1]	4 (0.2) [0.0-0.3]	14 (0.3) [0.2-0.5]	166 (10.9) [9.3-12.5]	154 (5.8) [4.9-6.7]	320 (7.7) [6.9-8.5]
Age-adjusted total % (95% CI)[b]	10.4 (8.8-12.0)	6.4 (5.4-7.4)	7.8 (6.9-8.7)	0.7 (0.3-1.1)	0.2 (0.0-0.4)	0.4 (0.2-0.6)	11.1 (9.4-12.8)	6.6 (5.6-7.6)	8.1 (7.2-9.0)
P value[c]	<.40	<.001	<.001	.02	.14	.002	.17	<.001	<.001

Abbreviation: AMD, acute macular degeneration.

[a] Percentages are based on varying denominators.

[a] Age-adjusted to 2010 US census data.[6]

[b] Values for age trend.

Table 2. Age- and Sex-Specific Prevalence of Distinct and Indistinct Soft Drusen in the Chinese American Eye Study

Characteristic	No. (%)[a]								
	Soft Distinct Drusen			Soft Indistinct Drusen			Any Soft Drusen		
	Men	Women	All	Men	Women	All	Men	Women	All
Age group, y									
50-59	193 (28.9)	320 (23.1)	513 (24.9)	45 (6.7)	31 (2.3)	76 (3.7)	224 (33.5)	343 (24.7)	567 (27.6)
60-69	185 (33.5)	260 (29.9)	445 (31.3)	35 (6.3)	41 (4.7)	76 (5.3)	205 (37.1)	228 (33.1)	493 (34.7)
70-79	82 (39.8)	116 (42.2)	198 (41.2)	17 (8.3)	18 (6.6)	35 (7.3)	95 (46.1)	126 (45.8)	221 (46.0)
≥80	45 (45.9)	55 (49.1)	100 (47.6)	11 (11.2)	21 (18.8)	32 (15.2)	53 (54.1)	70 (62.5)	123 (58.6)
Total [95%CI]	505 (33.1) [30.8-35.5]	751 (28.4) [26.7-30.1]	1256 (30.1) [28.7-31.5]	108 (7.1) [5.8-8.4]	111 (4.2) [3.4-5.0]	219 (5.2) [4.6-6.0	577 (37.8) [35.4-40.3]	827 (31.3) [29.5-33.0]	1404 (33.7) [32.2-35.1]
Age-adjusted total % (95% CI)[b]	33.3 (30.4-36.2)	30.1 (27.9-32.3)	31.1 (29.4-32.8)	7.2 (5.8-8.6)	4.9 (4.0-5.8)	5.6 (4.9-6.3)	38.2 (35.1-41.3)	33.5 (31.2-35.8)	35.0 (33.2-36.8)
P value[c]	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001

[a] Soft drusen and hard drusen were not mutually exclusive; percentages are based on varying denominators.

[b] Age-adjusted to the 2010 US census data.[6]

[c] Values for age trend.

years, those 80 years or older had an almost 3-fold higher prevalence of early AMD and any AMD (Table 1).

Of the 14 persons with late AMD, pure geographic atrophy was present in at least 1 eye in 2 male participants (14.3% [95% CI, 2.0%-42.8%]). Neovascular AMD was the more common form of advanced AMD, identified in at least 1 eye in 12 participants (85.7% [95% CI 57.2%-98.2%]), of whom 8 were men. The prevalence of advanced AMD was higher in older age groups in men (P = .02); there was a similar pattern with women (P = .002). Only 50 (15.6%) of the individuals with AMD self-reported the condition. The prevalence of any AMD, early AMD, and advanced AMD was identical in the 3852 participants who had gradable fundus photographs in both eyes. Bilateral early AMD was present in 65 (7.4%) cases; only 3 (0.3%) participants had bilateral advanced AMD.

Of the 320 cases of AMD, 8 (0.3% [95% CI, 0.0%-0.9%]) had evidence of visual impairment, defined as best-corrected visual acuity in the better-seeing eye of Snellen-measured 20/40 or worse. The primary cause of visual impairment in these 8 patients was AMD (3 [37.5%]), cataract (4 [50.0%]), and myopic retinopathy (1 [12.5%]).

Drusen

The prevalence of soft drusen was 33.7% in 1404 participants, with the highest prevalence (58.6%) among the 123 participants who were 80 years or older (**Table 2** and eTable 3 in the Supplement). Soft distinct drusen were more than 5 times as prevalent as soft indistinct drusen (1256 [30.1%] vs 219 [5.2%]). There was a significantly higher prevalence of each type of soft drusen (distinct and indistinct) in older participants (P < .001 for both). Males were more likely than females to have soft distinct drusen (505 [33.1%] vs 751 [28.4%]; P = .02), soft indistinct drusen (108 [7.1%] vs 111 [4.2%]; P = .007), and any soft drusen (577 [37.8%] vs 827 [31.3%]; P = .007); these differences remained after adjusting for age. Among participants 50 to 69 years of age, smaller drusen (<63 µm in diameter) were the most common (**Table 3** and eTable 4 in the Supplement). For those 70 years of age and older, drusen between 63 and 124 µm in diameter were most common. The overall prevalence of large drusen (≥125 µm in diameter) was 12.8% (not age adjusted). The frequency of these large drusen was higher among older age groups. There was no difference in the prevalence of various drusen sizes between sexes after adjusting for age (P = .25).

Table 3. Age- and Sex-Specific Prevalence of Largest Drusen by Drusen Size in the Chinese American Eye Study

Characteristic	Drusen Size, μm Diameter, No. (%)[a]											
	<63			63-124			125-249			≥250		
	Male	Female	All	Male	Female	All	Male	Female	All	Male	Female	All
Age group, y												
50-59	297 (44.4)	700 (50.4)	997 (48.5)	195 (29.2)	394 (28.4)	589 (28.6)	72 (10.8)	106 (7.6)	178 (8.7)	16 (2.4)	6 (0.4)	22 (1.1)
60-69	216 (39.1)	348 (40.0)	564 (39.6)	169 (30.6)	271 (31.1)	440 (30.9)	66 (12.0)	88 (10.0)	154 (10.8)	16 (2.9)	25 (2.9)	41 (2.9)
70-79	44 (21.4)	77 (28.0)	121 (25.2)	69 (33.5)	95 (34.6)	164 (34.1)	31 (15.1)	44 (16.0)	75 (15.6)	12 (5.8)	10 (3.6)	22 (4.6)
≥80	15 (15.3)	15 (13.4)	30 (14.3)	38 (38.8)	43 (38.4)	81 (38.6)	18 (18.4)	31 (27.7)	49 (23.3)	8 (8.2)	11 (9.8)	19 (9.1)
Total [95% CI]	572 (37.5) [35.0-39.9]	1140 (43.1) [41.2-45.0]	1712 (41.1) [39.6-42.6]	421 (30.9) [28.6-33.2]	803 (30.3) [28.5-32.1]	1274 (30.5) [29.1-31.9]	187 (12.3) [10.7-13.9]	269 (10.2) [9.1-11.4]	456 (10.3) [9.4-11.2]	52 (3.4) [2.5-4.3]	52 (2.0) [1.4-2.5]	104 (2.5) [2.0-3.0]
Age-adjusted total (95% CI)[b]	37.0 (34.0-40.0)	40.9 (38.5-43.3)	39.5 (37.6-41.4)	31.0 (28.2-33.8)	30.9 (28.8-33.0)	30.9 (29.2-32.6)	12.4 (10.6-14.2)	11.2 (9.9-12.5)	11.5 (10.4-12.6)	3.5 (2.5-4.5)	2.4 (1.7-3.1)	2.8 (2.3-3.3)
P trend[c]	<.001	<.01	<.001	<.35	.10	.06	.08	<.001	<.001	.004	<.001	<.001

[a] Percentages are based on varying denominators.

[b] Age-adjusted to the 2010 US census data.[6]

[c] Values for age trend.

Table 4. Age- and Sex-Specific Prevalence of RPE Abnormalities in the Chinese American Eye Study

Characteristic	No. (%)[a]								
	RPE Depigmentation			Increased RPE Pigment			Any RPE Abnormality		
	Men	Women	All	Men	Women	All	Men	Women	All
Age group, y									
50-59	25 (3.7)	21 (1.5)	46 (2.2)	44 (6.5)	32 (2.3)	76 (3.7)	49 (7.2)	36 (2.6)	85 (4.1)
60-69	20 (3.6)	17 (1.9)	37 (2.6)	30 (5.4)	28 (3.1)	58 (4.0)	33 (5.9)	33 (3.7)	66 (4.6)
70-79	6 (2.8)	3 (1.1)	9 (1.8)	18 (8.5)	9 (3.2)	27 (5.5)	18 (8.5)	9 (3.3)	27 (5.5)
≥80	2 (1.9)	6 (5.0)	8 (3.6)	6 (5.8)	10 (8.4)	16 (7.2)	6 (5.8)	10 (8.5)	16 (7.2)
Total [95% CI]	53 (3.4) [2.5-4.3]	47 (1.8) [1.3-2.2]	100 (2.4) [1.9-2.8]	98 (6.3) [5.1-7.5]	79 (2.9) [2.3-3.6]	177 (4.2) [3.6-4.8]	106 (6.8) [5.6-8.1]	88 (3.3) [2.6-3.9]	194 (4.7) [3.9-5.2]
Age-adjusted total (95% CI)[b]	3.4 (2.5-4.3)	1.8 (1.3-2.3)	2.4 (1.9-2.9)	6.4 (5.1-7.7)	3.2 (2.5-3.9)	4.3 (3.7-4.9)	6.9 (5.6-8.2)	3.5 (2.8-4.2)	4.7 (4.0-5.4)
P value[c]	.32	<.001	<.001	.17	<.001	<.001	.29	<.001	<.001

Abbreviation: RPE, retinal pigment epithelium.

[a] Percentages are based on varying denominators.

[b] Age-adjusted to the 2010 US census data.[6]

[c] Values for age trend.

RPE Abnormalities

We found RPE abnormalities in 4.7% of all participants (95%, CI 4.0%-5.4%) (**Table 4** and eTable 5 in the Supplement). The prevalence of retinal pigment abnormalities ranged from 4.1% in persons aged 50 to 59 years up to 7.2% in those 80 years or older. The prevalence of increased retinal pigment abnormalities and RPE depigmentation was higher in older age groups for women ($P < .05$) only. Males were more likely than females to have any RPE abnormalities even after adjusting for age (106 [6.8%] vs 88 [3.3%]; $P < .001$). Increased retinal pigment abnormalities were seen more frequently than RPE depigmentation in all age groups in both sexes (Table 4).

Comparison With Other Studies

A detailed comparison of age-specific and age-adjusted prevalence among similar population-based studies suggests that the prevalence of early and advanced AMD in CHES participants was higher than that reported for Chinese residing in northern China but lower than that in Chinese from Taiwan (eTables 6-8 in the Supplement).

Discussion

To our knowledge, CHES is the largest and most comprehensive population-based study of eye disease among people of Chinese ancestry aged 50 years or older. The population-based design and large sample size allowed calculation of precise prevalence estimates of AMD without being influenced by referral patterns inherent in clinic-based studies. A major strength of CHES is the use of standardized protocols to obtain stereoscopic color photographs of the macula and the masked grading process for AMD and its components.

Participation approaching 80% in CHES is reasonably high compared with similar population-based studies (eg, Beaver Dam Eye Study,[14] 83%; Baltimore Eye Survey,[15] 75%; and Shih-

pai Eye Study,[11] 66%). CHES is also larger than we had predicted given that the population is primarily first-generation, immigrant Chinese individuals.

Although our participants differed slightly regarding age and sex from eligible nonparticipants, the similarity of the groups with respect to other demographic factors and eye conditions suggests representativeness of the sample within age and sex categories. We report both age- and sex-specific and standardized estimates so that appropriate extrapolation or comparison can be made across other populations.

The age-adjusted prevalence of early AMD was higher in CHES (8.1%) than the prevalence of population-based studies of Chinese, including the Beijing Eye Study[10] (5.9%) and the Handan Eye Study[9] (4.6%). Prevalence was also higher in every age strata in the Beijing Eye Study compared with the Handan Eye Study, suggesting that the prevalence of AMD in northern Chinese may vary within this region of China. Participants in the Beijing Eye Study were a mix of rural and urban residents around Beijing, and participants in the Handan Eye Study (450 miles from Beijing) were all rural residents. This geographic variance suggests that environmental or behavioral factors related to urban living might be associated with the prevalence of early AMD. This hypothesis may also explain the comparable prevalence of early AMD between CHES and the Shihpai Eye Study of urban Chinese-Taiwanese persons, with the authors[11] also speculating that the lipid profile and westernization of the diet may be associated with the prevalence of AMD. Compared with other racial/ethnic groups, age-adjusted prevalence of early AMD was lower in Chinese American than in Latino individuals in the Los Angeles Latino Eye Study (LALES)[5] and in non-Hispanic white individuals in the Beaver Dam Eye Study[14] and the Baltimore Eye Survey.[15] The age-adjusted prevalence of early AMD was also lower in Chinese Americans than in African descendants in the Barbados Eye Study[16] and the Baltimore Eye Survey[15] but higher than that seen in non-Hispanic white individuals in the Blue Mountains Eye Study[17] for every age strata. It is also likely that the differences between CHES participants and non-Hispanic white individuals in the Blue Mountains Eye Study may be due to differences in the definition of early AMD.

In CHES, we found that the prevalence of both early and advanced AMD was higher in men than in women, and this sex difference remained after adjusting for age. The Handan Eye Study,[9] a population-based study in rural China, also found a higher prevalence of AMD in men. In contrast to CHES and the Handan Eye Study, neither the Beijing Eye Study[10] nor the Shihpai Eye Study[11] found a sex difference for early or advanced AMD in the Chinese participants. Similar sex differences in AMD prevalence were found in Latino individuals in LALES[5] but not in non-Hispanic white individuals in the Blue Mountain Eye Study[17] and the Beaver Dam Eye Study.[14] The cause of this sex difference in the prevalence of AMD is unknown. Although cigarette smoking is an important risk factor for AMD[18] and male Chinese Americans were more likely to smoke than were female Chinese Americans (35.3% vs 2.9%; $P < .001$), smoking cannot explain the sex difference in the prevalence of AMD, as it remained substantial after adjusting for smoking status. In addition, since non-AMD-related RPE pigmentary changes were excluded from the analysis, the increased prevalence of central serous retinopathy is unlikely to explain this higher prevalence in men.

Large drusen (≥125 μm diameter) are clinically important lesions in early AMD and have been found in longitudinal incidence studies[19,20] to predict the occurrence of advanced AMD. The age-specific prevalence of large drusen in CHES was higher than that in the Beijing Eye Study[10] but lower than that in the Shihpai Eye Study[11] (eTable 8 in the Supplement). The trends of large drusen prevalence observed in CHES are lower than those reported in Latinos in LALES[5] but higher than most reported[14,17] prevalences for non-Hispanic whites. These differences in the prevalence of large drusen may indicate that AMD develops and progresses differently in various racial/ethnic groups.

We observed a low prevalence of advanced AMD in CHES (0.4%) in general (eTable 7 in the Supplement). The overall prevalence in CHES is most similar to that of the Beijing Eye Study[10] (0.5%) but higher than that of the Handan Eye Study (0.1%).[9] Within CHES, the prevalence of advanced AMD was higher with each subsequent age group, and a similar trend is present in studies of northern Chinese[9,10] and Taiwanese-Chinese.[11] The prevalence of advanced AMD appears to be noticeably higher in people aged 80 years or older in the Shihpai Eye Study participants[11]; however, the prevalence should be interpreted cautiously because of the limited sample size within that age category. In comparison with other racial/ethnic groups (eTable 7 in the Supplement), Chinese Americans in CHES had a prevalence of advanced AMD similar to that of African descendants in the Barbados Eye Study[16] and the Baltimore Eye Survey[15] but lower than that of Latino[5] and non-Hispanic white individuals.[14,15,17]

In CHES, neovascular AMD was more prevalent (12 participants [0.3%]) than geographic atrophy (2 [0.1%]), a ratio almost identical to that found in Latino individuals from LALES.[5] All 4 cases of advanced AMD in the Handan Eye Study[9] and 19 of the 20 (95.0%) participants with advanced AMD in the Shihpai Eye Study[11] had neovascular AMD. The Beijing Eye Study[10] found almost a 1:1 ratio of geographic atrophy and neovascular AMD, with 5 cases of each type of advanced AMD. However, the small number of persons with advanced AMD in most of these studies limits further interpretation of these data.

The CHES cohort comprised primarily Mandarin-speaking immigrants, 68.7% of whom were from mainland China. Therefore, caution is warranted when extrapolating these estimates to Chinese populations of different geosocial or genetic background. Furthermore, age-standardized estimates should be used to compare and infer about prevalence differences across Chinese populations.

Conclusions

CHES provides data from what is, to our knowledge, the largest and most comprehensive study of AMD prevalence among people of Chinese ancestry aged 50 years or older. These data suggest a higher prevalence of early and advanced AMD in

CHES participants than in Chinese from northern China but lower prevalence than in Chinese from Taiwan. Similarly, the prevalence of large drusen in CHES was higher than that observed in North China and lower than that observed in Taiwan. The differences in prevalence observed between participants in CHES and other Chinese might indicate a potential role for environmental factors in the development and progression of AMD. The lower prevalence of both early and advanced AMD in Chinese Americans in CHES, in comparison with Latino and non-Hispanic white individuals, warrants further evaluation of behavioral, cultural, and genetic risk factors.

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