The Prevalence and Causes of Visual Impairment in an Elderly Chinese Bai Ethnic Rural Population: The Yunnan Minority Eye Study

Jun Li,[1,3,4] *Hua Zhong,*[2,4] *Ning Cai,*[2] *Tinghao Luo,*[2] *Juanjuan Li,*[2] *Xiaodan Su,*[2] *Xun Li,*[2] *Xuan Qiu,*[1] *Yongming Yang,*[2] *Yuansheng Yuan,*[2,*] *and Minbin Yu*[1,*]

Purpose. To assess the prevalence and causes of visual impairment in the elderly Bai ethnic group in rural China.

Methods. Random cluster sampling was used to identify the Bai ethnic group 50 years and older living in the Dali county of Yunnan, China. Presenting visual acuity (PVA) and best-corrected visual acuity (BCVA) were measured using the Early Treatment Diabetic Retinopathy Study visual chart. Blindness and low vision were defined according to World Health Organization criteria. The major cause of visual impairment was identified for all participants who were visually impaired.

Results. Of the 2742 eligible individuals, 2133 (77.8%) participated in the study, and 2115 (77.1%) had visual acuity data available. With the PVA, the prevalence of blindness and low vision was 3.59% and 15.22%, respectively. When the BCVA was used, these rates were reduced to 2.88% and 7.75%. Blindness and low vision were associated with older age and lack of education, but no sex difference was seen. Based on the BCVA, the predominant causes of blindness were cataract (70.5%), corneal opacity (8.2%), and glaucoma (6.6%). The majority of PVA-defined low vision cases were attributable to cataract (53.0%) and uncorrected refractive error (22.0%).

Conclusions. A higher rate of visual impairment was seen in this Bai nationality sample than has been reported from the Han nationality population in rural China. Since potentially treatable eye disease, cataract, and uncorrected refractive error were the most important causes of visual impairment in this population, affordable provision of surgery and low-vision rehabilitation programs would help to address this problem. (*Invest Ophthalmol Vis Sci.* 2012;53:4498–4504) DOI:10.1167/iovs.12-9429

Visual impairment remains a major public health problem worldwide. A global initiative—VISION 2020: The Right to Sight—was launched in 1999 by the World Health Organization (WHO) and the International Agency for Prevention of Blindness with the aim of eliminating avoidable blindness by 2020.[1] In 2002, WHO estimated that there were 161 million people with visual impairment, of whom approximately 37 million were blind. Over 90% of the visually impaired live in developing countries. The prevalence of visual impairment in developed countries was significantly lower than that reported for those developing countries.[2–8] In China, WHO estimated the prevalence of blindness in people ≥50 years as 2.3%.[2] This estimation was mainly based on two major population-based studies conducted in Shunyi,[7] a suburban area near Beijing, and Doumen,[8] a county in rural Guangdong Province. However, Shunyi is not rural and Doumen is quite affluent. Therefore, the estimates above could have underestimated the magnitude of visual impairment among the ethnic population living in economically underdeveloped areas. China has a total of 56 different recognized ethnic groups, many living in dissimilar environments. All the preceding studies focused on ethnic Han Chinese populations, none on ethnic minorities. This study, the Yunnan Minority Eye Study (YMES), was designed to determine the prevalence and impact of eye diseases among rural southwestern Chinese populations of the minority nationality (including the Bai, Dai, and Yi nationality). As a part of YMES, the initial results of the prevalence and causes of visual impairment in an Elderly Bai Population are now reported.

The 2000 national census estimated that the population of Bai nationality was 1.86 million in China and approximately 80% live in concentrated communities in the Dali Bai Autonomous Prefecture in Yunnan Province in the southwestern region of China.[9] The rest are scattered in Xichang and Bijie in neighboring Sichuan and Guizhou provinces, respectively. Archaeological finds from Canger and Haimenkou show that the Erhai area (Dali) was inhabited as early as the Neolithic Age.[10] Dali County, located in the west of Yunnan, was the political, economic, and cultural center of the Dali Bai Autonomous Prefecture. In 2000, Dali had an estimated population of 521,169, of whom 66.6% are of Bai nationality and 95,567 are ≥50 years old.[11] The average annual income per rural resident is 3078 Yuan (<485 USD).

There have been no published reports on the prevalence and causes of visual impairment in the Bai ethnic group living in rural China. To address this gap in knowledge, the authors conducted a population-based survey in a sample of Bai population aged 50 years and older living in Dali.

From the [1]State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou, China; [2]The First Affiliated Hospital of Kunming Medical University; and the [3]Second People's Hospital of Yunnan Province, Kunming, China.

[4]These authors contributed equally to the work presented here and should therefore be regarded as equivalent first authors.

Supported by National Natural Science Foundation of China Grant 30860309 and Yunnan Province Science and Technology Project Grant 2009CA007.

Submitted for publication January 4, 2012; revised April 28 and May 30, 2012; accepted June 2, 2012.

Disclosure: **J. Li**, None; **H. Zhong**, None; **N. Cai**, None; **T. Luo**, None; **J. Li**, None; **X. Su**, None; **X. Li**, None; **X. Qiu**, None; **Y. Yang**, None; **Y. Yuan**, None; **M. Yu**, None

*Each of the following is a corresponding author: Minbin Yu, Department of Glaucoma, Department of Optometry, Zhongshan Ophthalmic Center, Guangzhou 510060, People's Republic of China; max-yu@tom.com.

Yuansheng Yuan, Department of Ophthalmology, The First Affiliated Hospital of Kunming Medical University, No. 295 Xichang Road, Kunming 650032, People's Republic of China; 1119abcd@163.com.

Investigative Ophthalmology & Visual Science, July 2012, Vol. 53, No. 8
Copyright 2012 The Association for Research in Vision and Ophthalmology, Inc.

Downloaded from tvst.arvojournals.org on 06/28/2022

METHODS

Sampling and Enumeration

Ethical approval was obtained from the Kunming Medical University Ethics Review Board. The study was conducted in accordance with the tenets of the World Medical Association's Declaration of Helsinki.

Dali is a county-level city covering an area of 1815 square kilometers. Dali has nine rural towns and two urban towns (the Xiaguan and Gucheng town). Each rural town comprises many small administrative villages. In this study, a random cluster sampling method was used to identify eligible participants. A village with a population size of approximately 1000 would be considered a potential sampling unit. Based on geographic proximity, villages with a population size smaller than 750 would be combined and those with a population size larger than 1500 would be divided and regrouped. In this way, study authors created 259 arbitrary cluster sampling units; each cluster unit had a population size of between 900 and 1100. With a computer-based randomization program offered by the Zhongshan Ophthalmic Center, 12 clusters were randomly selected to reach a target sample size of this study. Field work was conducted from January 2010 to April 2010. Listing of households with the names of residents ≥50 years of age were obtained from the village registers. By door-to-door household visits, the name, age, sex, education level, and spectacle usage of subjects was obtained. Unregistered Bai adults ≥50 years of age who had been living in the village longer than 6 months were enumerated and included in the study. Individuals who had been certified as being out of the location for more than 6 months were excluded from the study, despite their household registration. Written informed consent was obtained from the participants at the examination site.

Eye Examination

Study participants were examined according to a prescheduled date established at the time of enumeration. Identity of the subjects was verified using the subjects' official photo identity cards. A standard questionnaire was administered by a trained interviewer to collect details of ophthalmic history, general medical history, income, and education. Distance visual acuity (VA) was measured employing an Early Treatment Diabetic Retinopathy Study logMAR E-chart (Precision Vision, Villa Park, IL) with a standard illumination box. VA measurement began at a distance of 4 m with the top line (20/200). If the orientation of at least four of the five optotypes was correctly identified, the subject was then tested by dropping down to line 4 (20/100) line, to line 7 (20/50), to line 10 (20/25), and finally to line 11 (20/20). If the individual failed to identify the top line at 4 m, the subject was advanced to 2 m and then to 1 m, progressing down the chart as described earlier. The lowest line read successfully was assigned as the VA for the eye. Testing for counting fingers, hand movement, light perception, or no light perception was checked on those who unable to identify any optotypes on the chart. The VA was measured in each eye initially without refractive correction or with distance glasses if worn. All the participants with a presenting VA (PVA) ≤20/25 in either eye received subjective refractive measurements and the best-corrected VA (BCVA) was noted. Subjective refraction was performed by a trained optometrist for those subjects, and autorefractor (RM-8000; Topcon, Tokyo, Japan) readings were used as the starting point for subjective refraction carried out without cycloplegia. For those in whom subjective refraction was not performed, particularly the elderly examined in their homes, BCVA was assumed to be the same as pinhole vision. Intraocular pressure (IOP) was measured by a study ophthalmolgist using a handheld tonometer (Tono-Pen AVIA; Reichert Inc., Depew, NY) device after instilling topical anesthesia (0.4% Benoxil [oxybuprocaine]; Santen Pharmaceuticals, Osaka, Japan). Goldmann applanation tonometry was performed on an optional basis for all glaucoma suspects. The detailed examination of the eyelid, globe, pupillary reflex, lens, and fundi was carried out by an experienced ophthalmologist using a slitlamp (model SL-1E; Topcon), a +90-diopter (D) lens at ×16 magnification and direct ophthalmoscopy. The participants were examined at local community facilities; those who failed to come to the examination site were examined in their home using portable equipment.

Patients with BCVA ≤20/40 had their pupils dilated for examination. Similarly, if participants' lens and fundus status could not be examined satisfactorily, their pupils were also dilated. Individuals with shallow anterior chambers did not have their pupils dilated. Eyes presenting with PVA ≤20/40 were assigned a principal cause of visual impairment by the same experienced oculist. Refractive error was considered the cause of visual impairment for those with a VA ≤20/40 that could be subsequently improved to >20/40 after correction. Cataract was regarded as the main cause of visual impairment if there was no evidence of retinal abnormality in an eye with significant cataract that obscured the vision. Myopic maculopathy was considered only in those with a refractive error exceeding −6.0 D in either eye, in conjunction with one or more of the following ophthalmologic findings: tessellated fundus with yellowish white diffuse or grayish white patchy chorioretinal atrophy, macular hemorrhage, or posterior staphyloma.[12] Age-related macular degeneration (AMD) as a reason for visual impairment was characterized by soft drusen of the retinal pigment epithelium, subfoveal hemorrhage, subretinal and intraretinal edema without any retinal reason detected for it, or a subfoveal disciform scar. Glaucoma was defined according to the International Society for Geographical and Epidemiological Ophthalmology Classification.[13] Diabetic retinopathy was present if the macula showed cystoid macular edema, hard exudates, intraretinal hemorrhages, and microaneurysms. A self-reported diagnosis of diabetes mellitus was a relatively important but not necessary part of the diagnosis of diabetic retinopathy. Other causes for visual impairment were determined according to clinical routine diagnosis.

Definitions

Visual impairment was defined as a BCVA of <20/63 in the better-seeing eye, according to WHO categories of visual impairment.[14] Low vision and blindness were defined as a VA <20/63–20/400 in the better-seeing eye and <20/400, respectively. In addition, the rates of visual impairment were also reported according to the more commonly used definition of legal blindness (a VA ≤20/200 in the better eye) and low vision (a VA <20/40 to >20/200 in the better eye) in the United States. When two or more disorders might have caused the visual impairment in same eye, the group of examiners was asked to decide which disease was the main cause. If cataract and a posterior-segment lesion of the optic nerve or retina coexisted and removal of cataract would not restore vision, the cause of visual impairment was considered to be the posterior-segment lesion. If dense cataract, corneal opacity, or other diseases prevented any view of the posterior segment while no signs suggestive of any other cause of visual loss were present, the cause of visual impairment was considered to be cataract, corneal opacity, or other diseases. If the two eyes of a subject were visual impaired from two different causes, the team ophthalmologist chose the major cause of impaired vision in the better-seeing eye as the cause for that participant. When the main cause of vision impairment was in doubt, a second experienced ophthalmologist examined the subject again, and then the diagnosis was determined by consensus of the two ophthalmologists.

Statistical Analysis

Prevalence estimates with 95% confidence intervals (CI) were calculated for blindness and low vision. Age- and sex-standardized prevalence of visual impairment and 95% CI were estimated via direct standardization of the study sample to the overall Dali population provided by the 2000 China Census. Association of blindness and low vision with age, sex, and education was estimated using logistic regression.

Downloaded from tvst.arvojournals.org on 06/28/2022

Table 1. Study Population by Age, Sex, and Education

	No. Enumerated (%)	No. Examined (%)	Examination Response Rate (%)
Age (y)			
50–59	1123 (41.0)	715 (33.5)	63.7
60–69	867 (31.6)	775 (36.3)	89.4
70–79	607 (22.1)	525 (24.6)	86.5
≥80	145 (5.3)	118 (5.5)	81.4
Sex			
Male	1315 (48.0)	769 (36.1)	58.5
Female	1427 (52.0)	1364 (63.9)	95.6
Education			
Illiteracy	994 (36.3)	759 (35.6)	76.4
Primary school	1095 (40.0)	868 (40.7)	79.3
Middle school	554 (20.2)	427 (20.0)	77.1
High school or higher	99 (3.6)	79 (3.7)	79.8
All	2742 (100.0)	2133 (100.0)	77.8

Results

A total of 2742 persons aged ≥50 years were enumerated, and 2133 (77.8%) participants were successfully examined. Women and the more elderly were most likely to attend the examination. Comparing the demographic characteristics of the enumerated sample with the total population of the Dali city (National Census in 2000), subjects aged 50 to 59 years were underrepresented in the sample (33.5% in the sample versus 45.7% in Dali). Those who refused were more likely to be male, but there was no difference in mean age between this group (64.1 years) and participants (64.6 years). Of the 608 nonexamined subjects, 593 (21.6%) cooperated only in the first step of household interview, and 15 (0.55%) could not be contacted during three visits for the household interview. The main reasons for nonexamination were their refusal to participate, being too busy, having good visual acuity, or our inability to contact the subjects after the interview. In the current study, 18 subjects were unable to complete VA testing successfully due to their incomprehension of such tests. As a result, the analysis of this study was based on the data from 2115 individuals. A total of 35.6% of participants had no education, and 23.7% had an education of secondary or higher level (Table 1).

Based on the WHO criteria, the unadjusted prevalence of presenting blindness and presenting low vision was 3.59% (n = 76; 95% CI, 2.80-4.39) and 15.22% (n = 322; 95% CI, 13.69–16.75), respectively. These rates were reduced to 2.88% (n = 61; 95% CI, 2.17–3.60) and 7.75% (n = 164; 95% CI, 6.61–8.89) when the BCVA was considered. Based on the US criterion, the unadjusted prevalence of presenting blindness and low vision was 4.96% (n = 105; 95% CI, 4.04–5.89) and 13.48% (n = 285; 95% CI, 12.02–14.93). Unilateral blindness (<20/200 in one eye) was found in 11.63% (n = 246; 95% CI, 10.26–13.00) of the subjects based on PVA, and decreased to 9.93% (n = 210) when BCVA was considered. (Table 2) The age- and sex-standardized prevalence estimate of BCVA-defined visual impairment using the WHO definition was 2.21% for bilateral blindness, 6.09% for bilateral low vision. All estimates of prevalence increased with age, but there was no difference in estimates between men and women. After adjusting for the effect of age and sex, those with a lower level of education (illiterate) tended to be associated with blindness and low vision (Table 3).

Cataract and refractive error together accounted for approximately 80.0% of the eyes with a PVA less than 20/63 to 20/200 or more. However, cataract-impaired eyes were found mostly among the older individuals (≥60 years) while refractive error was more common in the younger group (50 to 59 years). Among those aged 50 to 59 years, refractive error (44.9%) was the predominant cause of visual impairment (PVA <20/63). When BCVA is considered, refractive error is no longer a cause for visual impairment and cataract was assigned as the major cause of visual impairment across all levels of severity (Table 4). Cataract accounted for 53.0% of PVA-defined low vision and 64.5% blindness (Table 5). After refractive correction, cataract remained the leading cause of blindness (70.5%), whereas corneal opacity and glaucoma accounted for 8.2% and 6.6% of blindness among participants, respectively.

Discussion

This study provides the first population-based data on the prevalence and causes of visual impairment in the elderly Bai ethnic population (≥50 years) in China. The results reported here show that the prevalence of bilateral blindness (PVA <20/400 in the better eye) was 3.59%. The adjusted prevalence of presenting bilateral blindness was 2.79%, and using WHO definitions was 2.21%, which is similar to the WHO estimates.[2] Although direct comparison with previous studies in other developed countries might not be appropriate because of the variations in study age groups, the prevalence of blindness and

Table 2. Prevalence of Visual Impairment and Blindness Based on PVA and BCVA

	VA Definition		Prevalence with PVA		Prevalence with BCVA	
Category	Better Eye	Worse Eye	No. (%)	95% CI	No. (%)	95% CI
NN	≥20/63	≥20/63	1346 (63.64)		1594 (75.37)	
VI	≥20/200	<20/63 to ≥20/200	400 (18.91)	17.24–20.58	211 (10.45)	9.14–11.75
UL	≥20/200	<20/200	246 (11.63)	10.26–13.00	210 (9.93)	8.65–11.20
MB	<20/200 to ≥ 20/400	<20/200	47 (2.22)	1.59–2.85	29 (1.37)	0.88–1.87
SB*	<20/400	<20/400	76 (3.59)	2.80–4.39	61 (2.88)	2.17–3.60
WHO low vision	<20/63 to ≥20/400		322 (15.22)	13.69–16.75	164 (7.75)	6.61–8.89
US blindness	≤20/200		172 (8.13)	4.82–6.81	105 (4.96)	4.04–5.89
US low vision	<20/40 to >20/200		525 (24.82)	22.98–26.67	285 (13.48)	12.02–14.93
Total			2115		2115	

MB, moderate bilateral blindness; NN, normal/near normal; SB, severe bilateral blindness; UL, unilateral blindness; VI, vision impairment; WHO.

* Equivalent to WHO blindness definition (VA <20/400 in better eye).

Downloaded from tvst.arvojournals.org on 06/28/2022

Table 3. Presenting and Best-Corrected Visual Impairment (<20/63–20/400) and Blindness (<20/400) by Age, Sex, and Education

		Presenting Low Vision		Presenting Blindness		Best-Corrected Low Vision		Best-Corrected Blindness	
	No.	Prevalence No. (%)	Adjusted Odds Ratio (95% CI)	Prevalence No. (%)	Adjusted Odds Ratio (95% CI)	Prevalence No. (%)	Adjusted Odds Ratio (95% CI)	Prevalence No. (%)	Adjusted Odds Ratio (95% CI)
Age (y)									
50-59	715	36 (5.03)	—	5 (0.70)	—	13 (1.82)	—	4 (0.56)	—
60-69	774	82 (10.59)	2.14 (1.42–3.23)†	8 (1.03)	1.27 (0.41–3.92)*	35 (4.52)	2.46 (1.28–4.70)†	6 (0.78)	1.17 (0.33–4.18)*
70–79	516	146 (28.29)	6.47 (4.30–9.72)†	44 (8.53)	8.80 (3.36–23.03)†	80 (15.50)	8.48 (4.55–15.83)†	33 (6.40)	8.10 (2.77–23.74)†
≥ 80	110	58 (52.73)	17.99 (10.70–30.24)†	19 (17.27)	19.40 (6.89–54.63)†	36 (32.73)	21.94 (10.87–44.26)†	18 (16.36)	22.68 (7.30–70.48)†
Sex									
Female	1350	218 (16.15)	—	51 (3.78)	—	117 (8.67)	—	43 (3.19)	—
Male	765	104 (13.59)	0.88 (0.65–1.18)*	25 (3.27)	1.24 (0.70–2.20)*	47 (6.14)	0.76 (0.50–1.15)*	18 (2.35)	1.02 (0.53–1.96)*
Education									
Secondary or higher	506	36 (7.11)	—	3 (0.59)	—	14 (2.77)	—	1 (0.20)	—
Primary school	863	115 (13.33)	1.50 (0.99–2.26)	22 (2.55)	3.17 (0.93–10.86)*	54 (6.26)	1.63 (0.88–3.03)*	19 (2.20)	8.06 (1.06–61.28)†
Illiterate	746	171 (22.92)	1.79 (1.15–2.79)†	51 (6.84)	5.44 (1.56–19.01)†	96 (12.87)	2.01 (1.06–3.84)†	41 (5.50)	11.54 (1.49–89.38)†

* $P \geq 0.05$.
† $P < 0.001$.

low vision in the YMES was significantly higher than that reported for the Salisbury Eye Evaluation study[4] in the United States, the Blue Mountains Eye Study[5] in Australia, and the Rotterdam Study[15] in The Netherlands. The estimates obtained here are higher than adjusted prevalence estimates reported in the previous studies in Chinese Han population such as Beijing (0.34% in people ≥40 years; PVA <6/60)[16] and Handan (1.5% in people ≥50 years; PVA <20/400)[17]. This may be because all previous surveys are in the more prosperous areas of China compared with Dali. A higher prevalence of blindness might reflect a lower socioeconomic and eye health care system level in their corresponding areas. A recently conducted population-based survey of Han people in Kunming, Yunnan Province, targeted the same age groups (50 years or older) as the population[18] of this current study, and reported an adjusted prevalence of 2.3% for BCVA-defined blindness, which is similar to the result of the current study (2.21%). There was increasing evidence suggesting an association between age, sex, socioeconomic status, and the risk of visual impairment.[19] Dali is located approximately 300 km west of Kunming, and the Bai populations living in Dali have different customs and cultural backgrounds than Han residents of Kunming. The similar high altitude in Dali (1974 vs. 1892 m in Kunming) and the low gross domestic product per capita in Dali may account in part for the higher prevalence of visual impairment than was seen in previous studies in China. Nearly all the Bai ethnic group lives in rural of Yunnan, which is one of the poorest provinces in China; the results presented herein are likely to be more reflective of the elderly Bai ethnic rural population. The more elderly Bai population had more vision loss, but no sex difference in the magnitude of visual impairment was found, similar to the findings in the Beijing[20] and Liwan.[21] Rapid population aging in China in recent years may also have contributed to the higher estimates detected in the current study. In addition, illiterate Bai people had more blindness and low vision. This is probably because of limited accessibility to eye care services and a lack of awareness of eye diseases among these people.

In agreement with other population-based surveys on the Chinese Han population, cataract was the leading cause of blindness and low vision. This study revealed that approximately 62.2% of visual impairment was due to cataracts, the predominating cause of blindness (43 of 61) and low vision (97 of 164). The high altitude in Dali (1974 m) may account in part for the higher prevalence of visual impairment that was seen in the current study. It is possible that living in higher-altitude areas with increased exposure to ultraviolet light leads to a higher prevalence of cataract.[22] In this survey, the rate of cataract as a major cause of visual impairment increased with age, from 16.7% in people aged 50 to 59 years, 37.2% in those aged 60 to 69 years, 59.7% in those aged 70 to 79 years, to 66.5% in those aged 80 years or more. It was surprising that among Bai people with visual impairment caused by cataracts, only 17.0% (23 of 135) of them were diagnosed in the hospital and the remaining sufferers remained ignorant of the diagnosis. The reasons for no surgery in these subjects suffering cataract might be accounted for by the following three answers: (1) 45% of them believed that worsening vision was a normal part of growing older; (2) 30% could not afford cataract surgery; (3) 25% were afraid of losing vision after cataract surgery. Thus, enhancing the availability and accessibility of eye care services and improving the community awareness of age-related cataracts will reduce the rates of visual impairment caused by cataracts.

Refractive error was the second principal cause for visual impairment when PVA was used. Uncorrected refractive error accounted for approximately one-third of low vision cases, similar to the findings in Shunyi[7] and Doumen.[8] When BCVA was considered, refractive error was no longer the cause for

Downloaded from tvst.arvojournals.org on 06/28/2022

Table 4. Principal Cause of Impairment in Eyes with PVA and BCVA <20/63

	No. (%)							
	Eyes by Visual Acuity			Eyes by Age (y)				
Principal Cause	<20/63 to ≥20/200	<20/200 to ≥400	<20/400	50–59	60–69	70–79	≥80	Total
Cataract	318 (47.3)	84 (52.5)	162 (48.8)	26 (16.7)	125 (37.2)	298 (59.7)	115 (66.5)	564 (48.5)
	218 (61.2)	38 (48.1)	156 (50.2)	20 (27.4)	80 (41.7)	222 (64.2)	90 (66.7)	412 (55.2)
Refractive error	218 (32.4)	8 (5.0)	2 (0.6)	70 (44.9)	89 (26.5)	60 (12.0)	9 (5.2)	228 (19.6)
	0	0	0	0	0	0	0	0
AMD	31 (4.6)	23 (14.4)	16 (4.8)	5 (3.2)	16 (4.8)	38 (7.6)	11 (6.4)	70 (6.0)
	32 (9.0)	19 (24.1)	14 (4.5)	5 (6.9)	15 (7.8)	34 (9.8)	11 (8.1)	65 (8.7)
Myopic maculopathy	20 (3.0)	16 (10.0)	22 (6.6)	20 (12.8)	22 (6.6)	12 (2.4)	4 (2.3)	58 (5.0)
	31 (8.7)	3 (3.8)	15 (4.8)	15 (20.6)	20 (10.4)	10 (2.9)	4 (3.0)	49 (6.6)
Glaucoma	12 (1.8)	7 (4.4)	28 (8.4)	2 (1.3)	19 (5.7)	19 (3.8)	7 (4.1)	47 (4.0)
	10 (2.8)	4 (5.1)	28 (9.0)	2 (2.7)	17 (8.9)	17 (4.9)	6 (4.4)	42 (5.6)
Corneal opacity	9 (1.3)	3 (1.9)	32 (9.6)	9 (5.8)	12 (3.6)	17 (3.4)	6 (3.5)	44 (3.8)
	9 (2.5)	3 (3.8)	32 (10.3)	9 (12.3)	12 (6.3)	17 (4.9)	6 (4.4)	44 (5.9)
Pterygium	21 (3.1)	4 (2.5)	16 (4.8)	5 (3.2)	22 (6.6)	11 (2.2)	3 (1.7)	41 (3.5)
	17 (4.8)	3 (3.8)	16 (5.1)	4 (5.5)	18 (9.4)	11 (3.2)	3 (2.2)	36 (4.8)
Optic atrophy	5 (0.7)	1 (0.6)	8 (2.4)	0	3 (0.9)	6 (1.2)	5 (2.9)	14 (1.2)
	7 (2.0)	0	7 (2.3)	0	3 (1.6)	6 (1.7)	5 (3.7)	14 (1.9)
Diabetic retinopathy	4 (0.6)	1 (0.6)	1 (0.3)	4 (2.6)	2 (0.6)	0	0	6 (0.5)
	4 (1.1)	1 (1.3)	1 (0.3)	4 (5.5)	2 (1.0)	0	0	6 (0.8)
Undetermined	7 (1.0)	5 (3.1)	6 (1.8)	7 (4.5)	9 (2.7)	1 (0.2)	1 (0.6)	18 (1.5)
	9 (2.5)	2 (2.5)	6 (1.9)	6 (8.2)	9 (4.7)	1 (0.3)	1 (0.7)	17 (2.3)
Others	27 (4.0)	8 (5.0)	39 (11.7)	8 (5.1)	17 (5.1)	37 (7.4)	12 (6.9)	74 (6.4)
	19 (5.3)	6 (7.6)	36 (11.6)	8 (11.0)	16 (8.3)	28 (8.1)	9 (6.7)	61 (8.2)
All	672 (100)	160 (100)	332 (100)	156 (100)	336 (100)	499 (100)	173 (100)	1164 (100)
	356 (100)	79 (100)	311 (100)	73 (100)	192 (100)	346 (100)	135 (100)	746 (100)

For each principal cause, the first row represents the result based on presenting visual acuity while the second row represents the result based on best-corrected visual acuity.

visual impairment. Recently, the WHO pointed out that the use of "best corrected" vision overlooks a large proportion of persons with visual impairment, including blindness. For this reason, the WHO recommends using PVA as the criterion for visual impairment.

Compared with developed countries, visual impairment caused by AMD was less frequent (8.4%) in the Bai population. In Western countries, the predominant cause of visual impairment in the elderly population was mostly AMD. In the SEE study, AMD was the major cause of visual impairment among Caucasians, producing 70% of the cases of blindness and 33% of the cases of low vision.[4] In the Baltimore Eye Survey, the second cause of visual impairment was AMD, which contributed to 14.2% of the impaired eyes.[23] Among the

Table 5. Principal Causes of Low Vision and Blindness According to PVA and BCVA

	Based on PVA						Based on BCVA					
	Low Vision* (*n* = 322)		Blindness† (*n* = 76)		Visual Impairment‡ (*n* = 398)		Low Vision* (*n* = 164)		Blindness* (*n* = 61)		Visual Impairment‡ (*n* = 225)	
Causes	No.	%	No.	%	No	%	No.	%	No.	%	No.	%
Cataract	172	53.0	49	64.5	221	55.5	97	59.1	43	70.5	140	62.2
Refractive error	70	22.0	2	2.6	72	18.1						
AMD	21	6.5	3	4.0	24	6.0	17	10.4	2	3.3	19	8.4
Myopic maculopathy	16	5.0	7	9.2	23	5.8	16	9.8	2	3.3	18	8.0
Glaucoma	10	3.1	4	5.3	14	3.5	8	4.9	4	6.6	12	5.3
Corneal opacity	3	0.9	3	4.0	6	1.5	3	1.8	5	8.2	8	3.6
Pterygium	4	1.2	1	1.3	5	1.3	5	3.0	1	1.6	6	2.7
Diabetes retinopathy	3	0.9	0	0.0	3	0.8	3	1.8	0	0.0	3	1.3
Optic nerve atrophy	2	0.6	1	1.3	3	0.8	3	1.8	0	0.0	3	1.3
Phthisis/anophthalmus	0	0.0	2	2.6	2	0.5	0	0.0	2	3.3	2	0.9
Others	21	6.5	4	5.3	25	6.3	12	7.3	2	3.3	14	6.2

* Defined as visual acuity <20/63 and ≥20/400.
† Defined as visual acuity <20/400.
‡ Blindness plus low vision, defined as visual acuity <20/63.

Downloaded from tvst.arvojournals.org on 06/28/2022

Bai people, the rate of visual impairment caused by AMD was markedly higher than most of the related Chinese Han population surveys,[7,8,21] but significantly lower than that of studies in Shanghai (17.8%) [24] and Shihpai (10.4%).[12] The reasons for these discrepancies between the YMES and investigations on other studies in China have remained unclear so far. There are two possible reasons for the difference. First, it is possible that Dali's geographic location in high-altitude (1974 m) and low-latitude (Latitude 25°25 to 25°58 N) areas and long-term outdoor labor among Bai people increases exposure to ultraviolet light, leading to a higher prevalence of AMD.[25] Second, lower levels of education,[26,27] and more females[26,28] and elderly participants[29] in this study, combined with relatively poor access to eye care services in Dali, may contribute to these observed differences.

Myopic maculopathy was the third cause of BCVA-defined visual impairment in the Bai ethnic group, accounting for 8.0% of cases. The results are similar to previous findings from other Chinese Han populations: myopic maculopathy accounted for 12.5% of visual impairment in the Shihpai Eye Study in Taiwan,[12] 11.2% in the Handan Eye Study in Hebei,[17] and 9% of bilateral blindness in the Tanjong Pagar survey in Singapore.[30] There appears to be a difference between these results and those of European studies. The Rotterdam Study was the only study reporting a relatively high proportion (6%) of visual impairment cases attributable to myopic maculopathy.[15] Therefore, myopic maculopathy is a unique and important cause of visual impairment in the Chinese population.

Glaucoma was responsible for 5.3% of BCVA-defined visual impairment (4.9% of low vision and 6.6% of blindness) in the Bai population. This figure was close to that in the Handan,[17] in which glaucoma accounted for 6.0% of visual impairment (4.7% of bilateral low vision and 9.7% of bilateral blindness) cases, and also similar to the Beijing Eye Study,[16] which reported that 7.7% of bilateral blindness cases were the result of glaucoma. In contrast, this proportion is remarkably lower than the Tanjong Pagar survey in Chinese residents of Singapore[30], where glaucoma was identified as the leading cause of unilateral and bilateral blindness, affecting 34% and 60% of the population, respectively. The reason for this difference is unclear. A potential explanation is the Tanjong Pagar survey adopted both visual acuity and visual field criteria in defining blindness. However, in the current study's diagnostic protocols, study authors defined visual impairment only according to the WHO categories of visual impairment, and the visual field loss was not taken into account. This is because study authors intended to use similar criteria to our previous studies in China. Therefore, the true magnitude of glaucomatous visual impairment might be underestimated.

Though the current study's survey included a large sample size, high response rate (77.8%), and the use of standardized protocols, there still remain some limitations. Firstly, the relatively low response rate of the youngest group (aged 50–59 years, 63.7%) was a source of potential bias. Because the rates of visual impairment increase significantly with age, underrepresentation in younger people might result in overestimation of the true prevalence of visual impairment. Secondly, cataract and corneal opacity accounted for 62.2% and 2.7% of visual impairment, respectively, and severe lens and corneal opacity may prevent examiners from detecting posterior-segment eye diseases, leading to a possible underdetection of retinal pathology, myopic maculopathy, AMD, and glaucoma. Finally, similar to previous studies in China,[12,17,21] the Lens Opacity Classification System III was not used to diagnose cataract. Study authors adopted the clinical diagnostic criteria of cataract, which does not affect the analysis of the cause of blindness and low vision. Owing to nonstandardized grading of cataract, this current study has a significant limitation in the assessment and comparison of the severity of cataract.

In conclusion, study authors reported the primary results of prevalence and causes of visual impairment in elderly Bai ethnic group (≥50 years) in rural China. In this study, the prevalence of blindness and low vision is higher than that observed in the Chinese Han population. As potentially treatable eye diseases, cataract and uncorrected refractive error are the most important causes of visual impairment. When BCVA was considered, refractive error was no longer the cause for visual impairment. These findings justify the need for eye care programs and visual impairment rehabilitation services in Minority regions.

Acknowledgments

The authors thank Geoffrey Arden, City University London, for paper revisions.

References

1. Pararajasegaram R. VISION 2020-the right to sight: from strategies to action. *Am J Ophthalmol*. 1999;128:359–360.
2. Resnikoff S, Pascolini D, Etya'ale D, et al. Global data on visual impairment in the year 2002. *Bull World Health Organ*. 2004; 82:844–851.
3. Rubin GS, West SK, Munoz B, et al. A comprehensive assessment of visual impairment in a population of older Americans. The SEE Study. Salisbury Eye Evaluation Project. *Invest Ophthalmol Vis Sci*. 1997;38:557–568.
4. Munoz 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.
5. Attebo K, Mitchell P, Smith W. Visual acuity and the causes of visual loss in Australia. The Blue Mountains Eye Study. *Ophthalmology*. 1996;103:357–364.
6. 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 Experiment Ophthalmol*. 2000;28:268–273.
7. Zhao J, Jia L, Sui R, Ellwein LB. Prevalence of blindness and cataract surgery in Shunyi County, China. *Am J Ophthalmol*. 1998;126:506–514.
8. Li S, Xu J, He M, Wu K, Munoz SR, Ellwein LB. A survey of blindness and cataract surgery in Doumen County, China. *Ophthalmology*. 1999;106:1602–1608.
9. National Bureau of Statistics People's Republic of China. Major figures of the 2000 population census. Available at: http://www.stats.gov.cn/tjsj/ndsj/renkoupucha/2000pucha/html/t0201.htm. Accessed June 16, 2010.
10. China Kindness Tour. A introduction of Bai People. Available at: http://www.chinakindnesstour.com/Chinainfo/minority/EthnicMinority/Chinainfo_125.shtml. Accessed June 22, 2012.
11. National Bureau of Statistics People's Republic of China. Major figures of the 2000 population census. Available at: http://www.stats.gov.cn/tjsj/ndsj/renkoupucha/2000fenxian/htm/table2.htm. Accessed June 16, 2010.
12. Hsu WM, Cheng CY, Liu JH, Tsai SY, Chou P. Prevalence and causes of visual impairment in an elderly Chinese population in Taiwan: the Shihpai Eye Study. *Ophthalmology*. 2004;111: 62–69.
13. Foster PJ, Buhrmann R, Quigley HA, Johnson GJ. The definition and classification of glaucoma in prevalence surveys. *Br J Ophthalmol*. 2002;86:238–242.
14. Media Centre, World Health Organization. Magnitude and

Downloaded from tvst.arvojournals.org on 06/28/2022

causes of visual impairment. Fact Sheet no. 282. November 2004. Available at: http://www.who.int/mediacentre/factsheets/fs282/en/. Accessed June 16, 2010.

15. 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.
16. Xu L, Wang Y, Li Y, Cui T, Li J, Jonas JB. Causes of blindness and visual impairment in urban and rural areas in Beijing: the Beijing Eye Study. *Ophthalmology*. 2006;113:1134;e1131–e1111.
17. Liang YB, Friedman DS, Wong TY, et al. Prevalence and causes of low vision and blindness in a rural Chinese adult population: the Handan Eye Study. *Ophthalmology*. 2008;115:1965–1972.
18. Wu M, Yip JL, Kuper H. Rapid assessment of avoidable blindness in Kunming, China. *Ophthalmology*. 2008;115:969–974.
19. West S, Sommer A. Prevention of blindness and priorities for the future. *Bull World Health Organ*. 2001;79:244–248.
20. Xu L, Cui T, Yang H, et al. Prevalence of visual impairment among adults in China: the Beijing Eye Study. *Am J Ophthalmol*. 2006;141:591–593.
21. Huang S, Zheng Y, Foster PJ, Huang W, He M. Prevalence and causes of visual impairment in Chinese adults in urban southern China. *Arch Ophthalmol*. 2009;127:1362–1367.
22. Hu TS, Zhen Q, Sperduto RD, Zhao JL, Milton RC, Nakajima A. Age-related cataract in the Tibet Eye Study. *Arch Ophthalmol*. 1989;107:666–669.
23. Rahmani B, Tielsch JM, Katz J, et al. The cause-specific prevalence of visual impairment in an urban population. The Baltimore Eye Survey. *Ophthalmology*. 1996;103:1721–1726.
24. Zou HD, Zhang X, Xu X, Wang FH, Zhang SJ. [Prevalence study of age-related macular degeneration in Caojiadu blocks, Shanghai]. *Zhonghua Yan Ke Za Zhi*. 2005;41:15–19.
25. Tomany SC, Cruickshanks KJ, Klein R, Klein BE, Knudtson MD. Sunlight and the 10-year incidence of age-related maculopathy: the Beaver Dam Eye Study. *Arch Ophthalmol*. 2004;122:750–757.
26. Age-Related Eye Disease Study Research Group. Risk factors associated with age-related macular degeneration. A case-control study in the age-related eye disease study: Age-Related Eye Disease Study Report Number 3. *Ophthalmology*. 2000;107:2224–2232.
27. Xu L, Li Y, Zheng Y, Jonas JB. Associated factors for age related maculopathy in the adult population in China: the Beijing eye study. *Br J Ophthalmol*. 2006;90:1087–1090.
28. Buch H, Vinding T, la Cour M, Jensen GB, Prause JU, Nielsen NV. Risk factors for age-related maculopathy in a 14-year follow-up study: the Copenhagen City Eye Study. *Acta Ophthalmol Scand*. 2005;83:409–418.
29. Tomany SC, Wang JJ, Van Leeuwen R, et al. Risk factors for incident age-related macular degeneration: pooled findings from 3 continents. *Ophthalmology*. 2004;111:1280–1287.
30. Foster PJ, Oen FT, Machin D, et al. The prevalence of glaucoma in Chinese residents of Singapore: a cross-sectional population survey of the Tanjong Pagar district. *Arch Ophthalmol*. 2000;118:1105–1111.

Downloaded from tvst.arvojournals.org on 06/28/2022