

# Prevalence and causes of visual impairment in population more than 50 years old

## The Shaanxi Eye Study

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### Abstract

To assess the prevalence and causes of visual impairment (VI) in the elderly Chinese rural population in Shaanxi Province.

A population-based, cross-sectional study design was used to determine the extent of VI in Chinese people over the age of 50 years in Shaanxi Province. Visual acuity and best-corrected visual acuity were measured using the logarithm of minimum angle of resolution chart. Blindness and low vision were defined according to WHO criteria. The major cause of VI was identified for all participants who were visually impaired.

A total of 1912 residents completed a standard questionnaire and underwent a detailed eye examination, and the response rate was 90%. The overall prevalence of blindness and low vision were 1.5% and 8.2%. There was no statistically significant differences between genders in the prevalence of blindness and low vision ( $P > .05$ ). The prevalence of blindness and low vision was higher among older individuals ( $P < .05$ ) and lower ( $P < .05$ ) among those with the highest education level. Cataract, corneal opacity, and glaucoma were considered as the main causes of blindness, which accounted for 67.9%, 10.7%, and 7.1%, respectively. Cataract, refractive error, and age-related macular degeneration were always considered as the leading causes of low vision, which accounted for 66%, 14.7%, and 5.8%, respectively.

Cataract, corneal opacity, and glaucoma were the main causes of blindness and low vision in the population aged 50 years or more. The prevalence of these diseases that causes blindness and low vision was higher than that reported in other studies.

**Abbreviations:** AMD = age-related macular degeneration, BCVA = best-corrected visual acuity, CI = confidence interval, VA = visual acuity, VI = visual impairment, WHO = World Health Organization.

**Keywords:** causes, elderly rural Chinese, prevalence, visual impairment

## 1. Introduction

According to World Health Organization (WHO), visual impairment (VI) is an important health problem in both developed and developing countries. The estimated number

of visually impaired people worldwide is 285 million, with 39 million being blind and 246 million having low vision. About 65% of visually impaired and 82% of blind people are 50 years and older.<sup>[1-3]</sup>

The common causes of visual acuity (VA) loss as reported in other studies were uncorrected refractive errors, cataract, central corneal opacities, and retinal diseases.<sup>[4,5]</sup> In order to develop policies and priorities to assess eye health in the population,<sup>[6,7]</sup> it is important to have up-to-date information on the prevalence and causes of visual disorders in Shaanxi Province. These estimates provide the necessary information to prevent VI and improve eye health in Shaanxi Province. The investigation of the prevalence of blindness and low vision are mainly concentrated in big cities and suburban areas and relatively sparse in the rural population of China.

Some previous studies have reported important information on the prevalence of blindness and low vision in these areas, and these were higher in the Luxi area compared with northern and southern China as well as in other foreign countries. The prevalence of blindness and low vision increases with age and decreases with education. Age is a risk factor for blindness and low vision.<sup>[8]</sup> In Yifeng County, Jiangxi Province, the prevalence of binocular blindness among people aged 50 and over was slightly higher than the average level in China. Cataract is the main cause of blindness. The blindness rate due to cataract is higher than the national average, but the prevalence of VI is

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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relatively low. In addition, the prevalence of blindness and VI in different regions of China are very different at different times.<sup>[9]</sup> In Shaanxi Province, the population aged 60 years or older have reached 5.09 million by the end of 2010; however, there are only a few studies investigating the prevalence of VI in the elderly rural population.<sup>[10]</sup>

This study was part of a population-based eye study, which mainly focused on estimating the prevalence and reasons of blindness and low vision among rural residents aged 50 years or older in Shaanxi Province, China.

## 2. Materials and methods

### 2.1. Study population

This study was part of a population-based eye study of a rural population aged 50 years or older in Shaanxi Province, China. Shaanxi Province is the northwest of China, with a total area of 206,000 km<sup>2</sup> and a total population of 35.96 million in 2008.<sup>[11]</sup> GDP in Shaanxi in 2008 is 685.132 billion Yuan. GDP per capita is 19,052 Yuan. It has a relatively backward economy and poor health status. According to National Bureau of Statistics published in recent years' data, economic indicators of Shaanxi province ranked in 20 in 34 or so.

But according to National Bureau of Statistics published in recent years' data, economic indicators of Shaanxi province ranked in 20 in 34 or so. Advantages industries and especial industries, pillar industries, and strong industry in Shaanxi have also developed slowly.

By the end of 2010, Shaanxi Province has reached 5.09 million elderly people over the age of 60. At present, the average annual increase of elderly population in Shaanxi Province is 3%, and it is expected to reach 6.9 million by the year 2020.<sup>[12]</sup>

### 2.2. Sampling

According to the geographical differences in Shaanxi Province, 3 countries were randomly selected. The 3 countries' total population was 0.817 million, and the majority was from Han. The survey applied a proportionally stratified random cluster sampling and regarded rural area of these 3 countries as a basic unit. The target population was over the age of 50, and all residents registered as permanent residents of the village for 10 years or longer.

In this study, 2124 inhabitants were identified as targets; of whom, 1912 had completed eye examination and the response rate was 90%. We graded the educational level by 3 years, owing to the 3 years were the ordinary primary compulsory education prescribed by the Chinese government. The economic status of the participants was classified as lower or equal to \$160.7, as this figure was used as the standard of poverty in counties in Shaanxi.

The study followed the principles of the World Medical Association's Declaration of Helsinki and the municipal statutes of Shaanxi Province to protect personal information. The research program was approved by The Second Affiliated Hospital of Xi'an Medical College Ethics Committee.

### 2.3. Examinations

The investigation was conducted by a special equipped team, which was composed of 5 ophthalmologists and 5 ophthalmic assistants. All members were trained 2 weeks prior to the formal investigation to ensure the agreement on the diagnostic

criteria for eye diseases. Trained ophthalmic assistants used a standard questionnaire to conduct face-to-face interviews, which included information such as participants' demographic characteristics, diet, drinking, smoking, medical history, history of eye diseases and systematic diseases, as well as current visual symptoms. Then, the participants received detailed eye examinations by well-trained researchers using a standard protocol.

Trained ophthalmologists measured distance and near VA, VA with current refraction correction. Naked eye visual acuity was measured using the logarithm of the minimum angle of resolution (log MAR) plot at 3.8 m in ambient illumination. If the VA was less than 20/20, blindness and low vision were diagnosed according to WHO criteria and best corrected visual acuity (BCVA) was measured. The anterior segment and lens were examined using a slit lamp microscope.

All the participants received retinoscopy measurements, and the BCVA was noted by refractive correction. Retinoscopy was performed by a trained optometrist for those subjects. After pupil dilation, trained and skilled ophthalmologists used a direct ophthalmoscope to diagnose retinal diseases by fundus examination<sup>[13]</sup> using a direct ophthalmoscope and the fundus by indirect methods with 90 D lens. Further, experienced ophthalmologists examined other abnormalities of the optic disc, comprising cupping or excavation, notching, thinning of the neuroretinal rim, disc hemorrhages and loss of retinal nerve fiber layer. After the instillation of one drop of oxybuprocaine hydrochloride (0.4%) in each eye, intraocular pressure (IOP) was measured 3 times. An experienced and trained ophthalmologist conducted the measurement with Perkins applanation tonometry. The mean average of the 3 measurements was used for analysis.

Gonioscopy was carried out using Goldman 2-mirror lens. Angle grading was modified using the Shaffer classification system. Angles were considered to be open if more than 10°clock hours were clearly visible up to the spur in each eye; otherwise, they were judged as occlusive. All participants underwent papillary dilatation with 1% tropicamide except, those with occludable angles according to Van Herick method. All subjects received 1% tropicamide dilation, according to Van Herick method, except for patients with closed angle.<sup>[4]</sup>

### 2.4. Definition of low vision and blindness

Blindness and low vision were defined according to WHO criteria. Blindness was present if BCVA was worse than 20/400 (decimal VA, 0.05) in the better eye and low vision was present if BCVA was 20/60 (decimal VA, 0.3) or worse but 20/400 or better in the better eye.<sup>[14]</sup>

### 2.5. Causes of low vision or blindness

The main cause of vision loss was determined by trained researchers based on standard questionnaires and the records of detailed eye examination. If BCVA was worse than 20/60 (decimal VA, 0.3) in the better eye, ophthalmologists needed to define the cause of VI. Another ophthalmologist checked the completeness and validity of the standard questionnaires. And then they conducted a review for checking the correctness of the determination of cause to VI.

The information above provided all the data were available indeed.

**Table 1**  
**The prevalence of unilateral, bilateral blindness and low vision of population aged 50 years or older.**

Category	Male (n:683)	Female (n:1229)	All (n:1912)
	Prevalence N (%)	Prevalence N (%)	Prevalence N (%)
Bilateral Blindness*	11 (1.6)	17 (1.4)	28 (1.5)
Bilateral Low vision	34 (5.0)	68 (5.5)	102 (5.3)
Unilateral Blindness and Unilateral Low vision	21 (3.1)	33 (2.7)	54 (2.8)
Unilateral Blindness	59 (8.6)	77 (6.3)	136 (7.1)
Unilateral Low vision	68 (10.0)	68 (5.5)	123 (6.4)
low vision (WHO)*	55 (8.0)	101 (8.2)	156 (8.2)
Blindness (WHO)*	11 (1.6)	17 (1.4)	28 (1.5)

\*  $P < .05$

**2.6. Statistical analysis**

Data was entered into computer for verification by trained researchers independently. Database was created by Epi Info software (DOS version). Statistical analysis was performed using SPSS software version 19.0 (SPSS, Inc., Chicago, IL). The prevalence of blindness and low vision was estimated in percentage, and the 95% distribution was calculated with a 95% confidence interval (CI). The difference in the prevalence of blindness and low vision between gender and each age group was estimated by  $X^2$  test and Fisher exact test for comparing proportions.  $P < .05$  was considered as statistically significant difference.

**3. Results**

**3.1. The prevalence of blindness and low vision**

A total of 1912 eligible participants aged 50 years old were enrolled in the study with 90% response rate. The prevalence of blindness and low vision were presented in Table 1 according to WHO criteria [6]. The rates of gender-adjusted blindness were 1.4% for female and 1.6% for male, respectively ( $P > .05$ ). The rates of gender-adjusted low vision were 8.2% for female and 8.0% for male, respectively ( $P > .05$ ). The total rates of blindness and low vision for all persons were 1.5% and 8.2% according to

the WHO criteria, respectively (Table 1). There was no statistically significant differences between genders in the prevalence of blindness and low vision ( $P > .05$ ).

**3.2. Distribution of VI**

According to the WHO criteria, the prevalence and 95% CI of blindness and low vision are presented in Table 2 with different age, education, and economic status. We found that the prevalence estimates of blindness and low vision were higher among older participants. The prevalence of low vision in the 50 to 59 age group was 1.6% (95%CI 0.9–2.8), while it was up to 17.2% in the  $\geq 70$  year old age group (95%CI 13.7–21.3). The same results were found in the prevalence of blindness. There were significant differences between the prevalence of blindness and low vision in different age groups ( $P < .01$ ).

The prevalence of blindness and low vision was also different with various levels of education. The prevalence of blindness and low-vision among people with less than 3 years of education was higher than the group with a better educational level of 3 years or more. In the education degree  $\leq 3$  years group, the prevalence of blindness and low vision were 2.2% (95%CI 1.4–3.3) and 12.5% (95%CI 10.6–14.6), respectively. In the education degree  $> 3$  years group, the prevalence of blindness and low vision were 0.4% (95%CI 0–1.1) and 1.9 (95%CI 1.2–3.0), respectively. The prevalence of blindness and low vision showed similar trend in different economic conditions, which was decreased in the group with well economic status.

**3.3. Main causes of blindness**

According to the WHO criteria, there were 56 eyes of 28 participants with blindness. Cataract, corneal opacity, and glaucoma were the main causes of blindness, accounting for 67.9%, 10.7%, and 7.1%, respectively, which accounted for 85.7% of blindness. Refractive error, diabetic retinopathy, after cataract surgery, and ocular atrophy accounted for 3.6% of blindness.

**3.4. Main causes of low vision**

There were 312 eyes of 156 participants with low vision according to the WHO criteria. The main causes of VI were

**Table 2**  
**Distribution of blindness and low vision in different age, educational level, economic status.**

	No.	Low Vision		Blindness	
		No.	% (95%CI)	No.	% (95%CI)
Age (yr)					
50–	791	13	1.6 (0.9–2.8)	6	0.8 (0.3–1.6)
60–	616	36	5.8 (4.1–8.0)	8	1.3 (0.6–2.5)
70–	406	70	17.2 (13.7–21.3)	4	1.0 (0.3–2.5)
80–	99	37	37.4 (27.9–47.7)	10	10.1 (5.0–17.8)
		$P < .01$		$P < .01$	
Educational level (yr)					
$\leq 3$	1126	141	12.5 (10.6–14.6)	25	2.2 (1.4–3.3)
$> 3$	786	15	1.9 (1.1–3.1)	3	0.4 (0–1.1)
		$P < .01$		$P < .01$	
Per capita income (USD)					
$\leq 160.7$	933	112	12.0 (10.0–14.3)	18	1.9 (1.2–3.0)
$> 160.7$	979	44	4.5 (3.3–6.0)	10	1.0 (0.5–1.9)
	$P < .01$	$P = .127$			

**Table 3**  
Principal cause of blindness and low vision according to BCVA.

Causes	Blindness <sup>*</sup> (n=28)		low vision <sup>†</sup> (n=156)		Visual Impairment (n=184)	
	No.	%	No.	%	No.	%
Cataract	19	67.9	103	66	122	66.3
Glaucoma	2	7.1	3	1.9	5	2.7
Corneal opacity	3	10.7	3	1.9	6	3.3
Refractive error	1	3.6	23	14.7	24	13
Diabetes retinopathy	1	3.6	4	2.6	5	2.7
Eye atrophy	1	3.6	3	1.9	4	2.2
Others <sup>*,†</sup>	1	3.6	17	11	18	9.8

BCVA = Best-corrected visual acuity

<sup>\*</sup> Others include after cataract

<sup>†</sup> Others include optic nerve atrophy, pterygium, etc.

cataract, refractive error, and age-related macular degeneration (AMD), with 66%, 14.7%, and 5.8%, respectively. Diabetic retinopathy accounted for 2.6% of blindness while optic atrophy, ocular atrophy, corneal opacity, and glaucoma accounted for 1.9%. Retinitis pigmentosa accounted for 1.3% and other causes accounted for 1.9%, of which retinal branch vein occlusion accounted for 0.6%, pterygium accounted for 0.6%, and vitreous opacity accounted for 0.6% of blindness. Table 3 shows the main causes and the prevalence of low vision and blindness. Cataract was the leading cause of low vision and blindness, which were respectively 66% and 67.9%. Part of the reasons were irreversible, including glaucoma, high near retinopathy, and optic atrophy.

#### 4. Discussion

This study revealed the prevalence and causes of low vision and blindness in a rural population aged 50 years or older in Shaanxi Province, a district in Northwestern China. This is related to factors such as the backwardness of rural economic conditions in Shaanxi Province and the low level of medical and health care. The overall age- and gender-adjusted prevalence rate of low vision was 8.2% and 1.5% for blindness. VI was a public health problem in Shaanxi Province, northwestern China, and low vision and blindness rates were significantly higher. VI is a public health problem worldwide. According to WHO, there were approximately 161 million visually impaired people worldwide, and among them 37 million were blind. Over 90% of blind people live in developing countries, and blind and low vision problem cannot be ignored in China. Cataract is still the main cause of vision impairment in people aged 60 years and over in Western China. Especially in the eyes of severe cataract patients who affect self-care, the operation rate is still low. Economic factors significantly affect cataract patients' medical treatment.<sup>[1,5]</sup> This might be due to the relatively low level of economic development, low public awareness of eye disease prevention and treatment methods. In a survey of 212 participants with glaucoma in rural Yunnan, only 38 (18%) were aware of the disease and had been diagnosed previously with glaucoma or suspected glaucoma. In a survey of Canadians' understanding of eye disease and risk factors, 97.5% recognized the possibility of treatment for cataract, 91.5% for glaucoma, and 77.0% for macular degeneration.<sup>[16,17]</sup>

Shaanxi Province has poor eye care facilities. According to the research performed in rural clusters, the magnitude of VI is higher in rural areas than in urban areas. The differences in rural and

urban clusters might be ascribed to differences in accessibility and availability of eye care services and professionals. A nationwide study has reported progress in the reduction of the magnitude of VI.<sup>[5]</sup>

In developing countries, especially in poor areas, the economic, medical, and health conditions and the awareness of prevention and treatment of eye diseases are relatively poor. Many patients are not aware or have the economic ability to undergo surgical treatment. These 3 counties in this study were county-level cities and had rural towns and urban towns. Each rural town comprises many small administrative villages. Participants in these rural areas had a low level of education and economic status. Eye examination was never performed among the participants in our study, and hence early treatment could not be started.

Low vision and blindness rates increased with age, and most eye diseases were related to age. It might be more difficult to receive care in the elderly people. The prevalence rate was consistent with several studies, including the Barbados Eye Study, the Salisbury Ophthalmology Assessment Study, the Rotterdam Study, and the Andhra Pradesh Eye Disease Study.<sup>[18–22]</sup> With the improvement of education, low vision and blindness rate decreased.<sup>[13]</sup>

The blindness prevalence rate conducted in 3 rural areas compared favorably with the results of a recent methodologically similar survey in Shaanxi Province in 2003.<sup>[23]</sup> Among the population over 50 years of age in Shaanxi Province, the prevalence of moderate and severe bilateral blindness were 2.1% and 3.2%, respectively. After 7 years, in this study a similar survey conducted by the same team in Shaanxi province in 2010 showed that the blindness rate (1.5%) was significantly lower than previously reported (2.1%), but the prevalence of low vision (8.2%) was much higher than the previous report in 2003. We proposed that the accessible surgery for cataract in the rural population in Shaanxi province improved the decrease of blindness among 7 years. However, the increased prevalence of refractive error in the rural population leads to the higher rate of low vision these years. Therefore, the effort on the prevention to the increased rate of refractive error is much important in Shaanxi province.

Cataract was the leading cause of blindness in other parts of Asia, Europe, and the United States,<sup>[19–22,24–28]</sup> which accounted for 36.2% of blindness in Mongolia,<sup>[24]</sup> 39.1% in Malaysia,<sup>[28]</sup> 45.5% in India,<sup>[19]</sup> and 51.7% in Hong Kong<sup>[27]</sup>—slightly higher relative to the Singaporean Chinese population. Genetic predisposition and exposure to ultraviolet radiation might contribute to the relatively high prevalence rates of cataract in

Singaporean Chinese population.<sup>[29]</sup> In the current study, cataract was the leading cause of low vision (66%) and blindness (67.9%). The prevalence was significantly higher than that in other countries. The quality and convenience of tertiary level eye hospital facilities were lower in the rural areas of Shaanxi province, and it was impossible to receive further education on cataract surgery and to treat any vision loss that affected daily life.

According to previous population-based studies, glaucoma was the leading cause of blindness in Singaporean Chinese,<sup>[29]</sup> Mexican Americans,<sup>[30]</sup> African Americans in Barbados,<sup>[12]</sup> Latinos in Los Angeles,<sup>[31]</sup> and Mongolians.<sup>[24]</sup> Angle-closure glaucoma was mainly responsible for blindness in Asian countries,<sup>[24,29]</sup> while open-angle glaucoma was mainly found in other countries.<sup>[21,30,31]</sup> In the current study, glaucoma was the third leading cause of blindness in both eyes rather than the cause of refractive error in both eyes. It resulted in a blindness rate of 7.1%, which was consistent with the results of the Beijing Ophthalmic Research. The study reported 9.7% cases of blindness in both eyes. The result for glaucoma was also consistent with the results of the Shihpai Eye Study (8.3% of blind and low vision cases).<sup>[32]</sup> Corneal opacity was the second cause of blindness, which accounted for 10.7%. The reasons of high proportion of blindness included ocular trauma and all kinds of keratitis. This high proportion of blindness resulting from corneal opacity was related to economic level in our study.

Myopic macular degeneration or degenerative myopia was a cause of VI in the Tajimi Study,<sup>[33]</sup> the Shihpai Eye Study in Taiwan,<sup>[32]</sup> the Beijing Eye Study in China,<sup>[34]</sup> the Rotterdam Study,<sup>[20]</sup> studies in Denmark<sup>[35]</sup> and Italy.<sup>[36]</sup> In the current study, correctable refractive error (myopic macular degeneration) was still a major contributing cause of low vision, resulting in low vision in 14.7%. Optometry and ophthalmic technicians should be trained to perform regular vision screening tests, and the public should be aware of the need for proper correction of refractive devices to enhance optimal vision for daily activities.

AMD was the leading cause of VI in European populations,<sup>[20,22]</sup> but it was uncommon in Shaanxi Province, Northwest China, and other Asian countries because of the low prevalence of AMD.<sup>[19,26,27]</sup> Diabetic retinopathy was the cause of low vision, accounting for 2.6%.

We found that the vast majority of causes of low vision and blindness in our study population were treatable. This was a finding that indicates inadequate eye care services in rural areas in China, especially for people aged 50 years.

The use of VA measures to assess whole-body visual function was not sufficient, and the information that provided was limited. However, data on the causes of low vision and blindness were important for the optimal delivery of health services and the assessment of prevention plans and treatment options. Global initiatives such as Vision 2020: the right to sight had been launched by international organizations to reduce world blindness.<sup>[37]</sup> Strategies to improve global vision included efforts to improve the affordability, accessibility, and quality of eye care services and public education campaigns, then raising the awareness of the burden of eye diseases and reducing cultural or social barriers. National plans should include the development and improvement of rehabilitation, occupational, and social support services for visually impaired patients.

This study has some limitations. First, this study was conducted only in rural populations. Therefore, our results cannot be generalizable to urban populations. Second, rapid

assessment studies performed in this way underestimate posterior segment lesions because it is difficult to determine their diagnosis in undilated pupils. However, this does not affect the evaluation of the prevalence of VI in this population, as our operators are the senior ophthalmologists with 20 years of clinical experience. The results of this study are significant.

In conclusion, the sample reported in this study is small and the data collected is incomplete. The prevalence of low vision and blindness was 8.2% (low vision) and 1.5% (blindness) in a rural population aged 50 years older in Shaanxi Province. Cataract was the principal cause of bilateral low vision and blindness. Refractive error was also the main cause of low vision. According to the current studies, cataract and refractive error were treatable; therefore, if the availability of medical facilities improves, the prevalence of VI may decline. This problem can be solved by ensuring the affordability, accessibility, and quality of eye care services and public education.

### Author contributions

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