

Changed trends of major causes of visual impairment in Sichuan, China from 1987 to 2006

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Abstract

• **AIM:** To study the trends of major causes of visual impairment (VI) in adults in Sichuan, China and evaluate the effect of aging on the trends.

• **METHODS:** We used data from the National Sample Survey on Disabilities (NSSD) in Sichuan province conducted in 1987 and 2006. The age-adjusted prevalence of major causes of VI and the prevalence stratified by age in each cause were calculated and compared. The association between age and each cause of VI was also analyzed.

• **RESULTS:** Retinal disease increased and became the second leading cause of VI in 2006 while blinding trachoma decreased markedly. Cataract and non-trachomatous corneal diseases were among the leading causes of VI in both years. We found associations between age and causes of VI, with age showing the strongest association with cataract and relatively lower associations with other causes.

• **CONCLUSION:** In the last two decades, dramatic changes occurred in the major causes of VI with significantly increased retinal disease and decreased blinding trachoma. Aging of the population might be an important factor accounting for the changed trends of VI. Understanding the prevalence of VI, its major causes and trends over time can assist in prioritizing and developing effective interventional strategies and monitoring their impact.

• **KEYWORDS:** visual impairment; prevalence; trachoma; non-trachomatous corneal disease; cataract; retinal disease; glaucoma; eye trauma

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INTRODUCTION

Visual impairment (VI) is a global public health problem. It was estimated that in 2002 more than 161 million people suffered from VI, among whom 37 million were blind and 124 million had low vision^[1]. The primary causes of VI vary in countries and regions with different social, geographic, economic, demographic and cultural conditions^[1-4]. It is important to understand the trend of VI and its causes because it is essential for prioritizing and developing effective prevention and interventional strategies. There have been several studies investigating the VI in China, including the Beijing Eye Study, the Handan Eye Study in northern China, and the Nantong Survey in eastern China^[4-6]. However, China is a big country with a population of 1.3 billion with striking differences in climate, population and lifestyle across its territory. A single study on average VI

Table 1 Definition of visual impairment and its major causes in NSSD

	Definition
Visual impairment	
Low vision	Visual acuity of less than 6/18 (0.3, 20/60) but equal to or better than 3/60 (0.05, 20/400) in the better eye with best possible correction (visual impairment categories 1 and 2 in ICD-10)
Blindness	Visual acuity of less than 3/60 in the better eye with best possible correction (visual impairment categories 3, 4, and 5 in ICD-10)
Major causes of visual impairments	
Blinding trachoma	Presentation of trachomatous corneal opacity, trachomatous trichiasis or trachomatous entropion with other trachoma features, such as trachomatous conjunctival scarring, pannus and Herbert's pit by a slit lamp microscope
Non-trachomatous corneal disease	Non-trachoma induced corneal opacity, infiltration, ulcer, or degeneration by a slit lamp microscope
Cataract	Lens opacity by a slit lamp microscope
Retinal disease	Chorioretinal abnormalities caused by diabetic retinopathy, retinal detachment, degeneration, or dystrophy by a direct ophthalmoscope, or chorioretinopathy history
Glaucoma	Glaucoma diagnosis was considered when glaucoma surgery or medications history were present, by findings of an enlarged cup-disc ratio (C/D) or by cup-disc asymmetry between the two eyes with a severe visual field defect, with or without increased intraocular pressure (≥ 21 mmHg)
Non-glaucomatous optic neuropathy	Visual impairment associated with non-traumatic damage to the optic nerve and/or visual pathway, presenting with changes in the optic nerve head, relative afferent pupillary defect (RAPD) or optic neuropathy history
Eye trauma	Visual loss from physical or chemical injury to the globe or visual pathways

If cataract and retinal disease coexisted and removal of the cataract would not restore or improve vision, retinal disease was considered as the cause of the visual impairment; The severe visual field defect was measured by using a simplified visual field card (Figure 1)^[14]; Intraocular pressure was measured with a Goldmann appplanation tonometer (The 66 Vision Tech Corp., Suzhou, Jiangsu Province, China).

in China could not reflect the inter-provincial differences. Furthermore, previous studies focus on cross-sectional analysis of VI and often fail to investigate changes over time. Sichuan province is located in southwest China with a humid climate, a population of 84 million and a medium level of economic and social development in China (The nominal GDP per capita was \$189 and \$1 331 in 1987 and 2006, respectively, as compared the national GDP per capita of \$299 in 1987 and \$2 001 in 2006). There is no report on the major causes of VI and trends over a span of 20 years in this province.

In 1987 and 2006, two large-scale national representative surveys-the National Sample Survey on Disabilities(NSSD) - were conducted in all the 31 provinces of China^[7,8]. Using visual disability data collected from NSSD, we analyze the changes in the patterns of major causes of VI in adults (aged ≥ 18) in Sichuan. We believe that this paper provides valuable information regarding the prevalence of major causes of VI in Sichuan.

SUBJECTS AND METHODS

The information collected in the NSSD surveys was classified as visual, hearing, speech, physical disabilities, mental retardation, other intellectual disabilities, and multiple disabilities. Details of the design and implementation of NSSD have been reported elsewhere^[9,10].

The screening of visual disability (or VI) followed the guidelines proposed by the World Health Organization (WHO) in 1973^[11] (Table 1). Making a specific diagnosis of the primary causes of VI (*i.e.*, age related macular degeneration (AMD), diabetic retinopathy (DR), primary angle closure or open angle glaucoma) was impractical in such a large-scale survey. Therefore, the major causes of VI in NSSD were anatomically classified. Blinding trachoma was included in the NSSD survey because of the trachoma

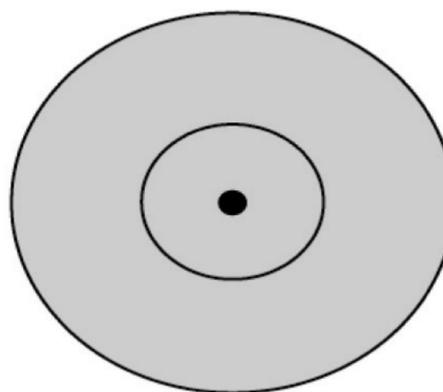


Figure 1 Simplified visual field card to detect severe visual defects in patients with high risk of glaucoma The card was placed at 33cm in front of the patient, requesting them to stare at the center of the card. Then the patients were asked whether they could see the small ring, the large ring or no ring at all. The small ring represents 5 degree of visual field and the large ring represents 10 degree of the visual field.

epidemic that occurred before the 1960s in China^[12,13](Table 1, Figure 1).

The distance visual acuity with pinhole glasses was performed at 4 meters using the illuminated logarithm of minimum angle of resolution (logMAR) E chart (The 66 Vision Tech Corp., Suzhou, Jiangsu, China). For each sampled subject with VI, primary causes of VI were identified through medical history, surgical history, visual function, and ophthalmic examination performed by ophthalmologists^[14]. Only one diagnosis was selected as the primary cause of VI and the cause of VI in the less affected eye was taken as the primary cause for participants with bilateral VI, even if two or more conditions existed in the same subject^[6]. Assignment of the principal cause of VI was confirmed by two trained ophthalmologists.

Both surveys in Sichuan province were supported by local agents of the Provincial Health Bureau and Disabled Persons' Federation. The Declaration of Helsinki was adhered to, and ethics approval was obtained from the Sichuan Province Disabled Person's Federation. Written informed consent was obtained from all participants.

Statistical Analysis Survey participants were divided into six age groups: 18-34, 35-44, 45-54, 55-64, 65-74 and ≥ 75 . In order to compare the prevalence of the seven major causes of VI between the two survey years, age-adjusted prevalence was calculated using direct standardization of each survey sample to the overall Chinese population in 2000 [15]. Generalized estimating equations (GEE) were used to determine the change in prevalence, taking into account the correlation of prevalence among different age groups between the two surveys. Contingency coefficients were calculated to compare the association between each cause of VI and age. The Bonferroni adjustment was used to correct for multiple comparisons. All the analyses were performed using SAS version 9.2 (SAS Institute Inc., Cary, NC, USA).

RESULTS

The demographic information is shown in the Table 2. In 1987, 36 131 households with a total of 93 341 adult participants were included. In 2006, the survey included 40 351 households and 93 382 adult participants.

In 1987, a total of 1 328 VIs were detected (1.42%) which included 609 individuals with blindness (45.8%) and 719 individuals with low vision (54.2%). In 2006, total of 2 442 had VIs (2.61%), which included 955 cases of blindness (39.1%) and 1 487 cases of low vision (60.9%).

The top three causes of VI changed from cataract, blinding trachoma, and non-trachomatous corneal diseases in 1987 to cataract, retinal disease and non-trachomatous corneal diseases in 2006. The largest decrease in prevalence occurred with blinding trachoma, which moved from the second leading cause of VI in 1987 to the seventh in 2006 (Table 3).

The age-adjusted prevalence (per 100 000) of the seven major causes of VI in 1987 and 2006 is shown in Table 3. Compared with 1987, the age-adjusted prevalence of all major causes of VI showed significant changes in 2006. Specifically, blinding trachoma experienced a tremendous decrease while the other 6 major causes experienced a significant increase in prevalence.

To consider the impact of age differences between the two survey years (Table 2), we calculated the age-adjusted prevalence and performed GEE analysis, which takes into account the correlation of prevalence among age groups between the two survey years (Table 3, the Mean Prevalence column). The GEE analysis further confirmed that between 1987 and 2006, significant changes occurred in the prevalence of blinding trachoma ($P=0.032$). The change in

Table 2 Demographic information for 1987 and 2006

	1987	2006
Total	93 341	93 382
Age groups	%	%
18-34 ^b	46.2	25.0
34-44 ^b	19.1	23.3
45-54 ^b	14.1	19.3
55-64 ^b	11.4	16.4
65-74 ^b	6.7	10.3
≥ 75 ^b	2.5	5.7
M (%)	50.2	49.0
F (%)	49.8	51.0
Mean age ^b	39.4 \pm 16.3	47.0 \pm 16.1
Age of males ^b	39.3 \pm 16.0	47.2 \pm 15.9
Age of females ^b	39.6 \pm 16.7	46.5 \pm 16.4

^b $P<0.01$.

the prevalence of eye trauma is of borderline significance ($P=0.051$), but the changes in the prevalence of the remaining five causes did not reach statistical significance.

The prevalence of the seven major causes of VI by age groups in 1987 and 2006 is shown in Table 4. In general, compared to 1987, VI from blinding trachoma decreased in 2006 among all age groups except those aged ≥ 75 . Significant changes in VI from eye trauma, retinal disease, and optic neuropathy were concentrated mainly in the population aged 55-74. VI from retinal disease and optic neuropathy increased in all groups aged ≥ 55 . VI from non-trachomatous corneal diseases, glaucoma, and cataract showed a significant change only in the population ≥ 65 (cataract and corneal disease) and ≥ 75 (glaucoma).

Table 5 shows the association between age and major cause of VI using contingency coefficient (CV). In 2006, the association between age and eye trauma was statistically significant, but with a small CV (0.0248); and in 1987 it showed no association with age. Cataract showed a large CV (0.1852 in 1987 and 0.2576 in 2006), indicating a relatively strong association with age. The remaining six causes of VI all had small CVs (all less than 0.1), indicating weaker associations with age.

DISCUSSION

Our findings indicate that cataract and non-trachomatous corneal diseases were still among the top three major causes of VI in both survey years. However, retinal diseases showed a significant increase from 1987 to 2006 and became the second leading cause of VI in 2006. VI by blinding trachoma in southwest China decreased significantly in 2006, compared to 1987 when it was the second leading cause of VI. We also found a significant increase in VI due to eye trauma and non-glaucomatous optic neuropathy. To our knowledge, this is the first study in southwest China that

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Table 3 Ranks and prevalence (per 100,000, 95% CI) of the seven major causes of visual impairments in adults in 1987 and 2006

Visual impairment ¹	Rank in 1987	Age-adjusted prevalence (95%CI)		Mean prevalence (95%CI)	
		1987	2006	1987	2006
Cataract	1	756.3(695.9-816.6)	938.3 (890.8-985.7)	637.4(587.1-690.6)	1481.0 (1404.5-1560.5) ^a
Retinal disease	4	77.0 (58.7-95.4)	277.6 (247.6-307.6)	73.9 (57.5-93.5)	387.7 (348.8-429.6) ^a
Corneal disease	3	125.8(101.9-149.8)	196.0 (171.4-220.6)	117.8 (96.9-142.0)	287.0 (253.7-323.4) ^a
Optic neuropathy	5	55.5 (39.6-71.4)	157.6 (134.6-180.6)	51.4 (37.9-68.2)	217.4 (188.5-249.4) ^a
Glaucoma	6	49.0 (34.2-63.8)	92.5 (76.5-108.4)	46.1 (33.3-62.6)	140.3 (117.3-166.4) ^a
Eye trauma	7	21.0 (11.5-30.5)	86.6 (68.5-104.6)	20.4 (12.3-31.8)	110.3 (90.0-133.8) ^a
Trachoma	2	284.4(248.5-320.3)	50.6 (38.9-62.3)	266.8 (234.7-302.0)	78.2 (61.3-98.3) ^a

¹Causes of visual impairment are listed in descending order according to their prevalence in 2006; ^a $P<0.05$.

Table 4 Prevalence (per 100 000, 95%CI) of the seven major causes of visual impairment by age group in 1987 and 2006

Visual impairment	Year	18-34	35-44	45-54	55-64	65-74	≥75
¹ Trachoma	1987	32.5	210.8	441.7	618.4	803.5	1062.5
	2006	¹ 0	¹ 9.2	¹ 27.7	¹ 58.8	¹ 238.7	643.6
¹ Eye trauma	1987	11.6	22.4	38.1	18.7	48.2	0
	2006	34.3	50.6	105.2	¹ 163.4	¹ 280.2	246.1
¹ Retinal disease	1987	20.9	61.7	152.3	131.2	208.9	85.0
	2006	51.4	128.7	304.4	¹ 568.6	¹ 1089.8	¹ 1419.6
Optica neuropathy	1987	11.6	72.9	106.6	65.6	96.4	127.5
	2006	38.6	92.0	127.3	¹ 352.9	¹ 560.5	¹ 813.9
Corneal disease	1987	27.8	95.3	159.9	253.0	321.4	552.5
	2006	38.6	36.8	105.2	372.5	¹ 788.8	¹ 1873.9
Glaucoma	1987	9.3	22.4	99.0	65.6	208.9	85.0
	2006	0	23.0	88.6	176.5	373.6	¹ 889.6
Cataract	1987	18.6	67.3	464.5	1077.5	3213.9	8457.3
	2006	8.6	23.0	293.3	1176.5	¹ 4483.7	¹ 13458.3

¹Significant difference in the age group between 1987 and 2006.

Table 5 Association of the seven major causes of visual impairment with age using contingency coefficient

Visual impairment	1987	2006
Cataract	0.1852 ^a	0.2576 ^a
Glaucoma	0.0254 ^a	0.0574 ^a
Trachoma	0.0547 ^a	0.0553 ^a
Corneal disease	0.0341 ^a	0.0846 ^a
Optic neuropathy	0.0174 ^a	0.0472 ^a
Retinal disease	0.0226 ^a	0.0646 ^a
Eye trauma	0.0084	0.0248 ^a

^a $P<0.05$.

investigated the changed patterns of major causes of VIs over a span of 20 years.

In the whole population, there was no significant change for cataract between 1987 and 2006. The difference, however, was significant in the population aged ≥ 65 years. The contingency coefficient analysis in Table 5 also indicated strong associations between age and the prevalence of cataract. In addition, a low cataract surgical rate will increase the number of VI from a treatable condition like cataract^[16]. In fact, the average CSR is far lower than the prevalence of VI from cataract (4 378.7 per 100 000) in the population aged 65-74 in 2006. Increasing the CSR is a big challenge

for the effective prevention of visual disability in China.

VI caused by corneal disease changed little, being the third major cause of VI in both surveys years, consistent with reports from other studies in China^[17-20]. The extremely low rate of corneal transplants, and the increased corneal endothelial decompensation induced by intraocular surgeries might be the reason for the high prevalence of VI by corneal diseases in China^[21,22].

One of the major changes found in our study is the increase in the prevalence of VI by retinal disease in Sichuan, the second leading cause of VI in 2006. The finding is consistent with other studies in China^[7,23]. It was reported that in the population aged ≥ 45 , a dramatic increase of diabetes mellitus was found in mainland China, as lifestyles rapidly changed from rural agricultural work to more sedentary urban livelihoods; although we did not specifically investigate the exact prevalence of diabetic retinopathy (DR), or VI from DR, an increasing consensus exists in that DR is becoming a major cause of retinopathy in mainland China^[4,24,25]. More efforts should be given to the control/prevention of VI from DR in the future.

We observed an increase in non-glaucomatous optic neuropathy and eye trauma in 2006 compared to 1987. We

have no clear clue regarding causes of the increase in optic neuropathy, and speculate that this might be due to an increase in the diagnosis of optic neuropathy from wider availability of health care and improved diagnosis. However, it should be noted that in 2006, a higher prevalence of VI by eye trauma was observed in all age groups, and a significant increase was observed in persons aged 55-74 (Table 4, Columns '55-64', '65-74'). Similar increases were reported in other parts of China^[26]. An increase in safety measures in the workplace in conjunction with careful driving might decrease the prevalence of eye trauma.

There was a significant decrease in VI due to blinding trachoma in 2006. Compared to 1987, among those aged 18-74, in 2006 there was a significant decrease in each age group (Table 4), and the prevalence of VI by blinding trachoma was the least prevalent of the seven major causes in each age group. A detailed description of the changing pattern of VI due to blinding trachoma has been presented elsewhere^[27]. A similar decreasing trend has been reported from other studies and reports in China^[28-30].

Many factors can impact the prevalence of visual disability, including aging in the population and availability of health care. However, recent research in China found consistent evidence of the important impact that aging has had on visual disabilities. This highlights the need to pay attention to the elderly to reduce the prevalence of visual disabilities, especially in developing countries like China^[31].

There are limitations to our current study. We emphasize that our study focuses on the major causes of VI instead of the actual prevalence of eye diseases in Sichuan. Thus, our results might not be comparable with others that focus on the prevalence of eye diseases. Since VI in our study is based on the visual acuity of the better eye after correction by pinhole glasses, the prevalence in the population with unilateral VI is unknown. As a result, the actual prevalence of the seven major causes might be higher than our results suggest. Additionally, as refractive error can greatly affect the diagnosis of VI, the visual acuity by pinhole glasses was checked to quickly get the corrected vision and the participants' refractive error, as a proxy to the best corrected vision. Moreover, in such large-scale nationwide surveys it is impractical to assess the accurate refractive condition and check the best visual acuity for each individual participant when wearing glasses. Refractive error can be easily corrected by wearing glasses, while VI from other causes cannot be easily corrected by refractive correction or medication^[32], although it probably is one of major causes of VI in China^[4]. The criteria to determine the major causes of the VI in the two surveys were not so strict. For example, retinal disease was not examined by ultrasound. It simply was not practical to give detailed diagnoses for each participant in

these large scale surveys.

In addition, the sampling schemes for the 1987 (systemic stratified sampling) and 2006 (multistage stratified sampling) surveys were slightly different. However, we believe that bias should be trivial considering the large sample size, random cluster sampling method and the CMH Chi-square test that takes into account the influence of differences in age distributions between the two survey years.

In summary, our analysis implies that aging is an important factor accounting for the different distributions of the seven major causes of VI between the two survey years. VI by blinding trachoma decreased significantly, while retinal disease, non-glaucomatous optic neuropathy, and eye trauma increased compared to 20 years prior. VI from cataract and corneal disease are still a big challenge in China. The changing patterns revealed in this paper have important implications for the nation's future public health policies and blindness prevention.

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