

# Blindness and eye disease in a Tibetan region of China: findings from a Rapid Assessment of Avoidable Blindness survey

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## ABSTRACT

**Introduction** The only population-based survey of blindness and visual impairment of a Tibetan population was conducted in the Tibet Autonomous Region in 1999.

**Methods and analysis** The Rapid Assessment of Avoidable Blindness methodology was used to conduct a survey of Kandze Tibetan Autonomous Prefecture, Sichuan Province of China in the Fall 2017. Using the 2010 census, 100 clusters of 50 participants aged 50 years or older were randomly sampled using probability proportionate to size.

**Results** Among the 5000 people enumerated, 4763 were examined (95.3% response). The age-adjusted and sex-adjusted prevalence of blindness, severe visual impairment, moderate visual impairment and early visual impairment (EVI) were 1.6% (95% CI: 1.08 to 2.38), 0.9% (95% CI: 0.7 to 1.5), 5.1% (95% CI: 4.4 to 5.7), and 7.45% (95% CI: 6.67 to 8.2), respectively. The prevalence of blindness among Tibetans was significantly higher than that among Han Chinese (2.2% (95% CI: 1.8 to 2.6) and 0.6 (95% CI: 0.2 to 1.7), respectively,  $p < 0.05$ ). Women bore a significant excess burden of EVI compared with men (8.5% (95% CI: 7.5 to 9.6) and 6.1% (95% CI: 5.1 to 7.2), respectively,  $p < 0.05$ ). Cataract was the primary cause of blindness (39.4%) followed by macular degeneration (10.6%) and corneal opacity (5.3%).

**Conclusion** Blindness and visual impairment in Kandze Tibetan Autonomous Prefecture is substantially less than an earlier study of a Tibetan region and now resembles other regions of China. About 58% of blindness and 67% of SVI were avoidable, primarily by providing cataract services. Eighty-three percent of EVI was avoidable by providing refractive services throughout the region.

## INTRODUCTION

Kandze Tibetan Autonomous Prefecture of Sichuan Province, People's Republic of China, set on the eastern end of the Tibetan plateau with 150 000 square kilometres, forms one of the highest and harshest human habitations on earth. Of its 1.1 million people (78% Tibetan), approximately 80% live in pastoral settings and small farming communities at an average elevation of 3500 m or as seminomadic herders at higher elevations.

## Key messages

### What is already known about this subject?

- Population-based prevalence studies of blindness and visual impairment among Tibetan people are rare, with the only prior study completed 18 years ago.

### What are the new findings?

- Using the Rapid Assessment of Avoidable Blindness methodology, this study of Kandze Tibetan Autonomous Prefecture, Sichuan Province of China estimated the prevalence of blindness, severe visual impairment and moderate visual impairment, among people over age 50 years as 1.6%, 0.9% and 7.45%, respectively. The prevalence of blindness and visual impairment among Tibetans was significantly lower than the 1999 study and approaching levels similar to Han Chinese.

### How might these results change the focus of research or clinical practice?

- About 59% of the blindness and visual impairment in Kandze Prefecture is avoidable primarily by providing better access to cataract and refraction services to the rural population.

For several decades, the Tibetan culture has faced unprecedented exposure to political and economic influence from other regions of China. At the same time, a growing percentage of Tibetans no longer follow their traditional pastoral lifestyle.<sup>1</sup> An ageing population has greatly increased the need for healthcare services, particularly for the diseases of ageing such as hypertension, stroke, diabetes, cancer and cataract.

The Kham Eye Centre in the Kandze Prefecture People's Hospital in Dartsedo (Kanding), the capital city, provides almost all of the surgical and most of the complex medical eye care in the prefecture. Started in 2010, it is a dedicated eye care facility that provides clinical services, teaches a range of eye care personnel, conducts research and

provides eye health education materials to county level hospitals. With six surgical ophthalmologists and three ophthalmic assistants, it conducts about 1500 to 2000 cataract operations per year. It also conducts about 20 diagnostic-screening camps annually and 20 surgical camps throughout in Kandze Prefecture. The 18 county level hospitals have very limited ophthalmic equipment and few supplies. No eye glass dispensaries are available outside of Dartsedo.

Previous blindness prevalence data of a Tibetan population comes from a study in 1999 of the Tibet Autonomous Region (TAR).<sup>2</sup> The age and sex standardized prevalence of blindness and severe visual impairment (SVI) among Tibetans age 50 years and older was two to three times higher than that reported for other regions of China: Zhongshan, Guangdong Province and Shunyi, Beijing Province (10.9%, 2.8%, 4.4% for TAR, Sunyi and Zhongshan, respectively).<sup>3,4</sup> In all three studies, women over age 50 had about twice the prevalence of blindness as men, similar to survey findings from most other settings.<sup>5</sup> The TAR survey also raised concerns about cataract surgical quality.<sup>6</sup>

At issue in the current survey is the impact of the Kham Eye Centre programme in Dartsedo, with its extensive community outreach programme throughout Kandze Prefecture, on the burden of blindness, particularly among women, and whether modern cataract surgical techniques are resulting in high quality cataract surgical outcome. This paper presents prevalence findings and cataract surgical coverage (CSC), while a companion paper presents details of cataract prevalence and outcome.

## METHODS

This is a population-based survey using the rapid assessment of avoidable blindness (RAAB) methodology. According to the 2010 census, the population of Kandze Tibetan Autonomous Prefecture was 1.09 million (0.56 million men; 0.53 million women) with 16.8% of the population aged 50 years and older. The sample size was calculated using the RAAB software (RAAB V.6, International Centre for Eye Health, London, UK) assuming a conservative estimate of the prevalence of blindness at 2.3% from the 1999 survey of the TAR.<sup>2</sup> Rounding to the nearest 1000 people, the sample size was calculated as 5000 with precision of 20%, 90% response, and a cluster design effect of 1.5. As per the WHO, blindness was defined as visual acuity in the better eye of less than 3/60, SVI as VA of 3/60 or better and less than 6/60, moderate visual impairment (MVI) as VA of 6/60 or better and less than 6/18 and early visual impairment (EVI) as VA of 6/18 to less than 6/12.

## Study sample

Census data by Administrative Village as well as by 5 year age group and sex data were obtained from the local statistics department (2010 China National Census). There were 2783 villages and communities in Kandze

prefecture, varying in population from 4 to 11 716. The standard RAAB 6.0 software was used to select 100 clusters by systematic random sampling of probability proportional to size. In each study cluster, 50 people aged  $\geq 50$  years were selected by compact segment sampling in large communities, while the nearby village was added if study subjects were not enough for one cluster in the selected study area.

## Survey methods

Two survey teams (each composed of an ophthalmologist, an ophthalmic assistant and a local community health worker) conducted the survey from August to December 2017. The clinical teams were trained by an International Centre for Eye Health certified RAAB trainer and obtained interobserver concordance of 0.8. After training, the teams conducted a pilot RAAB survey in one of the clusters. In order to make the best use of available transport, the two survey teams travelled together but examined different clusters on the same day. They examined 50 people above 50 years of age in each village. In the pastoral areas, enumerators requested people age 50 years and older to be present on the day of examination. People away from the home were typically younger than 50 years of age.

A letter of introduction describing activities was sent to the community leaders of towns and villages prior to the visit. Villagers were informed of the survey through either the health bureau in the county hospital or the township health unit. The reasons for the survey and details of the survey team's arrival dates were explained to the village head, village doctors and women's representatives.

All eligible people underwent a standardised ophthalmic examination in their household. Subjects were asked their ophthalmic medical history and whether they have distance or reading glasses. All subjects were assumed to be presbyopic. The team measured a distance of 5 m with a tapeline, marking the distance on the floor. VA was measured with a Snellen tumbling E chart with available correction. Pinhole was used for VA correction. The lens status of all participants was assessed with a portable slit lamp. All eyes that could not see 6/12 with available correction were examined for cause with a direct ophthalmoscope.

The Kandze Prefecture Health Bureau provided permission for the study. Verbal consent was obtained from all participants prior to examination. Data were entered daily. All statistical analyses were performed using a commercially available software package (Stata V.13.1, StataCorp, College Station, Texas, USA).

The distribution of ethnicity in the study sample was compared with the study population. Within the sample, examination status was presented by ethnicity and the difference with Han ethnicity was tested. The distributions of age (10-year intervals) and sex between sample and population were compared ( $\chi^2$  test).

The crude prevalence with 95% CI for blindness and grade of visual impairment were calculated by ethnicity,

**Table 1** Characteristic of study subjects by examination status by ethnicity, age group, and sex, n (%)

	Population in study areas	People selected	People examined	Not available	Refused	Unable
<b>Ethnicity</b>						
Tibetan	854 827 (78.3)	4323 (86.5)*	4127 (95.5)	101 (2.34)	46 (1.06)	49 (1.13)
Han	199 157 (18.2)	523 (10.5)*	495 (94.7)	8 (1.53)	5 (0.96)	15 (2.87)
Other	37 888 (3.47)	154 (3.08)	142 (92.2)	0 (0.00)	2 (1.30)	10 (6.49)†
Total	1 091 872 (100.0)	5000 (100.0)	4764 (95.3)	109 (2.18)	53 (1.06)	74 (1.48)
	<b>Male</b>		<b>Female</b>		<b>Total</b>	
<b>Age</b>	<b>Population in study areas</b>	<b>People examined</b>	<b>Population in study areas</b>	<b>People examined</b>	<b>Population in study areas</b>	<b>People examined</b>
50–59 years	44 718 (49.6)	802 (38.4)	41 013 (43.7)	1029 (38.4)	85 731 (46.6)	1831 (38.4)
60–69 years	29 629 (32.9)	730 (35.0)	31 134 (33.2)	852 (31.8)	60 763 (33.0)	1582 (33.2)
70–79 years	12 442 (13.8)	429 (20.6)	16 163 (17.2)	609 (22.8)	28 605 (15.5)	1038 (21.8)
80+ years	3364 (3.73)	126 (6.04)	5551 (5.91)	187 (6.99)	8915 (4.84)	313 (6.57)
Total	90 153 (100.0)	2087 (100.0)	93 861 (100.0)	2677 (100.0)	184 014 (100.0)	4764 (100.0)

\*More Tibetan and less Han Chinese selected compared their proportion of total population in study areas ( $p < 0.001$ )

†Other ethnic minorities had higher proportion of 'not available'.

sex, region and distance from hospital and logistic regression was used for comparisons between subgroups for these factors. The age-sex adjusted prevalence (age-sex adjusted to the 2010 Kandze Standard Population) for blindness and grade visual impairment and for percentage of CSC was also calculated by male and female.

## RESULTS

Among the 5000 people enumerated, 4764 (95.3%) were examined; male 2087 (43.8%) and female 2676 (56.2%). More Tibetan and fewer Han Chinese were selected compared with their total population in the study areas ( $p < 0.05$ ). Of the 236 participants not examined, 109 (2.2%) were not available, 53 (1.1%) refused examination and for 74 (1.5%), examination was not possible (table 1). Similar proportion of men and women were examined in each age group (Table 2)

The age and sex adjusted prevalence of presenting blindness, SVI, MVI and EVI were 1.6% (95% CI 1.08 to 2.4), 0.8% (95% CI 0.4 to 1.4), 4.3% (95% CI 3.3 to 5.4) and 6.4% (95% CI:5.3 to 7.8), respectively. Kandze

Prefecture had a substantial number of people with blindness (2929), SVI (1411), MVI (7812) and EVI (11,787) about 60% of which was avoidable (table 2).

Women bore a significant excess burden of EVI compared with men (8.5% (95% CI:7.5 to 9.6) and 6.1% (95% CI:5.1 to 7.2), respectively,  $p < 0.05$ ). The prevalence of blindness among Tibetans was significantly higher than that among Han Chinese (2.2% (95% CI 1.8 to 2.6) and 0.6% (95% CI 0.2 to 1.7), respectively,  $p < 0.05$ ). The prevalence of blindness, SVI and MVI were significantly higher in the pastoral versus agricultural areas. The prevalence of blindness and SVI were also significantly higher among people living further from the hospital in Dartsedo (table 3).

Cataract and complications of cataract surgery were the primary causes of blindness (39.4% and 8.5%, respectively) and SVI (51.1% and 11.1%, respectively). The next leading causes of blindness were macular degeneration (10.6%) and other posterior segment disease (16.0%) and corneal opacity (6.4%). Refractive error caused 0.0% of SVI and 15.7% of MVI. A total of 58.5% of the blindness and 66.7% of SVI were avoidable (table 4).

**Table 2** Age-adjusted and sex-adjusted prevalence of presenting (available correction) blindness and grade of VI: SVI, MVI and EVI. N is the estimated number of people 50 years and older with the condition

	Male		Female		Total	
	N	% (95% CI)	N	% (95% CI)	N	% (95% CI)
Blindness	1159	1.29 (0.68 to 2.53)	1767	1.88 (1.18, 3.10)	2929	1.59 (1.08 to 2.38)
SVI	581	0.64 (0.26 to 1.76)	828	0.88 (0.43 to 1.90)	1411	0.77 (0.43 to 1.40)
MVI	3715	4.12 (2.81 to 5.99)	4183	4.46 (3.25 to 6.12)	7812	4.25 (3.32 to 5.42)
EVI	4397	4.88 (3.48 to 6.83)	7271	7.75 (6.06 to 9.86)	11 787	6.41 (5.25 to 7.81)

EVI, early VI; MVI, moderate VI; SVI, severe VI; VI, visual impairment.

**Table 3** Sample prevalence of presenting (available correction) blindness and VI: SVI, MVI and EVI

	Blindness		Severe VI		Moderate VI		Early VI	
	N	% (95% CI)	N	% (95% CI)	N	% (95% CI)	N	% (95% CI)
<b>Ethnicity</b>								
Tibetan	89	2.16 (1.76 to 2.65)*	39	0.95 (0.69 to 1.29)	215	5.21 (4.57 to 5.93)	309	7.49 (6.72 to 8.33)
Han	3	0.61 (0.20 to 1.86)	5	1.01 (0.42 to 2.41)	21	4.24 (2.78 to 6.42)	34	6.87 (4.95,9.46)
Other	2	1.41 (0.35 to 5.48)	1	0.70 (0.10 to 4.86)	6	4.23 (1.90 to 9.11)	12	8.45 (4.85 to 14.3)
<b>Sex</b>								
Male	35	1.68 (1.21 to 2.33)	18	0.86 (0.54 to 1.37)	104	4.98 (4.13 to 6.00)	127	6.09 (5.14 to 7.20)
Female	59	2.20 (1.71 to 2.83)	27	1.01 (0.69 to 1.47)	138	5.16 (4.38 to 6.06)	228	8.52 (7.52, 9.64)†
<b>Region</b>								
Pastoral area	36	3.26 (2.36 to 4.48)	18	1.63 (1.03 to 2.57)	79	7.15 (5.77 to 8.83)	97	8.78 (7.25 to 10.6)
Agriculture area	54	1.57 (1.20 to 2.04)‡	25	0.73 (0.49, 1.07)‡	150	4.36 (3.73, 5.10)‡	241	7.01 (6.20 to 7.91)
Urban	4	1.83 (0.69 to 4.78)	2	0.91 (0.23 to 3.59)	13	5.94 (3.47 to 9.97)	17	7.76 (4.87 to 12.1)
<b>Distance from hospital, km</b>								
≤200	13	0.86 (0.50 to 1.47)	8	0.53 (0.26 to 1.05)	70	4.62 (3.67 to 5.80)	119	7.85 (6.60 to 9.32)
201–400	34	2.37 (1.70 to 3.29)	15	1.04 (0.63 to 1.72)	61	4.24 (3.32 to 5.42)	103	7.17 (5.94 to 8.62)
>400	47	2.59 (1.95 to 3.44)	22	1.21 (0.80 to 1.84)	111	6.13 (5.11 to 7.33)	133	7.34 (6.23 to 8.64)
P trend		<0.001		0.046		0.052		0.618
Total	94	1.97 (1.60 to 2.41)	45	0.94 (0.69 to 1.26)	242	5.08 (4.47 to 5.74)	355	7.45 (6.72 to 8.23)

\*The prevalence of blindness among Tibetan was significantly higher than that among Han Chinese with  $p=0.029$ .

†The prevalence of EVI among female was significantly higher than that among male with  $p=0.002$ .

‡The prevalence of blindness, SVI and MEVI in pastoral area were significantly higher than those in agriculture area with  $p=0.001$ ,  $p=0.009$  and  $p<0.001$ , respectively.

EVI, early VI; MVI, moderate VI; SVI, severe VI; VI, visual impairment.

Adjusted, CSC estimates for people with visual acuity  $<3/60$  were 85.8% (male 91.7%, female 82.1%); and for visual  $<6/60$  it was 82% (male 89.2%, female 77.5%) (table 5).

## DISCUSSION

Compared with the blindness prevalence study of the Tibetan Autonomous Region (TAR) in 1999,<sup>2</sup> this

**Table 4** Principal cause of blindness, SVI, MVI and EVI in persons, n (%)

	Blindness	SVI	MVI	EVI
1. Uncorrected refractive error	0 (0.00)	0 (0.00)	36 (14.9)	167 (47.0)
2. Aphakia, uncorrected	0 (0.00)	1 (2.22)	0 (0.00)	0 (0.00)
3. Cataract untreated	37 (39.4)	23 (51.1)	111 (45.9)	110 (31.0)
4. Cataract surgical complications	8 (8.51)	5 (11.1)	7 (2.89)	10 (2.82)
5. Non-trachomatous corneal opacity	6 (6.38)	0 (0.00)	3 (1.24)	5 (1.41)
6. High-myopic retinopathy	0 (0.00)	1 (2.22)	1 (0.41)	3 (0.85)
7. Glaucoma	3 (3.19)	0 (0.00)	0 (0.00)	1 (0.28)
8. Diabetic retinopathy	1 (1.06)	0 (0.00)	0 (0.00)	0 (0.00)
9. ARMD	10 (10.6)	8 (17.8)	38 (15.7)	35 (9.86)
10. Other posterior segment disease	15 (16.0)	6 (13.3)	36 (14.9)	20 (5.63)
11. All other globe/CNS abnormalities*	14 (14.9)	1 (2.22)	10 (4.13)	4 (1.13)
Total	94 (100.0)	45 (100.0)	242 (100.0)	355 (100.0)
A. Treatable (1, 2, 3)	37 (39.4)	24 (25.5)	147 (60.7)	277 (78.0)
B. Preventable (4, 5, 6, 7, 8)	6 (6.38)	1 (2.22)	4 (1.65)	8 (2.25)
C. Preventable (Ophthalmic services) (4, 9, 10)	12 (12.8)	5 (11.1)	7 (2.89)	11 (3.10)
D. Avoidable (A+B+C)	55 (58.5)	30 (66.7)	158 (65.3)	296 (83.4)
E. Posterior segment causes (8, 9, 10, 11, 12)	29 (30.9)	15 (33.3)	75 (31.0)	59 (16.6)

\*All other globe/central nervous system abnormalities: microphthalmos, anophthalmos, enucleated eye, amblyopia.

EVI, early VI; MVI, moderate VI; SVI, severe VI; VI, visual impairment.



**Table 5** Age-adjusted and sex-adjusted cataract surgical coverage by person in percentage

	Male (%)	Female (%)	Total (%)
VA <3/60	91.7	82.1	85.8
VA <6/60	89.2	77.5	82.0
VA <6/18	72.0	61.8	65.6

Kandze Tibetan Autonomous Prefecture study estimated substantially lower age-adjusted and sex-adjusted levels of blindness and SVI (VA<6/60) for people over age 50 years (10.9% and 2.4% for the TAR and Kandze, respectively) and for MVI (48.5% and 4.3% for TAR and Kandze, respectively).

The reduction in blindness and visual impairment in the current Kandze study compared with the 1999 TAR study was most likely due to a combination of lower prevalence of cataract blindness and visual impairment (13.8% and 1.9% (data not shown)) for TAR and Kandze, respectively) and an increase in CSC. The CSC in the TAR in 1999 ranged from 66% to 56% to 41% for people with presenting VA <3/60, <6/60 and <6/18, respectively,<sup>6</sup> compared with 86%, 82% and 66% for people in the same VA categories in the Kandze study. The remarkably high CSC in the TAR in 1999 reflected an extensive cataract surgical programme conducted by ophthalmologist from elsewhere in China.

The dramatic decrease in MVI in the two Tibet surveys (from 48.5% to 4.3%) is more difficult to explain in large part because the causes of MVI were not reported in the original TAR survey. However, the 1999 survey did report relatively poor visual outcome following cataract surgery (60% aphakic) and relatively high CSC.<sup>6</sup> Therefore, the high proportion of MVI could have resulted from poor cataract surgical outcome.

The prevalence of blindness in Kandze prefecture resembles two geographically similar Inner Mongolian counties (1.2%, 1.4% and 1.2% for Kandze Prefecture, Tuoketou and Shangdu Counties, respectively).<sup>7</sup> In all three places, about 50%–60% of blindness and SVI was due to cataract. The prevalence of blindness and visual impairment in Kandze prefecture also resembled findings from RAAB studies in Jiangxi Province and Chaonan Region in China<sup>8,9</sup> and in Nepal<sup>10</sup> but lower than the Hainan Province in China.<sup>11</sup>

Refractive error caused 15.7% of MVI and 0% of SVI in the current study which was much lower than a study in Inner Mongolia (SVI 25% and MVI 50%) and other regions of China (about 50% of MVI).<sup>7,12,13</sup> A recent study in neighbouring Nepal reported 65% of MVI due to refractive error. Outreach activities in Kandze Prefecture could substantially reduce MVI by adding refractive services to their programme of activities. Prior to this study, the Kham Eye Centre outreach programme did not conduct refraction or provide presbyopic glasses during eye camps. Nor did they provide glasses following

cataract surgery. Therefore, almost no Tibetans, and very few Han Chinese, were found wearing glasses.

In the current study, women and men did not have statistically significant differences in the estimates of blindness/SVI/MVI, but women continued to bear a significant excess burden of EVI compared with men (8.5% and 6.1%, respectively). This is a substantial improvement compared with the 1999 TAR study where women of all ages bore a significantly higher proportion of blindness/SVI compared with men (1.02% and 0.76%, respectively). The improved sex ratio is likely due to the strong community ophthalmology programme at the Kham Eye Center in Dartsedo that conducts about 20–25 eye ‘camps’ annually, about half of which are cataract surgical camps, reaching all 18 counties each year. The proportion of women undergoing cataract surgery in the eye camps and at the Kham Eye Centre was typically about 60%. Providing services closer to home improves service utilisation by women, especially those in the older age groups and with more SVI.<sup>14,15</sup> The residual sex differences for EVI found in Kandze prefecture resembles the inequity remaining in other populations. (reference 16 is in the list and correctly cited)<sup>16</sup>

In summary, blindness and visual impairment in Kandze Tibetan Autonomous Prefecture is substantially lower than an earlier study of the Tibetan Autonomous Region, now resembling other regions of China. About 58.5% of blindness is avoidable. Eye care planning should focus on improving eye care service utilisation by pastoral and rural agrarian populations, particularly women, as well as developing refractive services throughout the region.

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