·Investigation·

Prevalences and causes of vision impairment in elderly Chinese: a socioeconomic perspective of a comparative report nested in Jiangsu Eye Study

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Abstract

• AIM: To survey the prevalence and causes of visual impairment/blindness among elderly Chinese from different socioeconomic status in community-based design.

• METHODS: Cluster-sampling randomly selected residents from Binhu and Funing District, two areas representing different socioeconomic levels in China with Binhu in an advanced status and Funing in less-developed area. The participants subjected to ophthalmic examination. The presenting visual acuity (PVA) and best-corrected visual acuity (BCVA) were recorded. Visual impairment and blindness were defined according to World Health Organization criteria. The causes of visual impairment/blindness were identified by ophthalmic examination and/or questionnaire. The socioeconomic status included the per capita gross domestic product, numbers of hospital with ophthalmic service and the number of ophthalmologists per 1 million residents.

• RESULTS: We successfully included 12 867 participants form 2 areas in this study. The prevalence of PVA impairment (<20/63 to ≥20/400) in the better eye was 5.4% in Binhu and 23.6% in Funing, while the prevalence of blindness (<20/400) was 0.9% in Binhu and 2.3% in Funing. With BCVA, the prevalence of visual impairment was 2.4% in Binhu and 6.4% in Funing, while the prevalence of blindness was 0.8% in Binhu and 1.6% in Funing. The participants with older age and female gender had higher prevalence in visual impairment and blindness. The highest prevalences of vision impairment and blindness evaluated by BCVA at >80y age group reached 20.4% and 6.3% respectively. The prevalences of vision impairment and blindness evaluated by BCVA were 3.5% and 1.0% in male and 5.0% and 1.3% in female. The above differences were statistically significant (P<0.05). The predominant causes of visual impairment and blindness were cataract, retinal disorders and uncorrected refractive error in both areas. The socioeconomic status was associated with visual impairment and blindness.

• CONCLUSION: This community-based study build a sufficient sample size for an ophthalmic survey. Our data show the disparities on socioeconomic development and genders in visual impairment and blindness in China. Special emphasis of ophthalmic service should be placed on females and less-developed area.

• KEYWORDS: blindness; vision impairment; prevalence; community-based; socioeconomic development

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INTRODUCTION

Visual impairment is recognized as 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) with an aim to eliminate avoidable blindness by 2020[1]. In 2002, WHO estimated that there were 161 million people with visual impairment and approximately 37 million were legally blind. Over 90% of the visually impaired people live in developing countries. China, with a population of 1.3 billion accounting for 15% of the world's population, is estimated the prevalence of blindness in people ≥50y as 2.3% as reported in 2004[2]. In consistence with this estimation, a large scale of ophthalmic survey conducted in 2006-2007 reported the prevalence of blindness of 2.29% among older adults in rural China[3].

During past 20y, there were numerous ophthalmic surveys conducted in China [4-11], including similar studies in our Jiangsu province [12-15]. Despite steady growth of China's economy, there are increasing regional disparity in socioeconomic development. We hypothesize that this disparity might also impact the profile of residents' vision health and the data of previous studies on vision health might not reflect the real picture of nowadays. Southern Jiangsu and

Table 1 Study population by area *n* (%)

Areas	Geographical location	GDP (hundred million, ￥)	Total population	Real GDP per capita (￥)	Enumerated	Examined	Examination response rate (%)
Binhu	South	492.5	689 000	84 000	6722 (52.2)	6106 (35.5)	90.8
Funing	North	198.0	1 090 000	18 662	6145 (47.8)	5947 (34.6)	96.8

GDP: Gross domestic product.

northern Jiangsu has obvious differences in socioeconomic development. In this study, we selected Binhu in southern and Funing in northern Jiangsu as the sampling areas and collected the data with the focus on the prevalence and causes of visual impairment/blindness among adults ≥50 years of age.

SUBJECTS AND METHODS

A total of 12 867 persons aged ≥50y from the two areas were enumerated and a total of 12 053 (93.8%) participants with vision acuity (VA) data were collected (Table 1). The two areas represented different economic levels in Jiangsu Province with the per capita gross domestic product (GDP) in Binhu nearly 4.5 times higher than that in Funing District, The government of Binhu invested more resources in medical service including more hospitals with eye departments and more eye-doctors (Table 2).

The survey followed the protocol of a national study on vision health [3]. We randomly selected individuals according to the sampling frames constructed using geographically defined clusters based on district and village register data. Cluster boundaries were defined that each cluster would have a population of approximately 1000 individuals (all ages).

Sample size was based on an anticipated 4% prevalence for visual impairment <20/200 within an error bound (precision) of 20% with 95% confidence [4-5]. Assuming an examination response rate of 90%, and a design effect of 1.5 to account for inefficiencies associated with the cluster sampling design, a sample of 5315 persons ≥50 years of age was required for each area. Depending on the percentage of population ≥50 years of age, 28 clusters were randomly selected (with equal probability) from the sampling frame in Binhu and 30 clusters in Funing. Three clusters were selected for preliminary experiment. Geographically defined cluster sampling included 6722 individuals aged ≥50 years in Binhu district from January to December 2010. Actually 6106 persons were examined with the response rate of 90.8%. The same sampling was used in 6145 randomly selected individuals aged ≥50y in Funing from September 2010 to May 2011 and actually 5947 individuals were examined with the response rate of 96.8%.

The list of residents ≥50 years of age were obtained from the residence registers, followed by door-to-door household visits conducted by local government staff or community doctors. Those ≥50 years of age were enumerated by name, gender and age. Individuals temporarily absent at the time of the household visit were included in the enumeration.

Table 2 Resources of ophthalmic service by area

Areas	Hospitals with ophthalmic service	Ophthalmologists	Ophthalmologists per 1 million residences
Binhu	11	35	50.8
Funing	5	21	19.3

Unregistered adults ≥50 years of age were enumerated and included in the study sample if they had been living in the household for ≥6mo.

Study participants were examined at the community clinics or local government buildings. The trained health workers administered a standard questionnaire to collect details of demographic information, general medical history and ophthalmic history. All the responding subjects had their blood pressure and blood glucose measured, and then underwent ophthalmic examinations. Those who did not appear at the examination site were revisited by a member of the enumeration team to encourage participation. The physically disabled and those failing to come to the examination site after repeated contact were offered an ocular examination at their homes.

Distance VA was measured using an Early Treatment Diabetic Retinopathy Study logMAR E-chart (Precision Vision, Villa Park, IL, USA) 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 above. VA was recorded as the smallest line read with 1 or no errors. Testing for counting fingers, hand movement, light perception, or no light perception was checked on those unable to read the top line at 1 m. The VA was measured in each eye initially without refractive correction or with distance glasses if the participant routinely worn it. Those presenting with VA ≤20/25 in either eye were refracted to achieve best corrected VA (BCVA). Subjective refraction was performed by a trained optometrist for those subjects, and auto refractometer (AR-610; NIDEK, Japan) readings were used as the starting point for subjective refraction carried out without pupil dilation. For those in whom subjective refraction was not performed, particularly the elderly examined at their homes, BCVA was assumed to be the same as presenting visual acuity (PVA) if pinhole vision combined with examination findings indicated a

principal cause of impairment other than refractive error as described below.

Ocular examination of the eyelid, globe, pupillary reflex, lens and fundus was carried out by two study ophthalmologists. For those with aphakia/pseudophakia, surgical history (year and place) was obtained, with clinical details pertaining to the type of surgery and surgical complications noted during the examination. Participants with BCVA ≤20/40 had their pupils dilated for direct ophthalmoscopy and slit-lamp examination. Intraocular pressure measurement by applanation tonometry was performed on an optional basis for glaucoma suspects with optic disc abnormalities. Gonioscopy and ultrasound biomicroscopy (UBM) at light/dark states were utilized to inspect early angle-closure glaucoma without clinical symptoms.

Eyes with PVA ≤20/40 were assigned one principal cause of visual impairment and blindness out of 14 causes including uncorrected refractive error, amblyopia, cataract, posterior capsule opacification, corneal opacity/scar, phthisical/ disorganized/absent globe, glaucoma, other optic atrophy, macular degeneration, myopic maculopathy, diabetic retinopathy, retinal detachment, other retinal/choroidal changes and undetermined cause [3]. Uncorrected refractive error was assigned as the cause for eyes that were improved to ≥20/32 with refractive correction, or with pinhole vision when subjective refraction was not possible. Cataract was assigned when lens opacity was commensurate with visual impairment and no other abnormality could account for the decreased VA.

Affiliated Hospital of Nantong University Committee on Ethics on Research approved the implementation of the survey protocol. Informed written consent was obtained from all study participants. The study adhered to the tenets of the Declaration of Helsinki.

Statistical Analysis Original forms in hard copies were transferred to the data management and analysis center at the Affiliated Hospital of Nantong University. Computerized data entry was carried out using standardized programs (Epidata 3.0). Statistical analyses were performed using STATA 10.0 (Stata Statistical Software, Release 10.0, Stata Corp, College Station, TX, USA). Confidence intervals (CI) and P values of percentage comparison (significant at the $P \leq 0.05$ level) were calculated with adjustment for clustering effects and stratification associated with the sampling design.

VA was categorized as normal vision (≥20/32); mild visual impairment (near normal vision, 20/40 to 20/63); moderate visual impairment (<20/63 to 20/200); severe visual impairment (<20/200 to 20/400); and blindness (<20/400) in the better eye. Prevalence of moderate and severe visual impairment (<20/63 to 20/400) and blindness were calculated on the basis of both PVA and BCVA. The comparison of percentage was performed by χ^2 method. Multiple logistic regressions were used to analyze the correlation of age (using 10-year categories), gender and area with presenting and best-corrected visual impairment/blindness. Geographic location was explicitly included as a regression variable.

Table 3 Examined participants within each area by age and gender

n (%)

Parameters	Binhu	Funing	Total
Age (a)	63.4±8.4	64.4±8.7	63.9±8.5
50-59	2175 (35.6)	1995 (33.6)	4170 (34.6)
60-69	2590 (42.4)	2203 (37.0)	4793 (39.8)
70-79	1024 (16.8)	1464 (24.6)	2488 (20.6)
≥80	317 (5.2)	285 (4.8)	602 (5.0)
Gender			
M	2600 (42.6)	2467 (41.5)	5067 (42.0)
F	3506 (57.4)	3480 (58.5)	6986 (58.0)
Total	6106 (100)	5947 (100)	12053 (100)

RESULTS

The age and gender distribution of the examined population within each area is shown in Table 3. The distribution of age and genders of study participants were similar between the two areas.

The Table 4 shows the distribution within each area of PVA and BCVA in the eye with better VA. As for PVA, the overall prevalence of moderate/severe visual impairment (≥20/400 to <20/63) was 14.4%, with 5.4% in Binhu and 23.6% in Funing. The overall presenting blindness (<20/400) was 1.6%, with 0.9% in Binhu and 2.3% in Funing. As for BCVA, the overall prevalence of moderate/severe visual impairment was 4.4%, with 2.4% in Binhu and 6.4% in Funing. The overall blindness with best correction was 1.1%, with 0.8% in Binhu and 1.6% in Funing. The proportion above 20/40 for PVA is much higher in Binhu (76.7%) than in Funing (29.5%), as for BCVA 89.4% in Binhu and 73.1% in Funing, which suggest higher proportion of uncorrected refractive error in economically less-developed area.

PVA and BCVA (Tables 5 and 6) indicated that visual impairment and blindness were associated with area, age and gender. In general, the less-developed area had higher rates of visual impairment and blindness (Table 5). After adjusted against age and gender, the difference of the rates of visual impairment and blindness between the two areas remained (Table 6). The prevalences PVA and BCVA present a steady increases with age in both areas. The highest prevalences of vision impairment and blindness evaluated by BCVA at >80 years age group reached 20.4% and 6.3% respectively. The prevalences of vision impairment and blindness evaluated by BCVA were 3.5% and 1.0% in male and 5.0% and 1.3% in female (Table 6).

Principal causes of visual impairment and blindness are shown in Table 7. Cataract was the most common cause for visual impairment and blindness both in Binhu and Funing. Uncorrected refractive error was the second cause of visual

Table 4 Distribution of PVA and BCVA in the better eye *n* (%; 95%CI)

Parameters	Binhu		Funing	
	PVA	BCVA	PVA	BCVA
VA>20/40	4684 (76.7; 75.7-77.8)	5461 (89.4; 88.7-90.2)	1756 (29.5; 28.4-30.7)	4345 (73.1; 71.9-74.2)
20/63≤VA≤20/40	1038 (17.0; 16.1-17.9)	452 (7.4; 6.8-8.1)	2648 (44.5; 43.3-45.8)	1127 (19.0; 18.0-20.0)
20/200≤VA<20/63	298 (4.9; 4.3-5.4)	135 (2.2; 1.8-2.6)	1287 (21.6; 20.6-22.7)	339 (5.7; 5.1-6.3)
20/400≤VA<20/200	30 (0.5; 0.3-0.7)	12 (0.2; 0.1-0.3)[a]	118 (2.0; 1.6-2.3)	44 (0.7; 0.5-1.0)
VA<20/400	56 (0.9; 0.7-1.2)	46 (0.8; 0.5-1.0)	138 (2.3; 1.9-2.7)	92 (1.5; 1.2-1.9)

CI: Confidence interval; VA: Visual acuity; PVA: Presenting visual acuity; BCVA: Best-corrected visual acuity. [a]Confidence intervals were calculated using the exact binomial distribution instead of the normal approximation.

Table 5 Presenting and best-corrected visual impairment (<20/63-20/400) and blindness (<20/400) by area *n* (%)

Parameters	Binhu	Funing	*P*	Odds ratio (95% CI)
Visual impairment				
PVA	328 (5.4)	1405 (23.6)	<0.001	2.3 (2.2-2.5)
BCVA	147 (2.4)	383 (6.4)	<0.001	1.7 (1.5-1.8)
Blindness				
PVA	56 (0.9)	138 (2.3)	<0.001	1.6 (1.4-1.9)
BCVA	46 (0.8)	92 (1.6)	<0.001	1.4 (1.2-1.7)

CI: Confidence interval; VA: Visual acuity; PVA: Presenting visual acuity; BCVA: Best-corrected visual acuity.

impairment and blindness according to the PVA in both areas. Treatable causes of visual impairment accounted for nearly 70% of the total cases.

Of the 12 053 participants, 357 (2.96%) were with glasses for distance correction at the time of the examination, with 264 (73.9%) of these presenting with normal vision (VA>20/40) in one or both eyes. However, if everyone who was correctable to >20/40 in ⩾1 eye with refraction had had glasses, the overall percentage with normal vision would increase from 53.4% to 81.4%.

DISCUSSION

This survey enumerated a larger number of participants. The response rate of this survey exceeded 90% that was considered as sufficient, which attributed to the mandatory training for team members before the survey, repeated household visits as needed and offering the examinations at home when necessary. The study is a part of longitudinal cohort named after Jiangsu Eye Study. We reported here the baseline data that will be very important for the follow-up of the cohort. The data reflect the current spectrum of common eye diseases in China and the vision impairment distribution in the regions at different economic development levels.

This study recorded mild visual impairment (VA 20/40-20/63), which followed the design of the China Nine-province Survey [3]. The prevalence of mild visual impairment was 17.0% in Binhu and 44.5% in Funing with presenting vision; and the prevalence in Binhu was within the range (10.8%-27.4%) reported in the China Nine-province Survey while the prevalence of Funing was much higher.

Cataract was the most common cause for blindness and visual impairment based on PVA both in Binhu and Funing, which is consistent with other studies conducted in China[4-13]. Uncorrected refractive error was the leading cause of visual impairment in different parts of the world[7,16-19]. Similar to the result from the China Nine-province Survey [3], less than 1% of the examined population presented with spectacles for distance correction in Funing (0.77%). Because most participants in Funning were farmers, they were not accustomed to wearing glasses and thought it was not convenient to do their job. In contrast, higher percentage (5.09%) of the examined population in Binhu presented with spectacles than that in Funing. The Binhu district locates in the suburb of Wuxi that has 4 tertiary general hospitals and people in that area can expediently receive eye care. The Funing County locates in the middle of the north of Jiangsu Province and has big geospatial distance to major cities where basic eye care can be provided. So as a result of economic and geospatial factors, the accessibility and the relative affordability of eye care services is superior in Binhu than within Funing. This suggests that the lack of eye care and/or inaccessibility among rural Chinese might contribute to this disparity.

About half of those presenting with moderate/severe and mild vision impairment improved to normal vision at least in ⩾1 eye with BCVA, suggesting that refractive correction is one of the determinative factors in the outcome of eye care.

Our survey also provides evidence that visual impairment and blindness is associated not only with older age, as expected, but also with female gender and socioeconomic levels of the sampling areas. These findings are consistent with the 1996 Shunyi survey, 2001 Beijing survey, 2004 Liwan Eye Study 7, 2006 Sichuan survey [10], 2007 Harbin survey [11] the Nine-Province Survey[3] in China, 2001 Canada survey[20], and the Singapore Eye Studies [16,21]. In the absence of information on family income, the situation and per capita GDP of each area can be considered as a surrogate indicator of socioeconomic status. Even though the association was solid, we cannot establish a casual-effect relation between the socioeconomic status and vision outcomes with the data available.

In conclusion, the present study has added the data of the prevalence of visual impairment and blindness in the elderly

Table 6 Presenting and best-corrected visual impairment (<20/63-20/400) and blindness (<20/400) *n* (%)

Parameters	Visual impairment				Blindness			
	PVA		BCVA		PVA		BCVA	
	Prevalence	Odds ratio (95% CI)	Prevalence	Odds ratio (95% CI)	Prevalence	Odds ratio (95% CI)	Prevalence	Odds ratio (95% CI)
Age (a)								
50-59	246 (5.9)	Reference	55 (1.3)	Reference	22 (0.5)	Reference	12 (0.3)	Reference
60-69	527 (11.0)	2.2 (1.9-2.6)[b]	119 (2.5)	2.0 (1.5-2.8)[b]	51 (1.1)	2.1 (1.3-3.5)[b]	39 (0.8)	3.0 (1.5-5.8)[b]
70-79	720 (28.9)	6.9 (5.9-8.1)[b]	233 (9.4)	7.7 (5.7-10.4)[b]	76 (3.1)	5.7 (3.5-9.3)[b]	49 (2.0)	6.9 (3.6-13.1)[b]
≥80	240 (39.8)	14.8 (11.8-18.6)[b]	123 (20.4)	21.7 (15.5-30.3)[b]	45 (7.5)	16.2 (9.5-27.4)[b]	38 (6.3)	24.7 (12.6-48.3)[b]
Gender								
M	607 (12.0)	Reference	179 (3.5)	Reference	71 (1.4)	Reference	49 (1.0)	Reference
F	1126 (16.1)	1.8 (1.6-2.0)[b]	351 (5.0)	1.7 (1.4-2.1)[b]	123 (1.8)	1.4 (1.1-2.0)[a]	89 (1.3)	1.5 (1.1-2.2)[a]
Area								
Binhu	328 (5.4)	Reference	147 (2.4)	Reference	56 (0.9)	Reference	46 (0.8)	Reference
Funing	1405 (23.6)	2.4 (2.2-2.6)[b,c]	383 (6.4)	1.6 (1.5-1.8)[b,c]	138 (2.3)	1.6 (1.3-1.8)[b,c]	92 (1.6)	1.4 (1.2-1.7)[b,c]
Total	1733 (14.4)	-	530 (4.4)	-	194 (1.6)	-	138 (1.1)	-

CI: Confidence interval; VA: Visual acuity; PVA: Presenting visual acuity; BCVA: Best-corrected visual acuity. [a]*P*<0.05; [b]*P*<0.001; [c]Adjusted for age and gender.

Table 7 Principal causes of the loss of presenting visual acuity *n* (%)

Areas	Principal cause	<0.3-0.1	<0.1-0.05	<0.05	Total
Binhu	Cataract	332 (37.1)	38 (36.5)	146 (42.3)	516 (38.5)
	Refractive error	375 (42.0)	21 (20.2)	12 (3.5)	408 (30.4)
	Retina disorders	79 (8.9)	24 (23.1)	53 (15.4)	156 (11.6)
	AMD	63 (7.1)	18 (17.3)	35 (10.1)	116 (8.7)
	Amblyopia	24 (2.7)	7 (6.7)	9 (2.6)	40 (3.0)
	Corneal opacity/scar	13 (1.5)	2 (1.9)	15 (4.3)	30 (2.2)
	Optic atrophy	6 (0.7)	1 (1.0)	22 (6.3)	29 (2.1)
	Disorganized globe	0 (0.0)	0 (0.0)	25 (7.3)	25 (1.9)
	PCO	11 (1.2)	3 (2.9)	9 (2.6)	23 (1.7)
	Myopic maculopathy	6 (0.7)	3 (2.9)	13 (3.8)	22 (1.6)
	Diabetic retinopathy	10 (1.1)	1 (1.0)	2 (0.6)	13 (1.0)
	Glaucoma	4 (0.5)	1 (1.0)	5 (1.5)	10 (0.8)
	Retina detachment	0 (0.0)	2 (1.9)	3 (0.9)	5 (0.3)
	Other cause	48 (5.4)	7 (6.7)	49 (14.2)	104 (7.8)
	Total	892 (100)	104 (100)	345 (100)	1341 (100)
Funing	Cataract	1185 (41.1)	144 (39.0)	212 (32.6)	1541 (39.5)
	Refractive error	1292 (44.8)	81 (22.0)	53 (8.1)	1426 (36.5)
	Retina disorders	70 (2.4)	22 (6.0)	50 (7.7)	142 (3.6)
	Corneal opacity/scar	23 (0.8)	10 (2.7)	65 (10.0)	98 (2.5)
	AMD	44 (1.5)	5 (1.4)	26 (4.0)	75 (1.9)
	Amblyopia	43 (1.5)	3 (0.8)	11 (1.7)	57 (1.5)
	Myopic maculopathy	9 (0.3)	15 (4.0)	10 (1.5)	34 (0.9)
	Optic atrophy	11 (0.4)	3 (0.8)	19 (2.9)	33 (0.8)
	Disorganized globe	1 (0.0)	0 (0.0)	30 (4.6)	31 (0.8)
	Diabetic retinopathy	15 (0.5)	1 (0.3)	10 (1.5)	26 (0.7)
	PCO	7 (0.2)	3 (0.8)	13 (2.0)	23 (0.6)
	Glaucoma	10 (0.4)	0 (0.0)	13 (2.0)	23 (0.6)
	Retina detachment	2 (0.1)	1 (0.3)	4 (0.7)	7 (0.1)
	Other cause	244 (8.4)	103 (27.9)	185 (28.4)	532 (13.6)
	Total	2886 (100)	369 (100)	651 (100)	3906 (100)

AMD: Age-related macular degeneration; PCO: Posterior capsule opacification.

Chinese and established the baseline data of the Jiangsu Eye Study. As noted, special emphasis in health policy should be placed on the relatively high prevalence of visual impairment and blindness among females and on narrowing the disparity

between the areas in different developing levels. Refractive error correction may be an effective strategy in the intervention.

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Zhu RR designed the study, conducted the survey and drafted the manuscript; Shi J conducted the survey; Yang M performed the statistical analysis and Guan HJ designed the study and revised the manuscript

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