· Investigation ·

Visual acuity of urban and rural adults in a coastal province of southern China: the Fujian Eye Study

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Abstract

● **AIM:** To evaluate the vision status and sociodemographic associations of visual acuity (VA) in an urban and rural population in a coastal province of southern China.

● **METHODS:** The Fujian Eye Study, a population-based cross-sectional study, was performed from May 2018 to October 2019. Totally 10 044 participants over 50 years old from all nine cities in Fujian Province were enrolled, and underwent a questionnaire and a series of standard physical and ocular examinations. VA was measured by E Standard Logarithmic Visual Acuity Chart (GB 11533-1989). Data was double entered with EpiData v3.1 for data collation and Stata/SE statistical software v15.1 was used to analyze the data.

● **RESULTS:** Totally 8211 (81.8%) participants were finally included and were divided into urban populations (4678 subjects), rural populations (n=3533), coastal residents (n=6434), and inland residents (1777 subjects); 4836 participants were female. The mean age was 64.39±8.87y (median 64y; range 50-98y). The mean presenting VA was 0.61±0.30 (0.23±0.27 logMAR), and the mean best corrected visual acuity (BCVA) was 0.82±0.28 (0.08±0.19 logMAR). In the multiple regression analysis, BCVA was significantly correlated with several socioeconomic and biologic factors, including age (P<0.001), education level (P<0.001), income (P=0.005), rural residency (P<0.001), inland residency (P=0.001) and refractive error (P<0.001), while sex (P=0.194) was independent with BCVA.

● **CONCLUSION:** Accessible services and eye health policies targeting the elderly, people with high myopia and people living in rural or inland areas are needed.

● **KEYWORDS:** cross sectional eye study; presenting visual acuity; best corrected visual acuity; urban and rural; coastal and inland

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INTRODUCTION

With improvements in living standards and quality of life, improvement in visual function has become a hot topic. Visual acuity (VA) examination is an important content of a complete oculo-visual evaluation and is very important in the test of amblyopia, refractive error and ocular disease[1]. One of the key objectives of Universal Eye Health: A Global Action Plan 2014-2019 is to generate evidence of the magnitude of vision impairment (VI), which affects economic and educational opportunities, reduces quality of life, and increases the risk of death of approximately 441.1 million persons[2]. Right to Sight is also a very important global project in ophthalmology, launched by WHO in 1999. The project target is set to decrease the expected doubling of blind patients worldwide by the year 2020 as a result of decrease in both mortality and fertility prevalence with the population aging rapidly in most countries[3]. Recently, many reports displayed strong association between socioeconomics and prevalence and causes of VI and blindness which attract great interest to ophthalmologist and policy makers of public eye health[4]. Our study just conducted from 2018-2019, and could provide the latest prevalence and related factors of VI and eye diseases.

Many articles have reported the prevalence and risk factors for VA changes or VI worldwide, but few published studies have compared and analyzed VA and VI in both rural and urban regions and inland and coastal areas. Due to the specific geographic location, six cities in Fujian Province have coastlines and three cities are inland areas, differences between both rural and urban regions and inland and coastal areas can be explored at the same time. Therefore, the present Fujian Eye Study (FJES) aimed to evaluate the central VA as an important factor to visual function among rural and urban and inland and coastal populations in southern China and identify ocular and demographic associations. As we know, there are many factors that affect vision, not only the eyes, but also the physical body, even socio-economic and demographic factors. Many studies have reported the related factors a long time ago, such as age, sex, income, education, and refractive error, while these studies were not up to date and limited[5-8]. In order to fill this gap in knowledge and to comprehend the vision health status and factors correlated with major eye diseases and vision loss, the research group conducted a population-based cross-sectional investigation to obtain data about the eye health situation among Chinese individuals aged 50y and above living in Fujian Province. This survey was just operated before the COVID-19 outbreak, and this may guide the eye health policy-making in future.

SUBJECTS AND METHODS

Ethical Approval The Ethics Committee of Xiamen Eye Center affiliated to Xiamen University approved the 2018-2019 FJES protocol (Acceptance number: XMYKZX-KY-2018-001) and written informed consent was obtained from all participants.

Study Design The FJES was a population-based, cross-sectional investigation on the public eye health status of Fujian Province, Southeast China, including both rural and urban regions and inland and coastal areas. It was carried out to identify the prevalence and related factors associated with VI and ocular diseases in residents aged 50y and above and to comprehend the differences among and obstacles to eye health service use in such areas.

The calculation formula and baseline data used in this study were elaborated in our published article. Assuming a response rate of 80%, to obtain a sufficient sample size according to previous studies[9-14], 10 044 subjects were recruited in this study. The total population of Fujian Province (which has an area of 124 000 km^2) was 38.74 million (permanent population of the province at the end of 2016)[15], including 14.10 million rural population and 24.64 million urban population, or 7.84 million inland population and 30.90 million coastal population. Therefore, 4209 rural residents and 5835 urban residents, or 2190 inland residents and 7854 coastal residents were recruited respectively.

Recruitment Procedures Participants underwent a comprehensive physical examination in a mobile clinic, which was set up in specific location (in community centre, administrative office or hospital). Those who could not participate in on-site examination in the screening were inquired for the consent of home visit and simple ophthalmic examination. All the technicians and clinicians were trained uniformly, and each inspection requires the fixed cooperation of equipment and personnel.

The main contents of the survey include: general information (name, sex, age, telephone number, ID number, address); questionnaire (race, blood group, the socioeconomic status, disease history, living habits, *etc*.); presenting VA; refractive state; best corrected visual acuity (BCVA); slit lamp inspections and fundus inspections [multicolor optical coherence tomography (OCT) and non-mydriatic fundus photographs].

E Standard Logarithmic Visual Acuity Chart (GB 11533—1989) was used to measure presenting VA and BCVA at a distance of 5 meters. We followed the World Health Organization (WHO) definitions of VI with BCVA in better eye worse than 20/60 (equaled to 0.3 in E Chart) and blindness with BCVA in better eye of 20/400 or worse (equaled to 0.05 in E Chart).

Statistical Analysis Double data entry was performed with EpiData version 3.1 for data collation and the final data was analyzed with Stata/SE statistical software version 15.1. Data are shown as means±standard deviation (SD). Means of normally distributed parameters among different subgroups were compared using analysis of variance (ANOVA). Proportions was compared using Chi-square tests. The relations between VA and selected potential factors was examined using multiple Logistic regression. Normally distributed parameters were compared using linear correlation. Confidence intervals (95%CI) are presented. The statistical strengths of correlations are shown as correlation coefficients (r) or odd ratio (OR) values. All P values<0.05 were defined statistically significant.

RESULTS

Based on the WHO definitions considering BCVA, 196 (2.88%) residents were low vision, and 31 (0.39%) residents were blind. The response rate of the whole population was 81.8% (8211 out of 10 044), and 4836 were female. Totally 43.0% of the population was from a rural area, which was similar to the rural and urban population ratio in Fujian Province (58.1% *vs* 41.9%), and 78.4% of the population was from a coastal area, which was also similar to the inland and coastal population ratio in Fujian Province (79.8% *vs* 20.2%)[15]. The response rates in the rural and urban populations were 80.2% and 83.9%

Table 1 Baseline characteristics of eligible participants in Fujian Eye Study

Classification	Total study	Urban population	Rural population	P	Coastal population	Inland population	^{a}P
Subjects (n)	8211	4678	3533		6434	1777	
Females (n)	4836	2697	2139		3804	1032	
Age (y, mean±SD)	64.39±8.87	64.64±8.66	64.05±9.12	0.0028	64.49±8.74	64.00±9.30	0.0381
Presenting VA (mean±SD)	0.61±0.30	0.62±0.30	0.58±0.30	<0.0001	0.61±0.30	0.59±0.30	0.046
BCVA (mean±SD)	0.82±0.28	0.84±0.27	0.81±0.29	0.0001	0.84±0.28	0.78±0.29	<0.0001
Refractive error (diopters, mean±SD)	0.52±2.73	0.51±2.69	0.54±2.78	0.68	0.62±2.67	0.18±2.90	<0.0001
Refractive error groups (%)				0.531			<0.0001
<-10.00	1.24	1.13	1.38		1.12	1.68	
-10.00 to -6.00	1.3	1.49	1.05		1.15	1.87	
-6.00 to -3.00	3.65	3.67	3.61		3.1	5.66	
-3.00 to 0.00	14.99	15.02	14.96		14.57	16.55	
0.00	4.2	4.09	7.33		4.08	4.63	
0.00 to +3.00	69.91	70.14	69.6		71.15	65.34	
+3.00 to +5.00	4.09	3.89	4.36		4.18	3.79	
+5.00 to +10.00	0.56	0.53	0.6		0.58	0.48	
>+10.00	0.05	0.02	0.09		0.06	0	
Educational background (%)				<0.0001			<0.0001
Illiteracy	18.05	12.58	24.49		19.08	12.09	
Primary school	21.45	19.57	23.66		21.62	20.44	
Middle school	43.68	46.69	40.14		43.56	44.34	
College and above	16.82	21.16	11.72		15.74	23.13	
Income (%)				<0.0001			<0.0001
≤2000	48.76	40.02	61.51		51.04	37.99	
2000-5000	39.3	46.48	28.82		36.67	51.73	
>5000	11.94	13.5	9.67		12.3	10.28	

SD: Standard deviation; VA: Visual acuity; BCVA: Best corrected visual acuity; P-value represents the statistical significance of difference between rural and urban population; ^{a}P-value represents the statistical significance of inland population and coastal population difference.

and 81.9% and 81.1% for the inland and coastal populations, respectively. The rural and urban groups varied significantly in education and income levels, as did the inland and coastal groups (Table 1).

Visual Acuity Only a randomly selected eye per resident among the whole study population was included the statistical analysis. The mean presenting VA measured 0.61 (0.30). When the VA of finger counting (FC) or below were excluded, the mean presenting VA was 0.61 (0.30). When eyes with better VA were selected using in the statistical analysis, the mean presenting VA was 0.68 (0.29). Expressed as the negative logarithmic value of the minimal angle of resolution (logMAR), the mean presenting VA in residents was 0.23 (0.27) logMAR units. The mean BCVA measured 0.82 (0.28). When eyes with a VA of FC or less were excluded, the mean BCVA was 0.83 (0.28). When eyes with better BCVA were selected in the statistical analysis, the mean BCVA values were 0.88 (0.24) and 0.08 (0.19) logMAR units.

Regional Comparison Presenting VA was statistical significantly (P<0.0001) greater among the rural residents than among the urban residents [0.62 (0.30) *vs* 0.58 (0.30)]. Similarly, BCVA was statistical significantly (P=0.0001) greater among the urban residents than among the rural residents [0.84 (0.27) *vs* 0.81 (0.29)]. The presenting VA was statistical significantly (P=0.0460) greater among the coastal residents than among the inland residents [0.61 (0.30) *vs* 0.59 (0.30)]. Similarly, BCVA was statistical significantly (P<0.0001) greater among the coastal residents than among the inland residents [0.84 (0.28) *vs* 0.78 (0.29); Table 1].

Correlation of VA with Age Presenting VA and BCVA were both significantly associated with age (r=-0.33 and -0.42, P<0.0001). Stratifying the present FJES population into rural residents group and urban residents group and inland residents group and coastal residents group showed similar results (urban group: r=-0.30 and -0.39, P<0.0001; rural group: r=-0.36 and -0.44, P<0.0001; coastal group: r=-0.33 and -0.41, P<0.0001; inland group: r=-0.31 and -0.46, P<0.0001).

Since the rural residents subgroup was statistical significantly younger than the urban residents subgroup (Table 1), both groups were stratified by age. And as the coastal residents subgroup was significantly younger than the inland residents subgroup (Table 1), both subgroups were also randomly stratified by age. Table 2 shows the difference among age subgroups in detail.

Table 2 Visual acuity in the age stratification subgroups among different regional residents groups in Fujian Eye Study

Age group (y)	Urban group		Rural group		P	Coastal group		Inland group		P^a
	Number	Mean±SD	Number	Mean±SD		Number	Mean±SD	Number	Mean±SD	
Presenting VA										
50-54	637	0.72±0.33	597	0.71±0.30	0.3343	919	0.74±0.32	315	0.66±0.32	0.0001
55-59	748	0.71±0.29	625	0.70±0.29	0.5274	1044	0.70±0.29	329	0.71±0.30	0.5993
60-64	932	0.67±0.29	642	0.61±0.28	< 0.0001	1283	0.65±0.29	291	0.64±0.29	0.8966
65-69	987	0.62±0.27	655	0.56±0.27	< 0.0001	1335	0.59±0.27	307	0.59±0.27	0.8221
70-74	701	0.53±0.27	473	0.47±0.27	0.0001	936	0.51±0.27	238	0.49±0.26	0.2225
75-79	320	0.49±0.25	272	0.43±0.26	0.005	459	0.47±0.26	133	0.43±0.25	0.1229
80+	277	0.40±0.23	197	0.35±0.24	0.0466	358	0.38±0.23	116	0.38±0.24	0.9445
BCVA										
50-54	531	0.95±0.22	547	0.95±0.20	0.7583	769	0.97±0.20	309	0.92±0.24	0.0005
55-59	630	0.93±0.21	555	0.93±0.20	0.8262	873	0.94±0.20	312	0.91±0.22	0.0276
60-64	706	0.87±0.24	597	0.84±0.27	0.0335	1048	0.87±0.25	255	0.81±0.28	0.0005
65-69	768	0.84±0.26	587	0.80±0.28	0.009	1089	0.84±0.26	266	0.75±0.28	< 0.0001
70-74	540	0.74±0.27	436	0.69±0.30	0.0032	769	0.74±0.29	207	0.64±0.28	< 0.0001
75-79	230	0.65±0.28	245	0.60±0.31	0.085	359	0.65±0.31	116	0.56±0.26	0.0066
80+	186	0.52±0.27	177	0.50±0.31	0.5614	269	0.53±0.30	94	0.47±0.26	0.0614

VA: Visual acuity; SD: Standard deviation; BCVA: Best corrected visual acuity. P-value represents the statistical significance of difference between rural and urban population; $^a P$-value represents the statistical significance of inland population and coastal population difference.

Correlation of VA with Refractive Error Presenting VA and BCVA were all significantly associated with refractive error (r=-0.20 and -0.27, P<0.001). Stratifying the whole FJES residents into rural residents group and urban residents group and inland residents group and coastal residents group showed similar results (urban group: r=-0.22 and -0.20, P<0.0001; rural group: r=-0.17 and -0.20, P<0.0001; coastal group: r=-0.17 and -0.22, P<0.0001; inland group: r=-0.27 and -0.13, P<0.0001). Correspondingly, BCVA was statistical significantly (P<0.0001) lower in the high myopia residents subgroup, excluding the high hyperopia residents subgroup [0.48 (0.33) *vs* 0.85 (0.25)], with a myopic ametropia exceeding -6.00 diopters, than in non-high myopia group. BCVA also decreased significantly with astigmatism (r=-0.27, P<0.0001). And Table 3 shows the difference among refraction groups in detail.

Correlation of VA with Education In the whole (r=0.15 and 0.22, P<0.0001), the same as in the rural residents subgroup (r=0.15 and 0.25, P<0.0001), urban residents subgroup (r=0.12 and 0.17, P<0.0001), inland residents subgroup (r=0.18 and 0.35, P<0.0001) and coastal residents subgroup (r=0.14 and 0.21, P<0.0001), both presenting VA and BCVA were significantly associated with education level. Since the urban residents group and inland residents group had a statistical significantly higher educational background than their corresponding groups (Table 1), all the residents were stratified into different subgroups according to the educational background. Figure 1 presents the difference among educational subgroups in detail.

Correlation of VA with Income According to the univariate analysis including the whole study population, presenting VA and BCVA were significantly (r=-0.15 and -0.16, P<0.0001) associated with income level. The whole study population was stratified, and the correlations of income level with presenting VA and BCVA were significant in the rural residents group (r=-0.17, P=0.0013; r=-0.22, P<0.0001) and the coastal residents group (r=-0.16, P=0.0001; r =-0.16, P<0.0001). The correlations with BCVA in the urban residents group (r=-0.10, P<0.0001) and inland residents group (r=-0.22, P<0.0001) were significant, whereas the correlations with presenting VA did not vary significantly in the urban residents group (r=-0.09, P=0.0867) and inland residents group (r=-0.12, P=0.1185). Figure 2 shows the difference among income subgroups in detail.

Correlation of VA with Sex and Eye Among the FJES participants, 8063 (98.2%, 8036 out of 8211) had VA test results, including 4776 female residents and 3287 male residents, and 6823 (83.1%, 6823 out of 8211) had BCVA test results, including 4257 female residents and 2566 male residents. In the univariate analyses, presenting VA and BCVA were not significantly different between males and females [0.61 (0.31) *vs* 0.60 (0.29), P=0.1151; 0.82 (0.29) *vs* 0.83 (0.27), P=0.3761]. Moreover, there were no statistically significant difference between right eye and the left eye in presenting VA and BCVA [0.61 (0.30) *vs* 0.61 (0.30), P=0.8625; 0.82 (0.28) *vs* 0.83 (0.28), P=0.4050].

Multiple Regression Analysis Because some of these parameters, such as age and refractive error, there was

Table 3 Visual acuity in refraction stratification subgroups in different regional residents groups in Fujian Eye Study

Refractive error (diopters) groups	Urban group		Rural group		*P*	Coastal group		Inland group		P^a
	Number	Mean±SD	Number	Mean±SD		Number	Mean±SD	Number	Mean±SD	
Presenting VA										
<-10.00	42	0.10±0.12	37	0.15±0.16	0.1466	56	0.13±0.15	23	0.12±0.12	0.8176
-10.00 to -6.00	64	0.27±0.27	33	0.34±0.31	0.2508	67	0.30±0.28	30	0.29±0.30	0.941
-6.00 to -3.00	161	0.35±0.31	118	0.40±0.32	0.2055	188	0.36±0.31	91	0.38±0.31	0.623
-3.00 to 0.00	668	0.48±0.28	491	0.44±0.28	0.0113	891	0.47±0.28	268	0.46±0.28	0.774
0.00	183	0.76±0.24	142	0.69±0.29	0.0286	248	0.74±0.26	77	0.70±0.27	0.3424
0.00 to +3.00	3140	0.70±0.26	2298	0.66±0.27	<0.0001	4357	0.68±0.27	1081	0.69±0.26	0.9402
+3.00 to +5.00	172	0.37±0.20	141	0.36±0.20	0.6429	251	0.36±0.19	62	0.39±0.23	0.3205
+5.00 to +10.00	24	0.32±0.22	19	0.39±0.30	0.36	35	0.36±0.26	8	0.32±0.23	0.6945
>+10.00	0	-	1	0.08	-	1	0.08	-	-	-
BCVA										
<-10.00	41	0.33±0.22	39	0.32±0.25	0.8145	55	0.30±0.21	25	0.39±0.28	0.0914
-10.00 to -6.00	58	0.61±0.33	34	0.60±0.35	0.8755	62	0.59±0.34	30	0.66±0.31	0.3064
-6.00 to -3.00	136	0.71±0.31	118	0.77±0.30	0.1616	164	0.72±0.30	90	0.78±0.31	0.1004
-3.00 to 0.00	511	0.81±0.28	467	0.79±0.31	0.305	724	0.80±0.29	254	0.79±0.29	0.437
0.00	143	0.91±0.21	126	0.86±0.26	0.0694	200	0.90±0.22	69	0.84±0.26	0.062
0.00 to +3.00	2424	0.89±0.22	2042	0.87±0.24	0.0085	3518	0.89±0.22	948	0.83±0.25	<0.0001
+3.00 to +5.00	135	0.71±0.29	130	0.76±0.26	0.118	208	0.77±0.27	57	0.60±0.27	<0.0001
+5.00 to +10.00	18	0.54±0.28	18	0.63±0.35	0.3885	28	0.63±0.32	8	0.44±0.28	0.1302
>+10.00	0	-	2	0.21±0.13	-	2	0.21±0.13	-	-	-

VA: Visual acuity; SD: Standard deviation; BCVA: Best corrected visual acuity; *P*-value represents the statistical significance of difference between rural and urban population; ^{a}*P*-value represents the statistical significance of inland population and coastal population difference.

statistical significantly (*P*<0.0001) association between them, so a multiple linear or logistic regression analysis was needed to be carried out. The common parameters of age, degree of urbanization (urban *vs* rural), geographic location (coastal *vs* inland), refraction, education and income were analyzed, and associations with presenting VA and BCVA were significant (*P*<0.0001) for age, educational background, degree of urbanization and refractive error. Consistent with previous results, sex (*P*=0.194) was not statistical significantly associated with BCVA; conversely, it (*P*<0.0001) was statistically associated with presenting VA. There was statistically significant difference in income (*P*=0.005) and geographic location (*P*=0.001) with BCVA, whereas they (*P*=0.355 and 0.216) were not significantly correlated with presenting VA.

DISCUSSION

With the increase in the aging population, VI and blindness have become major public health problems worldwide and can impact an individual's health and quality of life, as well as society[1]. Some previous studies reported the prevalence of VI and its correlations with various factors, for instance, age, ethnic background and general health, in northern China[5-6], eastern China[9], inland urban areas in southern China[16], and Taiwan[7]; and the present study aimed to assess VA and its demographic and ocular correlations among several subgroups in detail in the population for which data have not been reported thus far. BCVA was statistical significantly associated with some sociodemographic factors, such as age, educational background, degree of urbanization, and geographic location. Sex was not statistical significantly correlated with BCVA considering the interdependence of the parameters with each other. According to our results, residents over 75y and residents with refractive error between 0.00 to -3.00 diopters had better presenting VA in urban area, while had no difference with BCVA between rural and urban areas, which may suggest the lower glasses use in mild myopia and in rural area. Presenting VA did not vary significantly between inland and coastal groups and BCVA was better in coastal group with nearly all age groups and with refractive error between 0.00 to +3.00 (0.89±0.22 *vs* 0.83±0.25) and +3.00 to +5.00 (0.77±0.27 *vs* 0.60±0.27) groups, which may revealed that residents with mild and moderate hyperopia in coastal area had better medical conditions and higher operation rate of cataract and other eye diseases, and paid more attention to the improvement of visual function. Presenting VA did not vary significantly between rural and urban groups and BCVA was better in urban group with all four education level groups, which revealed that urban residents had better medical conditions and higher operation rate of cataract and other eye diseases. Residents with middle and above education level had better BCVA in coastal area, while had no difference with presenting VA between inland and

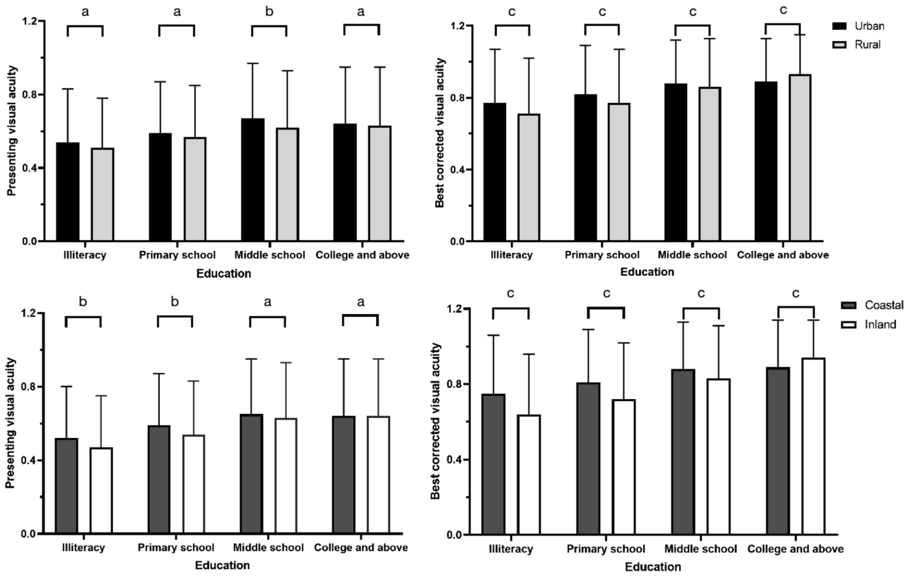

Figure 1 The comparisons of mean presenting VA and mean BCVA among different regional groups by education [a]P>0.05; [b]P<0.05; [c]P<0.001. VA: Visual acuity; BCVA: Best corrected visual acuity.

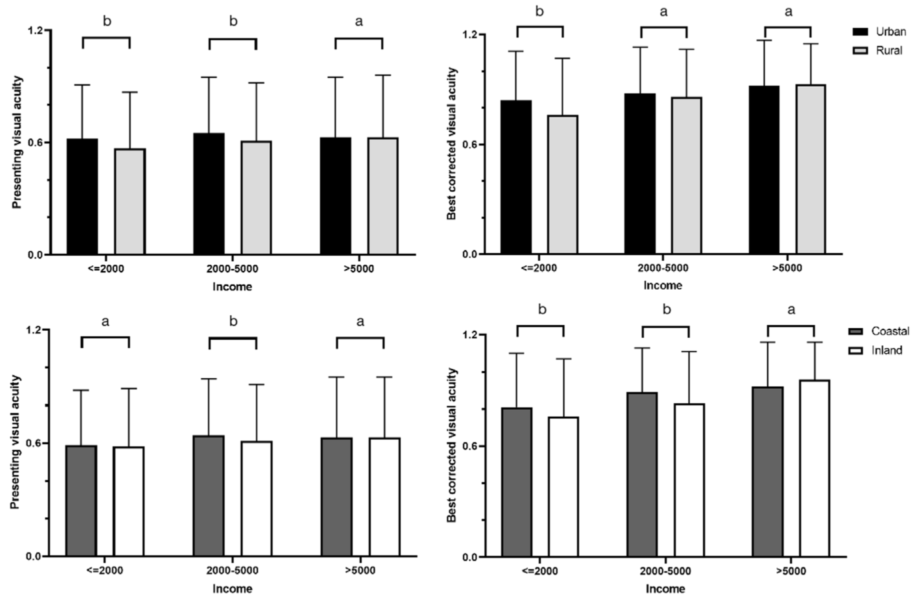

Figure 2 The comparisons of mean presenting VA and mean BCVA among different regional groups by income [a]P>0.05; [b]P<0.05; [c]P<0.001. VA: Visual acuity; BCVA: Best corrected visual acuity.

coastal areas. Residents with high income had no difference with presenting VA and BCVA between rural and urban and inland and coastal areas. All these results suggested residents with higher education level and higher income paid more attention to the improvement of visual function.

In the Shihpai Eye Study[7], also a population-based eye study, there was a statistically significant increase in the prevalence of low vision (P<0.001) from 0.83% among 65 to 69y age subgroup to 8.33% among 80y or older subgroup, and there was no statistically significant difference with gender in the rate of blindness or low vision. In the Beijing Eye Study[6], consistent with the FJES study on southern Chinese individuals, there was also no statistically significant difference with gender in VI prevalence. Interestingly, in a Russian Ural Eye and Medical Study[17], an increased prevalence of moderate-to-severe VI/blindness was associated with age, male sex and educational level. The Multi-Ethnic Study in White, Chinese, Black and Hispanic Participants showed that older age was statistical significantly correlated with VI in both women and men, especially in those with lower socioeconomic status (SES), while the influences of increasing age on men were more significant than that on women[18]. A national survey among Chinese adults found that older age, young or middle-age in males, old age in females, illiteracy, rural dwelling, non-eastern residency, single status, unemployment, and lower-income family status were associated with VI[19]. Our study found that there was no sex difference in BCVA; nevertheless, after age stratification, women over 65y were more likely to have VI than men.

However, controversial results also exist; for example, the Gutenberg Health Study (GHS) found that VA decreased statistically significant difference with age, was higher in men than in women, was lower in those with a low socio-economic status, and had multiple underlying ophthalmological pathologies. The prevalence of VI in the GHS study individuals was 0.37%, while the prevalence of blindness was 0.05%, which was lower than that in our study. This shows that medical conditions and demographic factors can have a great impact on VI[20]. The Brazilian Amazon Region Eye Survey showed that female sex, older age and a lower educational background were correlated with ≥6 lines of uncorrected VA impairment[21]. The Yazd Eye Study in Central Iran also found that VI was significantly associated with older age and female sex[22]. The Singapore Epidemiology of Eye Diseases Study found that female sex, older age, lower socioeconomic status (income and education), systemic comorbidities, diabetes and cognitive impairment were independently correlated with and increased risk of BCVA loss[8]. A study in Lodz, Poland, revealed that increasing age and female sex were independent risk factors for VI[23]. In the China Nine-Province Survey[9], VI and blindness were correlated with female sex, older age, geographic area (province), and lack of education for both BCVA and presenting VI. By comparison with a study in northern Chinese individuals in Beijing[6], and the Shihpai Eye Study[7], the present FJES study on southern Chinese residents in Fujian Province showed that VA did not differ by sex. Hashemi *et al*[24] reported that the major reason for the high VI prevalence in underserved Iranian villages was the lack of access to medical services. Refractive errors and cataract were responsible for nearly 80% of VI, which could be as a result of the cause of poverty in underserved villages. Our study demonstrated that age and refractive errors are the mainly risk factors of low vision.

Population-based studies around the world, such as the Beijing Eye Study[6,25], the Handan Eye Study[5,25], the Liwan Eye Study[16,26], the Russian Ural Eye and Medical Study[17], the Singapore Epidemiology of Eye Diseases (SEED) Study[27], the Global Burden of Disease Study[28], the Health ABC Study[29], the China Health and Retirement Longitudinal Study[30], the Shaanxi Eye Study[31], the National Eye Survey in Malaysia (NESII)[32], the Blue Mountains Eye Study[33], and the Chinese American Eye Study[34], have demonstrated that age is undoubtedly the most significant factor correlated with VI; however, associations of prevalence of low vision and unilateral blindness with age and other sociodemographic factors were not assessed in the rural and urban populations and the inland and coastal populations. Our research comprehensively analyzed the correlations between VA and a variety of sociodemographic factors at different levels.

In summary, our study integrated the results of life vision and corrected vision, and provided more comprehensive information for the summary of lens wearing rate and eye disease status. The present study revealed positive correlations between VA and a younger age, a higher educational level, a lower myopic refractive error, urban residency and coastal residency in southern Chinese individuals. Nearly 80% of Fujian Province are mountainous areas, with inconvenient transportation and limited economic and medical resources. In addition, the education level of rural women is generally low, as they are bound by traditional lifestyles, and their health literacy is poor. All of these factors may contribute to low vision. With large population, different geographical environment and aging problems in China, vision health still has a long way to go.

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REFERENCES

1 Leat SJ, Yakobchuk-Stanger C, Irving EL. Differential visual acuity - A new approach to measuring visual acuity. *J Optom* 2020;13(1):41-49.

2 Bourne RRA, Flaxman SR, Braithwaite T, *et al*. Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. *Lancet Glob Health* 2017;5(9):e888-e897.

3 West S, Sommer A. Prevention of blindness and priorities for the future. *Bull World Health Organ* 2001;79(3):244-248.

4 Wang W, Yan W, Müller A, Keel S, He MG. Association of socioeconomics with prevalence of visual impairment and blindness. *JAMA Ophthalmol* 2017;135(12):1295-1302.

5 Liang YB, Friedman DS, Wong TY, *et al*. Rationale, design, methodology, and baseline data of a population-based study in rural China: the Handan Eye Study. *Ophthalmic Epidemiol* 2009;16(2):115-127.

6 Xu L, Wang YX, Li YB, Wang Y, Cui TT, Li JJ, Jonas JB. Causes of blindness and visual impairment in urban and rural areas in Beijing: the Beijing Eye Study. *Ophthalmology* 2006;113(7):1134.e1-1134.11.

7 Hsu WM, Cheng CY, Liu JH, Tsai SY, Chou P. Prevalence and causes of visual impairment in an elderly Chinese population in Taiwan: the Shihpai Eye Study. *Ophthalmology* 2004;111(1):62-69.

8 Wong TY, Tham YC, Sabanayagam C, Cheng CY. Patterns and risk factor profiles of visual loss in a multiethnic Asian population: the Singapore epidemiology of eye diseases study. *Am J Ophthalmol* 2019;206:48-73.

9 Zhao JL, Xu X, Ellwein LB, *et al*. Prevalence of vision impairment in older adults in rural China in 2014 and comparisons with the 2006 China nine-Province survey. *Am J Ophthalmol* 2018;185:81-93.

10 Song PG, Wang H, Theodoratou E, Chan KY, Rudan I. The national and subnational prevalence of cataract and cataract blindness in China: a systematic review and meta-analysis. *J Glob Health* 2018;8(1):010804.

11 Jonas JB, Cheung CMG, Panda-Jonas S. Updates on the epidemiology of age-related macular degeneration. *Asia Pac J Ophthalmol* (*Phila*) 2017;6(6):493-497.

12 Li JQ, Welchowski T, Schmid M, Letow J, Wolpers C, Pascual-Camps I, Holz FG, Finger RP. Prevalence, incidence and future projection of diabetic eye disease in Europe: a systematic review and meta-analysis. *Eur J Epidemiol* 2020;35(1):11-23.

13 Thapa R, Bajimaya S, Paudyal G, Khanal S, Tan S, Thapa SS, van Rens G. Prevalence, pattern and risk factors of retinal vein occlusion in an elderly population in Nepal: the Bhaktapur retina study. *BMC Ophthalmol* 2017;17(1):162.

14 Delcourt C, le Goff M, von Hanno T, *et al*. The decreasing prevalence of nonrefractive visual impairment in older Europeans: a meta-analysis of published and unpublished data. *Ophthalmology* 2018;125(8): 1149-1159.

15 National Bureau of Statistics People's Republic of China. Major Figures of Annual Data of Fujian Province. https://data.stats.gov.cn/easyquery.htm?cn=E0103. Accessed on July 05, 2021.

16 He MG, Foster PJ, Ge J, Huang WY, Zheng YF, Friedman DS, Lee PS, Khaw PT. Prevalence and clinical characteristics of glaucoma in adult Chinese: a population-based study in Liwan District, Guangzhou. *Invest Ophthalmol Vis Sci* 2006;47(7):2782-2788.

17 Bikbov MM, Kazakbaeva GM, Zainullin RM, *et al*. Prevalence and causes of vision impairment and blindness in the Russian Ural eye and medical study. *Sci Rep* 2020;10(1):12397.

18 Fisher DE, Shrager S, Shea SJ, Burke GL, Klein R, Wong TY, Klein BE, Cotch MF. Visual impairment in white, Chinese, black, and hispanic participants from the multi-ethnic study of atherosclerosis cohort. *Ophthalmic Epidemiol* 2015;22(5):321-332.

19 Guo C, Wang ZJ, He P, Chen G, Zheng XY. Prevalence, causes and social factors of visual impairment among Chinese adults: based on a national survey. *Int J Environ Res Public Health* 2017;14(9):1034.

20 Wolfram C, Schuster AK, Elflein HM, Nickels S, Schulz A, Wild PS, Beutel ME, Blettner M, Münzel T, Lackner KJ, Pfeiffer N. The prevalence of visual impairment in the adult population. *Deutsches Arzteblatt Int* 2019;116(17):289-295.

21 Salomão SR, Berezovsky A, Furtado JM, *et al*. Vision status in older adults: the Brazilian Amazon region eye survey. *Sci Rep* 2018;8(1):886.

22 Katibeh M, Pakravan M, Yaseri M, Pakbin M, Soleimanizad R. Prevalence and causes of visual impairment and blindness in central Iran; the Yazd eye study. *J Ophthalmic Vis Res* 2015;10(3):279-285.

23 Nowak MS, Smigielski J. The prevalence and causes of visual impairment and blindness among older adults in the city of Lodz, Poland. *Medicine* (*Baltimore*) 2015;94(5):e505.

24 Hashemi H, Yekta A, Jafarzadehpur E, Doostdar A, Ostadimoghaddam H, Khabazkhoob M. The prevalence of visual impairment and blindness in underserved rural areas: a crucial issue for future. *Eye* (*Lond*) 2017;31(8):1221-1228.

25 Wu J, Ji QQ, Lin CX, Du YF, Li JY, Cao K, Wang NL, the Handan Eye Study Group and the Beijing Eye Study Group. Burden of visual impairment in mainland China: the Handan Eye Study and Beijing Eye Study. *Graefes Arch Clin Exp Ophthalmol* 2021;259(11):3501-3509.

26 Wang LH, Zhu ZT, Scheetz J, He MG. Visual impairment and ten-year mortality: the Liwan Eye Study. *Eye (Lond)* 2021;35(8):2173-2179.

27 Poh S, Tham YC, Chee ML, Dai W, Majithia S, Soh ZD, Fenwick EK, Tao YJ, Thakur S, Rim TH, Sabanayagam C, Cheng CY. Association between macular thickness profiles and visual function in healthy eyes: the Singapore epidemiology of eye diseases (SEED) study. *Sci Rep* 2020;10(1):6142.

28 GBD 2019 Blindness and Vision Impairment Collaborators; Vision Loss Expert Group of the Global Burden of Disease Study. Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: the Right to Sight: an analysis for the Global Burden of Disease Study. *Lancet Glob Health*. 2021 Feb;9(2):e144-e160.

29 Swenor BK, Wang JX, Varadaraj V, Rosano C, Yaffe K, Albert M, Simonsick EM. Vision impairment and cognitive outcomes in older adults: the health ABC study. *J Gerontol A Biol Sci Med Sci* 2019;74(9):1454-1460.

30 Cao GY, Yao SS, Wang KP, Han L, Chen ZS, Huang ZT, Zhang Q, Wang CX, Hu YH, Xu BB. Vision impairment, vision correction, and cognitive decline among middle-aged and older Chinese: results from the China health and retirement longitudinal study. *Aging Ment Heal* 2021;25(11):2028-2035.

31 He Y, Nie AP, Pei JZ, Ji Z, Jia J, Liu HF, Wan PF, Ji ML, Zhang CT, Zhu YN, Wang X. Prevalence and causes of visual impairment in population more than 50 years old. *Medicine* 2020;99(20): e20109.

32 Chew FLM, Salowi MA, Mustari Z, Husni MA, Hussein E, Adnan TH, Ngah NF, Limburg H, Goh PP. Estimates of visual impairment and its causes from the National Eye Survey in Malaysia (NESII). *PLoS One* 2018;13(6):e0198799.

33 Wang JJ, Foran S, Mitchell P. Age-specific prevalence and causes of bilateral and unilateral visual impairment in older Australians: the Blue Mountains Eye Study. *Clin Exp Ophthalmol* 2000;28(4):268-273.

34 Burkemper B, Torres M, Jiang XJ, Mckean-Cowdin R, Varma R. Factors associated with visual impairment in Chinese American adults: the Chinese American eye study. *Ophthalmic Epidemiol* 2019;26(5):329-335.