

Visual Impairment and Spectacle Use in University Students in Central China: The Anyang University Students Eye Study



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- **PURPOSE:** To investigate the prevalence and associations of visual impairment and spectacle use in university students in central China.
- **DESIGN:** Cross-sectional study.
- **METHODS:** This study included students aged 16–26 years in China. Study subjects from 2 universities underwent distance visual acuity (VA) assessment in both eyes with a logarithm of the minimum angle of resolution chart and their refractions were measured by cycloplegic autorefraction. Blindness was defined as presenting VA less than three-sixtieth in the better eye (World Health Organization definition), and visual impairment was defined as presenting VA less than six-twelfths.
- **RESULTS:** Overall, 9710 undergraduates were enumerated, 7704 (79.3%) subjects were included in this study. The prevalence of uncorrected VA less than six-twelfths and less than three-sixtieth in the better eye were 69.9% and 0.9%, respectively. Only 77.0% (4148/5388) of subjects with uncorrected VA in the better eye of less than six-twelfths wore glasses. For presenting VA, the prevalence of mild (VA < 6/12 to 6/18), moderate (VA < 6/18 to 6/60), and severe (VA < 6/60 to 3/60) visual impairment was 6.3%, 11.2%, and 0.7%, respectively. Overall, 71.7% (4300/6001) of students with myopia (spherical equivalent ≤ -0.5 diopters) wore spectacles. In multiple logistic regression analysis, visual impairment was associated with female sex ($P < .001$) and lower year level of education ($P = .006$) when presenting with VA.
- **CONCLUSIONS:** This study has documented a relatively high prevalence of visual impairment and relatively low spectacle coverage in Chinese university students. Given the potential impact of visual impairment, target education and accessible refraction services are highly important to

solve the problem. (*Am J Ophthalmol* 2019;206:168–175. © 2019 Elsevier Inc. All rights reserved.)

VISUAL IMPAIRMENT REMAINS A MAJOR PUBLIC health, social, and economic problem worldwide.^{1,2} In 2010, a report by the World Health Organization (WHO) estimated that 285 million people are affected by visual impairment worldwide, of whom 39 million are blind.³ Uncorrected refractive errors, which was included as 1 of the 5 priorities of the WHO in the global initiative for the elimination of avoidable visual impairment and blindness, constitute the leading cause of visual impairment globally.³ Importantly, as the prevalence of myopia in the young generation in East and Southeast Asia rapidly increases,^{4,5} myopic refractive error has become the major cause of correctable visual impairment.^{6,7} Wearing spectacles remains an easy, safe, and effective modality to correct refractive errors worldwide.

The effects of visual impairment and blindness caused by uncorrected refractive error are numerous, with reduced quality of life, loss of economic productivity, and restricted educational and employment opportunities as examples, leading to social and economic effects on individuals and communities.^{8–10} Global estimates released by the WHO revealed that the global economic productivity loss associated with visual impairment from uncorrected refractive error was \$268.8 billion after adjustment for country-specific labor force participation and employment rates.⁹ Therefore, epidemiologic data on the prevalence and associated factors of visual impairment and patterns of spectacle use are necessary for effectively planning screening programs and primary eye care interventions. The China Nine-Province Survey, examining the prevalence of visual impairment and blindness in 45 747 persons aged ≥ 50 years in rural populations in China, found that 10.8% of people had visual impairment (visual acuity [VA] < 20/63 to $\geq 20/400$ in the better eye) and 2.29% had blindness (< 20/400).¹¹ As part of the Refractive Error Study in Children, an evaluation of refractive error and visual impairment in Guangzhou demonstrated that the prevalence of a presenting VA of twenty-fortieth or worse in the better eye was 10.3% and only two-thirds of those children wore corrective spectacles.¹²

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Although numerous population- and school-based cross-sectional studies on visual impairment in mainland China have been performed,¹¹⁻¹⁸ there are no data specific to young adults. A review emphasized the need for epidemiologic studies that identify eye disease in this important and overlooked group.¹⁹ Even if results from university students may not generally apply to young adults of the same age, research focusing on college students is needed. Because highly educated university students have been shown to be at particular risk of myopia, studies are needed to define the extent of visual impairment and spectacle use in this population. A prevalence of 83.2% for myopia and 11.1% for high myopia was reported for central Chinese university students.²⁰ Furthermore, future leaders among various fields will tend to be drawn from this highly myopic group; thus, the problem of visual impairment and blindness is particularly important. To address the need for data characterizing the nature and magnitude of visual impairment, it is highly important to perform a well-designed epidemiology study of visual impairment and spectacle use among Chinese university students.

To the best of our knowledge, this is the first well-designed and large-scale study with comprehensive ophthalmologic examinations to provide visual impairment and spectacle use data among university students in mainland China. In this study, we aimed to report the prevalence of visual impairment and spectacle use, as well as the potential impact of demographic factors.

METHODS

- **STUDY POPULATION:** Ethics committee approval was obtained from the institutional review board of Beijing Tongren Hospital, Capital Medical University. All participants signed written informed consent before participating in the study according to the Declaration of Helsinki.

The Anyang University Students Eye Study (AUSES) is a university-based, cross-sectional study with comprehensive ophthalmologic examinations among university students in Anyang, Henan Province, central China. The detailed sample selection and methods have been described previously.²⁰ In brief, participants were selected using random cluster sampling on the basis of grade levels from 2 universities in Anyang, namely Anyang Normal University and Anyang Institute of Technology, both of which are multidisciplinary universities with undergraduate and graduate degree programs across various disciplines, including economics, computing, engineering, foreign languages, chemistry, and art. Subjects underwent examinations during September 2016–June 2017 at their respective school clinics.

- **SAMPLE SIZE:** The sample size of AUSES was calculated by using the prevalence of myopia in Chinese university students. On the basis of results from recent surveys in

Donghua University in Shanghai, the prevalence of myopia and high myopia in Chinese university students were 95.5% and 19.5%, respectively.²¹ We assumed a design effect of 2.0, a tolerated error of $0.1 \times$ (incidence of myopia or high myopia), and response rate of 80%. The sample size requirement was 3965 in the AUSES. However, because the researchers in the aforementioned study in Donghua University (Shanghai, China) used noncycloplegic refraction, they might have overestimated the prevalence of myopia,²²⁻²⁴ possibly leading to an underestimation of the necessary sample size. Excluding students in their final-year internships, ~30 000 undergraduates studied on-campus. Thus, we aimed to recruit one-third of all on-campus students at both universities.²⁰ With enumeration of grade-specific classes, the sampling frame was constructed. Each class represented a sampling frame cluster. Accordingly, one-third of all classes from each grade level were selected. Ultimately, a total of 9710 undergraduates were enumerated to participate in our study.

PROCEDURES

AT THE SCHOOL CLINICS, STUDENTS UNDERWENT A comprehensive, standardized examination procedure, including a detailed questionnaire; assessment of distant VA, dominant eye, intraocular pressure, accommodative response, refraction both before and after cycloplegia, ocular biometry, vertometer testing, digital fundus photography, and optical coherence tomography.

Distance VA was measured by using a logarithm of the minimum angle of resolution (logMAR) chart (Precision Vision, La Salle, Illinois, USA) at a distance of 4 meters and at 1 meter for those who could not read any letters at 4 meters. Students were tested monocularly with the right eye followed by the left eye. Students were notified in advance to bring their glasses when they visited the ophthalmic examination site. Subjects from both universities underwent examination of presenting corrected VA (if spectacles were worn) at first followed by uncorrected VA.

Cycloplegia was induced with a drop of 1% cyclopentolate (Alcon, Fort Worth, Texas, USA), followed by a drop of 0.5% tropicamide (Mydrin P, Santen Pharmaceutical Co, Ltd, Shiga, Japan) and a second drop of 1% cyclopentolate at a 5-minute interval. If pupillary light reflex was still present or the pupil size was <6.0 mm 30 minutes after the last drop, a third drop of 1% cyclopentolate was administered, and the examination was repeated after 15 minutes. Cycloplegic refraction was measured by using an autorefractor (HRK7000 A, Huvitz, Gunpo, South Korea) 3 times consecutively, with the average data used for analysis. All 3 readings needed to be at most 0.50 diopters (D) apart in both the spherical and cylinder components, otherwise the measurements were repeated.

• **DEFINITIONS:** In this study, we used the WHO categories of blindness and severe visual impairment. In addition, a category of mild and moderate visual impairment was defined as suggested by recent studies and for comparison with other surveys.^{11,14,25,26} Visual impairment was defined as follows: mild visual impairment was a presenting VA of less than six-twelfths to six-eightieths in the better eye, moderate visual impairment was a presenting VA of less than six-eightieths to six-sixtieths in the better eye, severe visual impairment was a presenting VA of less than six-sixtieths to three-sixtieths in the better eye, and blindness was a presenting VA of less than three-sixtieths in the better eye. Anyone with a presenting VA less than six-twelfths was classified as visually impaired.

The spherical equivalent (SE) was calculated by using the standard formula of the algebraic sum of the dioptric powers of the sphere and half of the cylinder (sphere + 0.5 × cylinder). Refractive errors were defined on the basis of cycloplegic refraction data of the right eye. Refractive errors were defined by SEs. Myopia and hyperopia were defined as an SE ≤ -0.5 D and ≥ +2.0 D in both eyes, respectively. Astigmatism was defined as an SE ≤ -1.0 D of cylinder in both eyes.

• **DATA MANAGEMENT AND STATISTICAL ANALYSIS:** All examination data were independently entered twice into a database with Epidata software 3.1 (The Epidata Association, Odense, Denmark) by 2 trained data entry clerks. When there were discrepancies between the database entries, the raw data were checked. SAS software (version 9.4, SAS Inc, Cary, North Carolina, USA) was used for cleaning, logically checking, merging, and analyzing data. Continuous variables were presented as mean ± SD. We used χ^2 tests to compare categorical variables between groups. An independent *t* test was used to compare the mean VA between male and female subjects. We employed multivariate logistic regression analysis using a stepwise backward method to explore factors associated with visual impairment and spectacle use. Age, sex, grade, region, and discipline prevalence estimates of visual impairment and spectacle use were calculated and analyzed. Odds ratios (ORs) and 95% confidence intervals (CIs) were presented. A 2-sided *P* value < .05 was considered statistically significant.

RESULTS

OF 9710 UNIVERSITY STUDENTS SELECTED, 7971 STUDENTS UNDERWENT our examinations (response rate 82.1%); among whom, 178 refused cycloplegia and 17 were excluded because of a lack of VA data. Furthermore, as students aged 16, 25, and 26 years only totaled to a sample size of 72, they were also excluded from the study population. Finally, 7704 (79.3%) subjects were included. The mean age of all subjects was 20.2 ± 1.43 (SD) years. Table 1 presents a distribution and comparison of age, sex, year level (year at university),

TABLE 1. Comparison of Subjects Included in and Excluded From Data Analyses by Age, Sex, Year Level, Region, and Discipline

Variable	Included n (%)	Excluded n (%)	<i>P</i> Value ^a
Age (y)			.086 ^b
16	—	11 (4.1)	
17	53 (0.7)	5 (1.9)	
18	781 (10.1)	20 (7.5)	
19	1991 (25.8)	52 (19.5)	
20	2031 (26.4)	58 (21.7)	
21	1451 (18.8)	28 (10.5)	
22	911 (11.8)	20 (7.5)	
23	352 (4.6)	9 (3.4)	
24	134 (1.7)	3 (1.1)	
25	—	36 (13.5)	
26	—	25 (9.4)	
Sex			.065
Male	2834 (36.8)	113 (42.3)	
Female	4870 (63.2)	154 (57.7)	
Year level			.073
Year 1	3688 (47.9)	114 (42.7)	
Year 2	2345 (30.4)	80 (30.0)	
Year 3	1671 (21.7)	73 (27.3)	
Region			.248
Urban	3019 (39.2)	114 (42.7)	
Rural	4685 (60.8)	153 (57.3)	
Discipline			.098
Liberal arts	4456 (57.8)	168 (62.9)	
Science and engineering	3248 (42.2)	99 (37.1)	
All	7704 (100.0)	267 (100.0)	

^a χ^2 test.
^bOnly for those aged 17–24 years.

region, and discipline between included and excluded subjects, with no significant differences between them for these demographic parameters (*P* > .05 for all).

Large correlation coefficients for VA were observed between the 2 eyes (*r* = 0.815). The mean ± SD uncorrected VA of the right and left eye were 0.69 ± 0.42 logMAR and 0.63 ± 0.43 logMAR, respectively. For presenting VA, these values were 0.23 ± 0.29 logMAR and 0.19 ± 0.28 logMAR, respectively. Table 2 shows the distribution of uncorrected and presenting VA. Uncorrected VA less than six-twelfths in the better eye was found in 5388 of 7704 (69.9%) students; 70 of these students (0.9%) were blind. However, presenting VA less than six-twelfths in the better eye was found in 1407 (18.3%) students, with no students presenting blindness. Uncorrected VA differed between male and female subjects. Male subjects had significantly better uncorrected VA than female subjects in both eyes (*P* < .001). This trend was also observed for presenting VA in both eyes (*P* < .001).

TABLE 2. Distribution of Uncorrected and Presenting VA and Percentage Wearing Glasses

VA category	Uncorrected VAVA No.; % (95% CI)	Wearing glasses No.; % (95% CI) ^a	Presenting VA No.; % (95% CI)
≥6/12 in better eye	2316; 30.1 (29.0–31.1)	201; 8.7 (7.5–9.8)	6297; 81.7 (80.9–82.6)
<6/12 to 6/18 in better eye	607; 7.9 (7.3–8.5)	258; 42.5 (38.6–46.4)	487; 6.3 (5.8–6.9)
<6/18 to 6/60 in better eye	3772; 49.0 (47.8–50.1)	2936; 77.8 (76.5–79.2)	865; 11.2 (10.5–11.9)
<6/60 to 3/60 in better eye	939; 12.2 (11.5–12.9)	884; 94.1 (92.6–95.6)	55; 0.7 (0.5–0.9)
<3/60 in better eye	70; 0.9 (0.7–1.1)	70; 100.0	0; 0 (0)
All	7704; 100.0	4349; 56.5 (55.3–57.6)	7704; 100.0

VA = visual acuity.

^aPercentage among those with corresponding uncorrected VA.**TABLE 3.** Visual Acuity in Right Eyes by Spherical Equivalent on the Basis of Cycloplegic Refraction

Refractive errors	No.	Uncorrected Visual Acuity	
		LogMAR (Mean ± SD)	Snellen Equivalent
Hyperopia (D)t			
≥+2.0	71	0.24 ± 0.27 ^a	20/35
Emmetropia (D)			
>–0.5 to <+2.0	1224	0.02 ± 0.13	20/20
Myopia (D)			
>–1.0 to ≤–0.5	486	0.27 ± 0.17 ^a	20/35
>–1.5 to ≤–1.0	473	0.43 ± 0.17 ^a	20/55
>–2.0 to ≤–1.5	531	0.60 ± 0.17 ^a	20/80
>–2.5 to ≤–2.0	598	0.68 ± 0.18 ^a	20/100
>–3.0 to ≤–2.5	593	0.78 ± 0.18 ^a	20/120
>–3.5 to ≤–3.0	599	0.84 ± 0.21 ^a	20/140
>–4.0 to ≤–3.5	547	0.93 ± 0.21 ^a	20/170
>–4.5 to ≤–4.0	521	0.97 ± 0.21 ^a	20/185
>–5.0 to ≤–4.5	506	1.00 ± 0.22 ^a	20/200
≤–5.0	1555	1.10 ± 0.23 ^a	20/250

D = diopter; LogMAR = logarithm of the minimum angle of resolution.

^a*P* < .001 (compared with students with emmetropia).

Table 3 shows the mean uncorrected VA of the right eye for different categories of SE on the basis of cycloplegic refraction. Students with myopia or hyperopia had significantly lower mean uncorrected VAs than those with emmetropia (*P* < .001). Students with myopic SEs of ≤–1.0 D, –1.5 D, and ≤–5.0 D had mean uncorrected VAs of less than six-twelfths, six-eightieths, and six-sixtieths, respectively.

Using the presenting VA of the better eye, the overall prevalence of mild, moderate, and severe visual impairment was 6.3% (95% CI 5.8%–6.9%), 11.2% (95% CI 10.5%–11.9%), and 0.7% (95% CI 0.5%–0.9%), respectively. However, no subject presented blindness according to presenting VA. Of 1407 students presenting VAs less

than six-twelfths, 1372 (97.5%) had myopia, 9 (0.6%) had hyperopia, and 218 (15.6%) had astigmatism (alone or in combination with other refractive errors). Overall, 98.2% of students had refractive errors. The prevalence of visual impairment stratified by age, sex, year level, region, and discipline is shown in Table 4. In our multiple logistic regression analysis controlling for all variables, visual impairment was significantly associated with female sex (OR 1.446, 95% CI 1.262–1.658; *P* < .001) and lower year level of education (OR 0.878, 95% CI 0.799–0.964; *P* = .006), while age (*P* = .287), region of habitation (*P* = .315), and discipline (*P* = .167) were not significantly associated.

Overall, the prevalence of spectacle wear was 56.5% in this study. Moreover, 5674 of 7704 students (73.6%) reported they had spectacles, but only 4349 of 5674 (76.6%) wore their spectacles for the examination. Only 77.0% (4148/5388) of subjects with uncorrected VAs less than six-twelfths in the better eye wore glasses (Table 5). Overall, 71.7% of students with myopia wore spectacles, as did 20.0% of the students with hyperopia and 71.7% of the students with astigmatism (alone or in combination with other refractive errors). In our multiple logistic regression analysis adjusting for uncorrected VA, among subjects whose uncorrected VA was less than six-twelfths in the better eye, wearing spectacles was significantly associated with male sex (OR 1.456, 95% CI 1.235–1.717; *P* < .001) and higher year level of education (OR 1.144, 95% CI 1.021–1.281; *P* = .021), while age (*P* = .243), region of habitation (*P* = .786), and discipline (*P* = .077) were not significantly associated.

DISCUSSION

THIS IS THE FIRST STUDY TO PROVIDE LARGE-SCALE REPRESENTATIVE DATA ON THE PREVALENCE AND ASSOCIATIONS OF VISUAL IMPAIRMENT AND SPECTACLE USE IN UNIVERSITY STUDENTS IN MAINLAND CHINA. Although the prevalence of myopia is extremely high among university students in mainland

TABLE 4. The Prevalence of Visual Impairment Stratified by Age, Sex, Year Level, Region, and Discipline

Variable	No.	Visual Impairment		
		Mild No.; % (95% CI)	Moderate No.; % (95% CI)	Severe No.; % (95% CI)
Age (y)				
17	53	6; 11.3 (2.5–20.1)	4; 7.5 (0.2–14.9)	1; 1.9 (0–5.7)
18	781	45; 5.8 (4.1–7.4)	91; 11.9 (9.4–13.9)	5; 0.6 (0.1–1.2)
19	1991	129; 6.5 (5.4–7.6)	229; 11.5 (10.1–12.9)	14; 0.7 (0.3–1.1)
20	2031	126; 6.2 (5.2–7.3)	235; 11.6 (10.2–13.0)	16; 0.8 (0.4–1.2)
21	1451	97; 6.7 (5.4–8.0)	174; 12.0 (10.3–13.7)	8; 0.6 (0.2–0.9)
22	911	51; 5.6 (4.1–7.1)	86; 9.4 (7.5–11.3)	6; 0.7 (0.1–1.2)
23	352	23; 6.5 (3.9–9.1)	34; 9.7 (6.6–12.8)	5; 1.4 (0.2–2.7)
24	134	10; 7.5 (3.0–12.0)	12; 9.0 (4.1–13.9)	0; –
Sex				
Male	2834	159; 5.6 (4.8–6.5)	249; 8.8 (7.7–9.8)	9; 0.3 (0.1–0.5)
Female	4870	328; 6.7 (6.0–7.4)	616; 12.6 (11.7–13.6)	46; 0.9 (0.7–1.2)
Year level				
Year 1	3688	228; 6.2 (5.4–7.0)	453; 12.3 (11.2–13.3)	29; 0.8 (0.5–1.1)
Year 2	2345	150; 6.4 (5.4–7.4)	252; 10.7 (9.5–12.0)	12; 0.5 (0.2–0.8)
Year 3	1671	109; 6.5 (5.3–7.7)	160; 9.6 (8.2–11.0)	14; 0.8 (0.4–1.3)
Region				
Urban	3019	178; 5.9 (5.1–6.7)	326; 10.8 (9.7–11.9)	22; 0.7 (0.4–1.0)
Rural	4685	309; 6.6 (5.9–7.3)	539; 11.5 (10.6–12.4)	33; 0.7 (0.5–0.9)
Discipline				
Liberal art	4456	310; 7.0 (6.2–7.7)	529; 11.9 (10.9–12.8)	36; 0.8 (0.5–1.1)
Science and engineering	3248	177; 5.4 (4.7–6.2)	336; 10.3 (9.3–11.4)	19; 0.6 (0.3–0.8)
All	7704	487; 6.3 (5.8–6.9)	865; 11.2 (10.5–11.9)	55; 0.7 (0.5–0.9)

China,^{20,21} there are no epidemiologic data on the level of visual impairment and blindness. We discovered that the prevalence of bilateral visual impairment on the basis of presenting VA was 18.3%, and only 77.0% of subjects with bilateral uncorrected VAs less than six-twelfths wore glasses. Of the 1407 (18.3%) students with presenting VAs less than six-twelfths, 98.2% had refractive errors.

Comparing our findings with those of population-based studies of adults conducted in China reveals some important differences. The prevalence of low vision (presenting VA <6/18 to 3/60) found here was higher than the prevalence estimates reported in previous surveys, such as the Nine-Province Survey (10.8% in adults aged ≥50 years),¹¹ Handan Eye Study (4.7% in adults aged ≥30 years),¹⁷ study in the Baoshan District of Shanghai (8.82% in adults aged ≥60 years),¹⁴ and the study in Inner Mongolia (9.8% in adults aged ≥40 years).²⁷ We hypothesize that this may be due to the higher prevalence of refractive errors in our subjects. Although, some previous studies found a higher prevalence of low vision than ours, such as the study in Shunyi County (18.2% in subjects aged >50 years)²⁸ and Doumen County (19.9% in subjects aged >50 years),²⁹ these studies were conducted in rural China 20 years ago. At that time, relatively underdeveloped public healthcare systems and primary eye care may explain the higher prevalence of low vision. However, unlike the adult studies above, we

did not find blindness in our research. Of the 70 university students with blindness defined as uncorrected VA less than three-sixtieth in our study, all of them wore their spectacles for the examination, and thus, no individual belonged in the category of blindness on the basis of presenting VA. In addition, university students need to live independently on campus. Any students presenting uncorrectable blindness would likely have previously attended a special school before going to college.

Compared with another university-based study conducted in Ghana, the prevalence of bilateral visual impairment (presenting VA in the better eye ≤6/12) was reported as 3.08%,³⁰ which is much lower than that reported in our study. The prevalence of visual impairment in our study was also higher than that reported in population-based studies, including studies of young adults in Asia, such as India (0.8% in subjects aged 20–29 years)³¹ and Malaysia (1.38% in subjects aged 20–29 years).³² Although differences in demographic and socioeconomic characteristics may contribute to this variation, we suspect it was mostly caused by the extremely high prevalence of myopia among university students in mainland China. The Chinese Ministry of Education has released statistical reports on higher education that show the number of university students in China reached 26 million in 2018. In view of the high prevalence of myopia and the large number of college students,

TABLE 5. Characteristics of Subjects with Uncorrected Visual Acuties in the Better Eye of Less Than Six-twelfths Wearing and Not Wearing Spectacles

Variable	Wearing Spectacles No.; % (95% CI)	Not Wearing Spectacles No.; % (95% CI)
Age (y)		
17	29; 74.4 (60.0–88.7)	10; 25.6 (11.3–40.0)
18	425; 77.1 (73.6–80.7)	126; 22.9 (19.3–26.4)
19	1088; 77.0 (74.8–79.2)	325; 23.0 (20.8–25.2)
20	1097; 76.6 (74.4–78.8)	335; 23.4 (21.2–25.6)
21	789; 76.7 (74.1–79.3)	240; 23.3 (20.7–25.9)
22	471; 78.6 (75.3–81.9)	128; 21.4 (18.1–24.7)
23	177; 75.6 (70.1–81.2)	57; 24.4 (18.8–29.9)
24	72; 79.1 (70.6–87.6)	19; 20.9 (12.4–29.4)
Sex		
Male	1486; 80.2 (78.3–82.0)	368; 19.8 (18.0–21.7)
Female	2662; 75.3 (73.9–76.7)	872; 24.7 (23.3–26.1)
Year level		
Year 1	1950; 75.4 (73.7–77.0)	637; 24.6 (23.0–26.3)
Year 2	1326; 78.9 (76.9–80.8)	355; 21.1 (19.2–23.1)
Year 3	872; 77.9 (75.4–80.3)	248; 22.1 (19.7–24.6)
Region		
Urban	1619; 77.8 (76.1–79.6)	461; 22.2 (20.4–23.9)
Rural	2529; 76.5 (75.0–77.9)	779; 23.5 (22.1–25.0)
Discipline		
Liberal arts	2364; 75.6 (74.0–77.1)	765; 24.4 (22.9–26.0)
Science and engineering	1784; 79.0 (77.3–80.7)	475; 21.0 (19.3–22.7)
All	4148; 77.0 (75.9–78.1)	1240; 23.0 (21.9–24.1)

the visual impairment of college students deserves special attention.

As found in other studies,^{14,26,33} our study observed that visual impairment was significantly associated with female sex. This may be predominantly explained by the higher prevalence of myopia in female subjects than in male subjects in our study. Like many previous studies that reported that the region of habitation was not significantly related to visual impairment in their multivariate analysis model,^{26,34} our study also did not find any association. Although university students come from different regions, they all have a high level of education. Furthermore, they have the same access to public eye health care at the university, and thus, there may be no difference between regions. Previous studies have shown that the prevalence of visual impairment was significantly associated with older age,^{14,26,34} whereas we did not find this association. We hypothesized that this is due to the narrow age range and cohort differences within our study, which were difficult to pick up over short time frames. However, we found that visual impairment was associated with lower year level of education. This finding may be due to university students relying on themselves for daily activities and having a relatively higher demand for quality of life. Students

acquired glasses as they reached the university. This trend can be found in Table 5.

Spectacles are the easiest, most common, and most effective method to correct refractive errors worldwide. Data on spectacle use among university students in mainland China are scarce. Our study found that the rate of spectacle use was 56.5% in a group of Chinese university students. This rate of spectacle use is higher than those reported in a sample of suburban Chinese adults aged ≥ 60 years (44.1%)¹⁴ and a population-based sample of Indian adults aged ≥ 40 years (29.5%).³⁵ It is also higher than the rates reported for urban and rural Chinese children (8.1%)³⁴ and school children in Northern Ireland (25.0%).³⁶ The extraordinarily high prevalence of myopia among university students in mainland China (83.2%) may almost entirely explain this difference.²⁰

Among subjects in Anyang with uncorrected VAs less than six-twelfths in the better eye, 77.0% wore spectacles. This reported value is higher than that reported for school children in China.^{12,13,16,37} The mistaken belief of some parents that spectacles may lead to progression of refractive error and weaken the eyes may explain the lower rate of spectacles use among Chinese children.^{16,38,39} Unlike school children, university students have a high level of education and have a better understanding through their learning. Furthermore, they rely on themselves for daily activities and have a relatively higher demand for quality of life, therefore having a higher need for spectacles. However, 23.0% of university students with VAs less than six-twelfths in the better eye did not wear spectacles. Thus, public health and eye care services, as well as low cost and high-quality spectacles, are needed for university students. Among subjects with uncorrected VAs in the better eye of less than six-twelfths, wearing spectacles was significantly associated with male sex and higher year level of education. Therefore, eye care services should pay more attention to females and lower year level of university students.

Although a higher prevalence of myopia was found among science and engineering students in the present study,²⁰ liberal art students had a significantly higher risk of visual impairment than both science and engineering students. This inconsistency may be explained by the finding that spectacle use was significantly higher among science and engineering students. These data might be useful for providing targeted eye care services, such as the provision of spectacles, if resources for all students are limited.

Potential limitations of this study include the lack of data on the best-corrected VA. On the basis of presenting VA, students with less than six-twelfths vision were suggested to visit the local eye hospital for special examinations. However, we did not collect the results of those students. Therefore, we cannot assess the percentage of persons with VAs less than six-twelfths that could be corrected with refraction and benefit by wearing glasses. He and associates found that 1364 children (aged 5–15 years) had

uncorrected VAs of equal to or less than twenty-fortieths in at least 1 eye, and 1272 (93.3%) achieved VAs equal to or greater than twenty–thirty-seconds in both eyes with refractive correction in southern China.¹² Wu and associates found that 2046 children (aged 4–18 years) in East China with uncorrected VAs equal to or less than twenty-fortieths in 1 or both eyes, and 1975 (96.6%) children attained VAs equal to or greater than twenty–thirty-seconds by providing adequate correction of refractive error.⁴⁰ In another university-based study conducted in Ghana, researchers found refractive error (96.2%) to be the most common cause of bilateral visual impairment (presenting VA in the better eye $\leq 6/12$).³⁰ In these above studies, >90% of the persons with uncorrected VAs less than six-twelfths could be corrected with refraction in children and adolescents. In our study, most of the students who had uncorrected VAs less than six-twelfths and did not wear glasses (23.0%) could have their vision corrected

with refraction. Our data can be used to provide information to target education and accessible refraction services to university students. This study was conducted as a university-based investigation, rather than as a population-based investigation. Thus, the prevalence of visual impairment and spectacle use may be overestimated if these results are applied to young adults in China in general. This is because university students have higher levels of myopia than their peers who did not pursue higher education. This study only provides the first large cross-sectional data on the prevalence of visual impairment and spectacle use in university students in mainland China.

In conclusion, this survey provided valuable findings on the prevalence of visual impairment and spectacle use in Chinese university students. On the basis of the information from this study, planning eye care services for refractive error correction can be established for this vulnerable group.

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