

# Prevalence and Determinants of Spectacle Nonwear Among Rural Chinese Secondary Schoolchildren

## *The Xichang Pediatric Refractive Error Study Report 3*

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**Objective:** To study spectacle wear among rural Chinese children.

**Methods:** Visual acuity, refraction, spectacle wear, and visual function were measured.

**Results:** Among 1892 subjects (84.7% of the sample), the mean (SD) age was 14.7 (0.8) years. Among 948 children (50.1%) potentially benefiting from spectacle wear, 368 (38.8%) did not own them. Among 580 children owning spectacles, 17.9% did not wear them at school. Among 476 children wearing spectacles, 25.0% had prescriptions that could not improve their visual acuity to better than 6/12. Therefore, 62.3% (591 of 948) of children needing spectacles did not benefit from appropriate correction. Children not owning and not wearing spectacles had better self-reported vi-

sual function but worse visual acuity at initial examination than children wearing spectacles and had a mean (SD) refractive error of  $-2.06$  (1.15) diopter (D) and  $-2.78$  (1.32) D, respectively. Girls ( $P < .001$ ) and older children ( $P = .03$ ) were more likely to be wearing their spectacles. A common reason for nonwear (17.0%) was the belief that spectacles weaken the eyes. Among children without spectacles, 79.3% said their families would pay for them (mean, US \$15).

**Conclusions:** Although half of the children could benefit from spectacle wear, 62.3% were not wearing appropriate correction. These children have significant uncorrected refractive errors. There is potential to support programs through spectacle sales.

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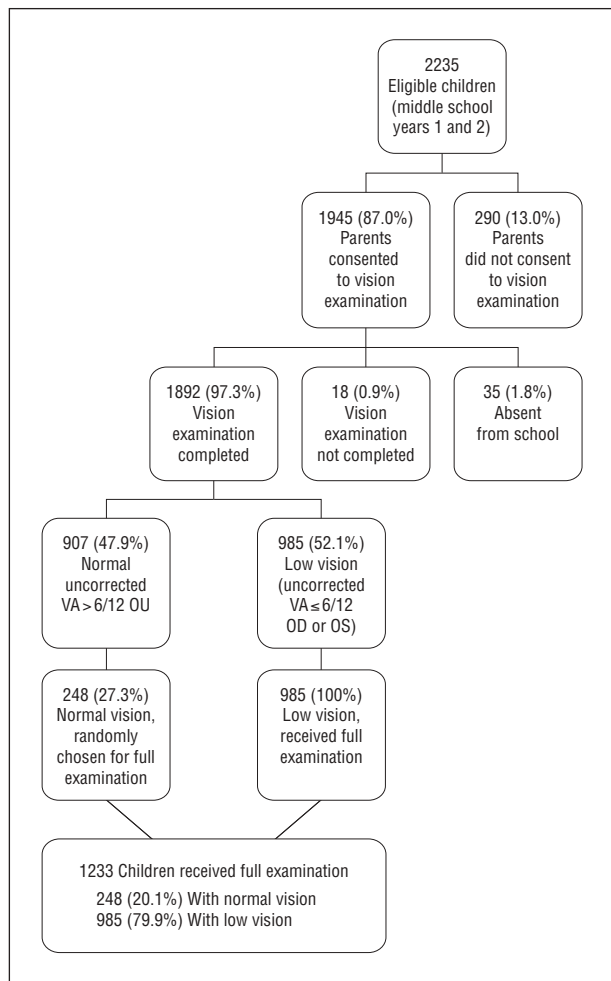
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UNCORRECTED REFRACTIVE error has been identified as the leading cause of visual disability among school-aged Asian,<sup>1-4</sup> Hispanic,<sup>5</sup> and European populations.<sup>6</sup> Inclusion of uncorrected refractive error would increase estimates of the worldwide prevalence of visual impairment by 61%.<sup>7</sup> Refractive error is the most easily remediated cause of vision loss: spectacles are inexpensive, noninvasive, and effective. However, this simple solution has not been effectively applied in many parts of the world, with school-aged children bearing significant visual burden.

Lack of access to accurate spectacles is an important cause of uncorrected refractive error in many areas. However, it has been shown that, even when spectacles are provided free, they are worn by fewer than 1 in 6 children and are available for use at school in less than half of cases.<sup>8</sup> Older urban children, precisely those at greatest risk for myopia, are least likely to wear their spectacles and are more likely to be concerned about their appearance and about being teased.<sup>8</sup>

Few large school-based<sup>9</sup> or population-based<sup>10</sup> studies have reported on patterns of directly observed spectacle wear, and none (to our knowledge) have examined risk factors or reasons for spectacle nonwear. A better understanding of these factors will be a critical first step in combating the leading cause of childhood visual disability.

The Xichang Pediatric Refractive Error Study (X-PRES) is a school-based examination of refractive error prevalence and patterns of spectacle wear among 1900 children in junior middle school years 1 and 2 (age range, 13-17 years) in rural China. The reported prevalence of myopia among Chinese children is one of the highest in the world.<sup>2-4,11,12</sup> Because of compulsory education in this age range, the sample is likely representative of the local population. The present study provides data on (1) the proportions of spectacle ownership and wear among children with uncorrected visual acuity (VA) worse than 6/12 OD or OS and who could achieve normal VA with spectacle wear, (2) the proportion of spectacle wearers who have accurate correction, and (3) risk factors for



**Figure 1.** Flowchart showing the recruitment of rural Chinese secondary schoolchildren into the Xichang Pediatric Refractive Error Study.

nonownership and nonwearing of spectacles and for wearing of inaccurate spectacles.

## METHODS

The methods of the X-PRES have been reported in detail elsewhere.<sup>13</sup> Xichang is a rural village with a population of 109 673 (2002 census<sup>14</sup>) located in eastern Guangdong Province, People's Republic of China. The population depends largely on agriculture and farming, including the cultivation of fruit trees, ducks, and fish. The mean income in 2004 for agricultural workers in Jiedong County, to which Xichang belongs, was 4120 renminbi (RMB) (US \$572),<sup>15</sup> compared with 18 864 RMB (US \$2620) for Guangdong Province as a whole in the same year.<sup>16</sup> Eye services are provided through a freestanding eye clinic associated with the government-run medical clinic and supported by the Caring Is Hip program of the Li Kai Shing Foundation. Spectacles and refractive services are available for purchase at the clinic and at private optical shops in the village, although there are no local programs providing free spectacles. Annual government vision screening is provided in schools, but the effect of the program is undercut by its low specificity (<30%).<sup>17</sup> Secondary school enrollment has been reported at greater than 91% for nearby areas of rural Guangdong Province.<sup>18</sup>

A school-based survey of refractive error and spectacle use was administered in Xichang from May 1, 2007, through July 15, 2007, as preparation for a program to increase spectacle wear

among children with myopia in the region. The protocol was approved by the ethics committee at the Joint Shantou International Eye Center, the parent hospital for the Xichang Eye Clinic. Informed consent was obtained from parents of all participating children, and the principles of the Declaration of Helsinki were followed throughout the study.

## PARTICIPANTS

Cluster-based random sampling was used to select 2235 children in middle school years 1 and 2 from all 3 middle schools in Xichang. Thirty-five classes were selected at random from 55 eligible classes at the 3 schools, with a mean class size of approximately 60 to 70 children. Parents of all children in selected classes were sent invitation letters explaining the objective and methods of the study. Parents were asked to return forms indicating whether they were willing for their children to participate in the study.

## ASSESSMENT OF VISION

Uncorrected VA and VA wearing habitual refraction, if available, were measured by trained study personnel in well-lit areas during daylight hours at a distance of 6 m separately for each eye of each child. Children who did not have their spectacles at school were asked to bring them for vision assessment on another day. Identical illuminated tumbling E Snellen charts (Shantou City Medical Equipment Ltd, Shantou, People's Republic of China) were used for all testing. The nontested eye was covered by the subject using a handheld occluder, with proper occlusion and neutral head position monitored by the examiner. The right eye was tested first. A single optotype of each size was presented first, starting at 6/30. If a letter was failed, testing began 2 lines above, with the child being asked to read all optotypes on the line sequentially. A subject had to identify correctly more than half of the letters on a given line (eg, 3 of 5 or 4 of 6) to be considered as having that level of VA.

## BASIC QUESTIONNAIRE

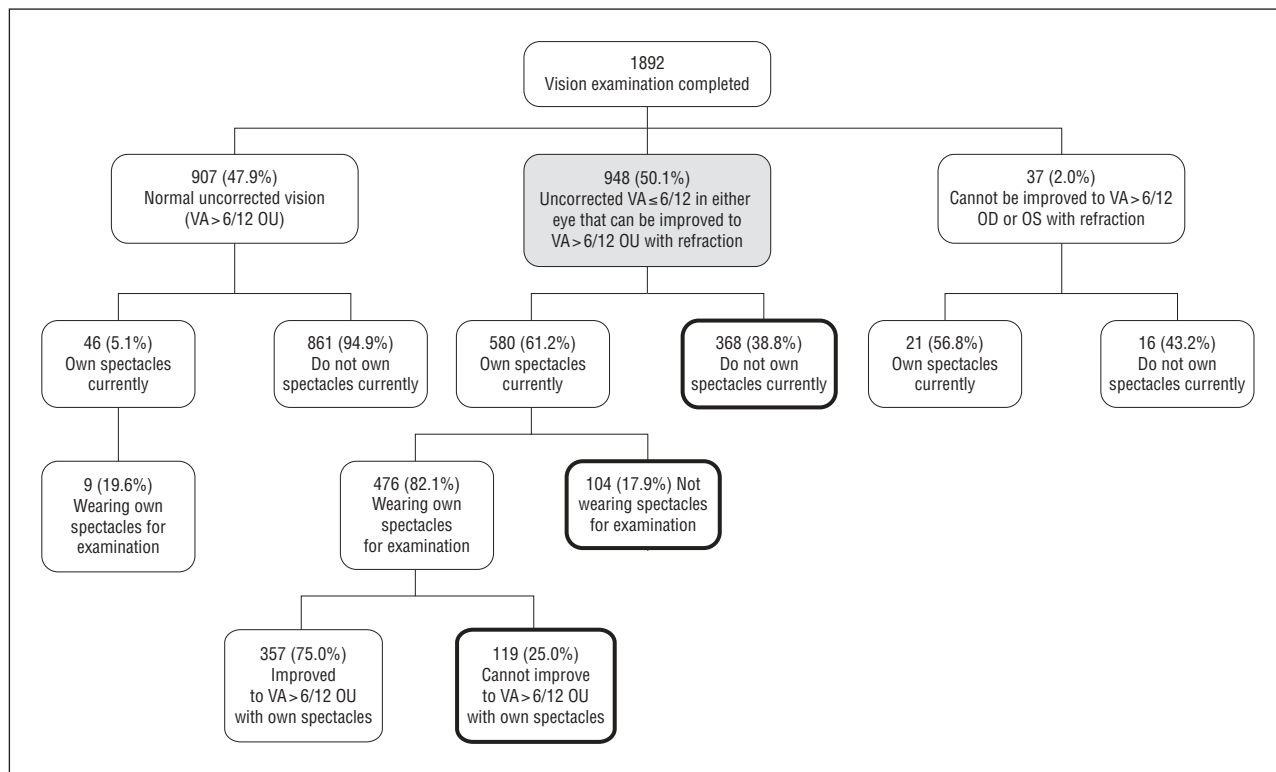
All 1892 study subjects (**Figure 1**) were given a basic self-administered questionnaire by study personnel before being told the results of their vision assessment. The basic questionnaire included questions about age, sex, parental education, history of spectacle wear, single most important reason for spectacle nonwear, and willingness to pay for spectacles (using a "bidding format").<sup>19</sup>

The basic questionnaire included a Chinese translation of an instrument developed originally by Fletcher et al<sup>20</sup> to assess self-reported visual function (VF) in rural Asia. This instrument has previously been validated for use in Chinese<sup>21,22</sup> and is described elsewhere in detail.<sup>20</sup>

Briefly, the VF questionnaire assesses overall vision, visual perception, limitation in daily activities, peripheral vision, near vision, sensory adaptation, light-dark adaptation, visual search, color discrimination, glare disability, and depth perception. The questionnaire can be administered in 5 to 10 minutes. The overall VF scale score ranged from 0 (worst) to 100 (best).<sup>20</sup> Because none of the activities described in the questionnaire were age specific, it was unnecessary to modify the original questionnaire for use in children.

## DETAILED EXAMINATION

All subjects with uncorrected VA of 6/12 or worse OD or OS (n=985) and a 25% random sample of subjects with VA better than 6/12 OU (n=248) (**Figure 1**) underwent a detailed examination consisting of the following elements: (1) cycloplegia with cyclopentolate hydrochloride (Cyclogyl; Alcon Laboratories Inc, Fort Worth,



**Figure 2.** Flowchart showing ownership, wear, and accuracy of spectacles among rural Chinese secondary schoolchildren in the Xichang Pediatric Refractive Error Study. The box indicating 948 children with refractive error correctable by spectacles is highlighted in gray; the boxes indicating children who did not own or wear spectacles or who had inaccurate spectacles are indicated by black borders.

Texas), 1%, and tropicamide (Mydriacyl; Alcon Laboratories Inc), 1%, 1 drop each every 5 minutes for a total of 3 drops of each medication, followed by autorefractometry in each eye (RK-F1 refractometer/keratometer; Canon, Inc, Tochigi, Japan) with refinement by an ophthalmologist; (2) measurement of current spectacles (if worn) by an ophthalmologist; and (3) slitlamp (YZ5F1; Suzhou Liuliu, Suzhou, People's Republic of China) examination of the anterior and posterior segments by an ophthalmologist.

### STATISTICAL ANALYSIS

Raw data are given as mean (SD) or as frequency (percentage), as appropriate. Vision expressed as the minimum angle of resolution (the decimal equivalent of the Snellen fraction) was minus logarithm transformed to correct its skewness before statistical analysis, although the untransformed numbers are given in the tables for clarity. All univariate comparisons were made using *t* test, Pearson product moment correlation  $\chi^2$  test, or Fisher exact test. Analysis of variance trend test was used to assess linear trends of data across the 3 groups of self-reported spectacle wear status (answering yes, occasionally, or no). Logistic regression analysis was used to assess potential factors associated with ownership and wearing of spectacles. All statistical analyses were performed using commercially available software (SPSS 14.0; SPSS Inc, Chicago, Illinois). All statistical tests were 2-sided;  $P < .05$  was considered statistically significant.

### RESULTS

There were 2235 children in the sample. Parental permission was granted for 1945 children (88.5% of returned forms, 87.0% of the sample), and 1892 of these (97.3% of consenting children, 84.7% of the sample) were exam-

ined (Figure 1). Among participating children, 1233 subjects underwent a more detailed examination that included refraction; 985 (79.9%) were children who had failed vision screening (uncorrected VA,  $\leq 6/12$  OD or OS), and 248 (20.1%) were children with normal VA in both eyes selected as part of a planned 25% random sample (which ultimately included 26.9% of children with normal VA).

The mean (SD) age of all 1892 examined children was 14.7 (0.8) years (age range, 11.4-17.1 years), 51.2% were female, and 26.4% were wearing spectacles. The mean (SD) self-reported VF of children failing screening (67.8 [15.9]) was significantly worse than that for children with normal VA (84.7 [11.3]) ( $P < .001$ ).

Among 985 children failing vision screening, 948 (96.2%) had VA that could be improved to better than 6/12 OU with refraction. These children, 50.1% of the examined sample, had vision deficits that could benefit from spectacle wear and form the basis of the remaining analyses (Figure 2).

Among these 948 children who could benefit from spectacle wear, 368 (38.8%) indicated that they did not currently own them (Figure 2). Among 580 children owning spectacles, 104 (17.9%) could not present them at school, despite attempted reexamination at a later date. Among 476 children wearing spectacles, 119 (25.0%) had correction that could not improve their VA to better than 6/12 OU. Therefore, 62.3% (591 of 948 [indicated by bold-faced boxes in Figure 2]) of children whose VA could be improved to better than 6/12 (or  $>20/40$  Snellen VA) OU with refraction did not own or were not wearing spectacles or were wearing inaccurate correction.

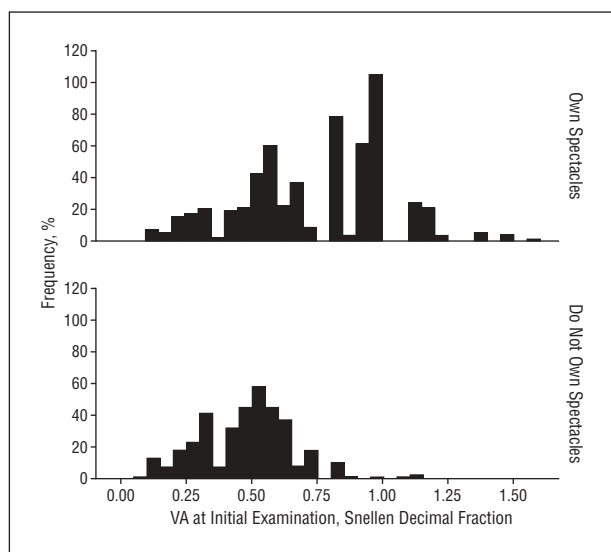
**Table 1. Characteristics of 948 Rural Chinese Secondary Schoolchildren With Uncorrected Visual Acuity (VA) Worse Than 6/12 in at Least 1 Eye and Whose Vision Can Be Improved With Spectacle Wear**

Variable	Own Spectacles			Wear Spectacles			Current Spectacles Do Not Improve Vision <sup>a</sup>		
	No (n=368)	Yes (n=580)	P Value	No (n=104)	Yes (n=476)	P Value	No (n=119)	Yes (n=357)	P Value
Age, mean (SD), y	14.68 (0.81)	14.70 (0.81)	.64	14.58 (0.79)	14.73 (0.82)	.10	14.62 (0.78)	14.76 (0.82)	.10
Sex, No. (%)									
Male	159 (43.2)	226 (39.0)	.20	62 (59.6)	164 (34.5)	<.001	33 (27.7)	131 (36.7)	.08
Female	209 (56.8)	354 (61.0)		42 (40.4)	312 (65.5)		86 (72.3)	226 (63.3)	
Educational level of parents, No. (%)									
≤Primary	78 (21.2)	143 (24.7)	.33	28 (26.9)	115 (24.2)	.55	28 (23.5)	87 (24.4)	.76
Junior school	179 (48.6)	247 (42.6)		46 (44.2)	201 (42.2)		50 (42.0)	151 (42.3)	
High school	107 (29.1)	183 (31.6)		30 (28.8)	153 (32.1)		38 (31.9)	115 (32.2)	
≥College	4 (1.1)	7 (1.2)		0	7 (1.5)		3 (2.5)	4 (1.1)	
Visual function, mean (SD)	75.2 (13.6)	63.5 (15.6)	<.001	66.5 (13.9)	62.8 (15.8)	.03	59.7 (14.9)	63.9 (16.0)	.01
VA at initial examination, mean (SD) <sup>b</sup>	0.47 (0.18)	0.74 (0.28)	<.001	0.37 (0.16)	0.82 (0.24)	<.001	0.52 (0.12)	0.92 (0.18)	<.001
Uncorrected VA, mean (SD) <sup>b</sup>	0.47 (0.18)	0.27 (0.14)	<.001	0.37 (0.16)	0.25 (0.12)	<.001	0.19 (0.08)	0.27 (0.12)	<.001
Spherical equivalent, mean (SD), D <sup>b,c</sup>	-2.06 (1.15)	-3.41 (1.48)	<.001	-2.78 (1.32)	-3.55 (1.47)	<.001	-4.42 (1.56)	-3.26 (1.32)	<.001

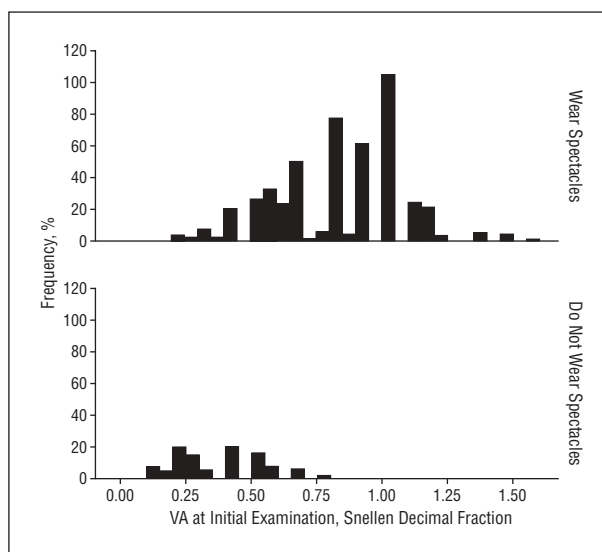
<sup>a</sup>To better than 6/12 OU.

<sup>b</sup>Mean of the 2 eyes; VA is expressed as the minimum angle of resolution (ie, the decimal equivalent of the Snellen fraction) for ease of interpretation, although the logarithm of this value is used for statistical calculations.

<sup>c</sup>Unavailable for 1 child with full examination.



**Figure 3.** Distribution of visual acuity (VA) at initial examination (mean of the 2 eyes, expressed as the minimum angle of resolution [ie, the decimal equivalent of the Snellen fraction]) among rural Chinese secondary schoolchildren owning (n=580) and not owning (n=368) spectacles among those who would benefit in either eye from spectacle wear.



**Figure 4.** Distribution of visual acuity (VA) at initial examination (mean of the 2 eyes, expressed as the minimum angle of resolution [ie, the decimal equivalent of the Snellen fraction]) among rural Chinese secondary schoolchildren wearing (n=476) and not wearing (n=104) spectacles among children who owned them at the time of examination (n=580).

Among 948 children with poor uncorrected VA that could improve with refraction, those who did not own spectacles had significantly better self-reported VF but significantly worse VA at initial examination than children who owned spectacles (**Table 1**). Uncorrected VA was better and the refractive error less myopic among the spectacle nonwearers, although their mean refractive error was still in excess of 2 diopter (D) of myopia, and their mean uncorrected VA was worse than 6/12. **Figure 3** shows the distribution of VA at initial examination among children owning and not owning spectacles.

Among 580 children with poor uncorrected VA who owned spectacles, girls were significantly more likely to

wear them than were boys (**Table 1**). Among nonwearers of spectacles compared with wearers, self-reported VF was higher, but VA at initial examination was lower. Uncorrected VA was significantly better and the refractive error less myopic among spectacle nonwearers, although their mean refractive error was still almost -3.0 D, and their mean uncorrected VA was worse than 6/15. **Figure 4** shows the distribution of VA at initial examination among children owning but not wearing spectacles.

Children wearing inaccurate spectacles had worse VF, worse VA at initial examination and worse uncorrected VA, and more myopic refractive error than children wearing accurate spectacles (**Table 1**). The mean VA at ini-

**Table 2. Ownership of Spectacles and Potential Predictors Among 948 Rural Chinese Secondary Schoolchildren With Uncorrected Visual Acuity (VA) of 6/12 or Worse OD or OS Whose VA Can Be Improved to Better Than 6/12 OU**

Variable	Own Spectacles		Univariate Model		Multivariate Model	
	No (n=368)	Yes (n=580)	Odds Ratio	P Value	Adjusted Odds Ratio (95% Confidence Interval) <sup>a</sup>	P Value
Age, mean (SD), y	14.68 (0.81)	14.70 (0.81)	1.04	.64	1.05 (0.86-1.28)	.62
Sex, No. (%)						
Male <sup>b</sup>	159 (41.3)	226 (58.7)	1 [Reference]		1 [Reference]	
Female	209 (37.1)	354 (62.9)	1.19	.20	1.19 (0.87-1.64)	.25
Visual function, mean (SD)	75.19 (13.56)	63.49 (15.56)	0.95	<.001	0.97 (0.96-0.98)	<.001
Uncorrected VA, mean (SD) <sup>c,d</sup>	0.47 (0.18)	0.27 (0.14)	1.77	<.001	1.43 (1.29-1.59)	<.001
Best-corrected VA, mean (SD) <sup>c,d</sup>	1.08 (0.14)	1.05 (0.13)	1.44	.004	0.82 (0.61-1.12)	.21
Spherical equivalent, mean (SD), D <sup>c</sup>	-2.06 (1.15)	-3.41 (1.48)	0.42	<.001	0.67 (0.57-0.80)	<.001

<sup>a</sup>Adjusted for other factors in logistic regression model.

<sup>b</sup>Reference group for comparisons.

<sup>c</sup>Mean of the 2 eyes; VA is expressed as the minimum angle of resolution (ie, the decimal equivalent of the Snellen fraction) for ease of interpretation, although the logarithm of this value is used for statistical calculations.

<sup>d</sup>Odds ratio per 0.1-U increase in logarithm of the minimum angle of resolution.

**Table 3. Wearing of Spectacles and Potential Predictors Among 580 Rural Chinese Secondary Schoolchildren Whose Visual Acuity (VA) Can Be Improved to Better Than 6/12 OU and Who Own Spectacles**

Variable	Wear Spectacles		Univariate Model		Multivariate Model	
	No (n=104)	Yes (n=476)	Odds Ratio	P Value	Adjusted Odds Ratio (95% Confidence Interval) <sup>a</sup>	P Value
Age, mean (SD), y	14.58 (0.79)	14.73 (0.82)	1.25	.10	1.39 (1.04-1.86)	.03
Sex, No. (%)						
Male <sup>b</sup>	62 (27.4)	164 (72.6)	1 [Reference]		1 [Reference]	
Female	42 (11.9)	312 (88.1)	2.81	<.001	2.82 (1.77-4.51)	<.001
Visual function, mean (SD)	66.52 (13.92)	62.83 (15.84)	0.98	.03	1.00 (0.98-1.02)	.91
Uncorrected VA, mean (SD) <sup>c,d</sup>	0.37 (0.16)	0.25 (0.12)	1.52	<.001	1.46 (1.26-1.69)	<.001
Best-corrected VA, mean (SD) <sup>c,d</sup>	1.06 (0.13)	1.05 (0.12)	1.05	.81	0.81 (0.53-1.25)	.35
Spherical equivalent, mean (SD), D <sup>c</sup>	-2.78 (1.32)	-3.55 (1.47)	0.66	<.001	0.89 (0.72-1.09)	.25

<sup>a</sup>Adjusted for other factors in logistic regression model.

<sup>b</sup>Reference group for comparisons.

<sup>c</sup>Mean of the 2 eyes; VA is expressed as the minimum angle of resolution (ie, the decimal equivalent of the Snellen fraction) for ease of interpretation, although the logarithm of this value is used for statistical calculations.

<sup>d</sup>Odds ratio per 0.1-U increase in logarithm of the minimum angle of resolution.

tial examination among the children with inaccurate spectacles was approximately 6/12.

In models of spectacle ownership and wear among children potentially benefiting from spectacles, lower self-reported VF, worse uncorrected VA, and more myopic spherical equivalent refraction were predictive of owning spectacles (**Table 2** and **Table 3**), and older age, female sex, and worse uncorrected VA were associated with spectacle wear among those who owned them (**Table 4**). Best-corrected VA was not predictive of spectacle wear or ownership.

In addition to observed spectacle wear, data were collected about children's self-reported frequency of wearing spectacles and reasons for nonwear. Decreasing frequency of self-reported spectacle wear was associated with increasing self-reported VF, worse VA at initial examination, better uncorrected VA, and less myopic refractive error ( $P < .001$ , test for trend) (Table 4). However, children reporting that they "sometimes" wore spectacles still had a mean spherical equivalent of almost -3 D and a mean uncorrected VA worse than 6/15.

The most common reasons for nonwearing of spectacles, accounting for almost three-fourths of nonwear-

ers, were "Wear only when needed or on special occasions" and "Worried spectacles will make eyes weak." These findings are summarized in Table 4.

Among all children participating in the study, 85.2% (1612 of 1892) indicated that their families would be willing to pay something for spectacles if needed. Although children already owning spectacles were significantly ( $P < .001$ ) more willing to pay for them, 79.3% (292 of 368) of children who would benefit from but did not own spectacles were willing to pay something. Among children willing to pay for spectacles, the mean amount was US \$15, with the following groups willing to pay significantly more: those already owning spectacles ( $P < .001$ ), wearers whose VA was improved with spectacles ( $P = .04$ ), and those whose parents had at least a high school education ( $P < .001$ ).

#### COMMENT

Although half of the middle school children in this rural Chinese setting could benefit from refraction, almost two-thirds of these did not own or wear spectacles or had inaccurate correction. This is similar to the proportion of

**Table 4. Self-reported Spectacle Wear Among 687 Rural Chinese Secondary Schoolchildren Who Indicated That They Had Ever Worn Spectacles and Reasons for Nonwear Among 389 Children Who Admitted to at Least Occasionally Not Wearing Spectacles**

Variable	No. (%)	Visual Function, Mean (SD)	VA at Initial Examination, Mean (SD) <sup>a</sup>	Uncorrected VA, Mean (SD) <sup>a</sup>	Spherical Equivalent, Mean (SD), D <sup>a</sup>
Self-reported spectacle wear					
Yes	298 (43.4)	61.2 (16.1)	0.78 (0.27)	0.25 (0.15)	-3.82 (1.86)
Occasionally <sup>b</sup>	349 (50.8)	66.2 (15.1)	0.72 (0.31)	0.37 (0.24)	-2.94 (1.73)
No	40 (5.8)	71.4 (16.0)	0.63 (0.41)	0.63 (0.41)	-2.51 (2.38)
Reasons for spectacle nonwear among those reporting at least occasionally not wearing spectacles	389 (56.6) <sup>c</sup>	66.7 (15.2)	0.71 (0.32)	0.40 (0.27)	-2.90 (1.80)
Do not need spectacles, do not help	28 (7.4)	70.9 (14.9)	0.75 (0.43)	0.73 (0.43)	-3.18 (3.62)
Broke or lost spectacles	20 (5.3)	63.8 (15.1)	0.54 (0.39)	0.35 (0.23)	-3.22 (1.81)
Headache or other symptoms	24 (6.4)	72.1 (12.4)	0.77 (0.33)	0.53 (0.36)	-2.58 (2.34)
Teased or embarrassed about spectacles	12 (3.2)	61.3 (13.2)	0.77 (0.35)	0.45 (0.38)	-1.91 (2.59)
Wear only when needed or on special occasions	211 (56.1)	66.4 (15.5)	0.73 (0.30)	0.35 (0.21)	-3.02 (1.60)
Worried spectacles will make eyes weak	64 (17.0)	65.8 (14.6)	0.66 (0.30)	0.35 (0.21)	-2.82 (1.38)
Forgot spectacles	14 (3.7)	72.7 (16.3)	0.64 (0.31)	0.51 (0.30)	-1.99 (0.92)
Other	3 (0.8)	76.9 (11.8)	0.43 (0.14)	0.43 (0.14)	-1.17 (1.52)

Abbreviation: VA, visual acuity.

<sup>a</sup>Mean of the 2 eyes; VA is expressed as the minimum angle of resolution (ie, the decimal equivalent of the Snellen fraction) for ease of interpretation, although the logarithm of this value is used for statistical calculations.

<sup>b</sup> $P < .001$ , test for trend among the 3 groups according to spectacle wear status.

<sup>c</sup>Missing for 13 subjects.

60% without necessary spectacles reported by He et al.<sup>11</sup> Data from urban regions of China further underscore the widespread nature of the problem.<sup>23</sup>

Children who did not own or wear spectacles had better self-reported VF but worse VA at initial examination than children who owned and wore spectacles. It is not surprising that children who have a better estimate of their vision are less likely to wear spectacles. However, the visual deficits among these children were significant. The mean refractive error and uncorrected VA of children not wearing or owning spectacles were 2 to 3 D of myopia and 6/12 to 6/15 or worse, respectively. More significant visual deficits are present among many children (Figures 3 and 4). This is particularly concerning in light of recent evidence that correction of modest amounts of myopia is associated with significant improvement in VF.<sup>24</sup>

Girls owning spectacles in the present study were significantly more likely to wear them than were boys, even when adjusting for the higher myopia prevalence among female students. However, girls still had significantly worse VA at initial examination than boys in this population. From the standpoint of improving the vision of children in this rural Chinese setting, it would seem that interventions might concentrate even further on improved wearing of spectacles among girls.

With regard to other program strategies, improving vision among children with inaccurate spectacles should be simple in that these children have already demonstrated a willingness to wear spectacles and manifest an awareness of their vision deficit in their poorer self-reported VF (Table 1). Improving vision among non-owners and nonwearers of spectacles may be more challenging. Despite their significant visual and refractive deficits in many cases and their worse mean VA at initial examination, these children as a whole consider themselves as having better VF than their spectacle-owning and spectacle-wearing peers.

Self-reported and observed spectacle wear and ownership in this population seem to be driven largely by uncorrected VA (Tables 2 through 4). Best-corrected VA is not a significant predictor of spectacle ownership or wear in this population (Tables 2 and 3). In effect, children seem not to be motivated by potential improvements in VA. This is perhaps not surprising; 50.1% of those whose vision could benefit from spectacles (Figure 2) did not own them ( $n=368$ ) or had inaccurate correction ( $n=119$ ) and were unaware of what their best-corrected VA might be. If outreach efforts demonstrated directly to children what their corrected VA could be, it is possible that spectacle wear might be improved. If children currently not owning spectacles could be persuaded to obtain and wear accurate correction at the 82.1% rate of current owners in this population, the proportion of children achieving full benefit from refractive correction might be almost doubled, from 37.2% to 69.5%. The fact that more than 79.3% of children would be willing to pay for spectacles, at a mean figure of US \$15, suggests that such programs might be self-supporting.

An important cause of spectacle nonwear that is potentially amenable to educational strategies is the belief that spectacles weaken the eyes. In fact, available evidence suggests that reducing or delaying spectacle wear is not successful in reducing myopia progression.<sup>25</sup>

Even among children wearing accurate spectacles, the mean (SD) VF (63.9 [16.0]) was significantly worse than that for children with normal uncorrected VA (84.7 [11.3]) ( $P < .001$ ). Children owning spectacles were instructed to answer the VF questions on the basis of their corrected VA, which for these children was between 6/6 and 6/7.5. Self-reported VF in the school setting may be sensitive to modest decrements in vision, consistent with reports that spectacle correction of vision in the 6/7.5 to 6/9 range significantly improves children's VF.<sup>24</sup> Alternatively, it is possible that subtle distortions not readily

measurable by Snellen charts (such as micropsia introduced by myopic correction) influenced subject responses. Vision-related quality of life with refractive surgery has been reported to exceed that with spectacles.<sup>26</sup> More studies are needed to better understand the phenomenon of poor self-reported VF among spectacle-wearing children with good corrected VA, as well as its implications for programs aimed at improving vision through enhanced spectacle wear.

The results of the X-PRES must be understood in the context of its limitations. Although 87.0% of the subjects in our sample were examined, parental consent could not be obtained for 13.0% of students, and we could not obtain even demographic information about these children. Therefore, we cannot exclude the possibility that unexamined children differed in important ways from those who elected to participate. Our sample was school based rather than population based. School attendance is compulsory for children in this age range, and findings from nearby areas of rural Guangdong Province indicate that secondary school enrollment rates exceed 91%.<sup>18</sup> Still, our results must be applied with caution to the local population, let alone the population of rural China.

It was impractical in this setting to perform unannounced examinations of spectacle wear as has been reported for studies in Mexico<sup>8</sup> and South Africa.<sup>27</sup> This limits comparisons with these other data and implies that spectacle wear as measured herein likely overrepresents actual day-day use, underestimating the extent of visual disability associated with spectacle nonwear.

Finally, our willingness-to-pay data for spectacle purchase were based on the responses of the children and may not represent the attitudes of parents making the actual expenditure. Nevertheless, the willingness-to-pay data obtained from children demonstrated associations in the expected direction: children who owned spectacles were willing to pay more than those who did not, as were those with correction that improved their vision optimally compared with those whose spectacles did not.

Despite its limitations, the present article represents the first large school-based study of which we are aware to report detailed patterns and determinants of spectacle use in China. Understanding these behaviors is a critical prerequisite to redressing the severe burden of uncorrected refractive error in rural China. Separate reports from the X-PRES describe the effect of interventions to increase the uptake of refractive services in this population.<sup>28</sup>

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