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ORIGINAL ARTICLE

Need and Challenges of Refractive Correction in Urban Chinese School Children

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ABSTRACT: *Purpose.* Uncorrected refractive error is recognized as the principal cause of visual impairment in school-aged children. Although correction of refractive error is easy, safe, and effective, many children are without the necessary spectacles. Empiric research on barriers to refractive correction remains limited, precluding the formulation of effective remedial actions. The aims of this study were to characterize parental awareness and other barriers to spectacle use among children considered to be in need of refractive correction and to determine the proportion undercorrected for those already with spectacles. *Methods.* A population-based sample of children 5 to 15 years of age was examined in Guangzhou, China. Visual acuity was measured followed by cycloplegic refraction and best-corrected vision. Parental awareness of the child's vision difficulties, spectacle use, and frequency of vision checkups were collected by questionnaire. Associations between these variables and demographic and socioeconomic characteristics were investigated with multiple logistic regression. *Results.* Among the 4359 examined children, 919 (21.1%) were found to be in need of refractive correction. Need was defined as uncorrected visual acuity ≤0.50 in both eyes correctable by at least two lines in the better eye. Parental awareness was apparent for 85% of cases; 74% had spectacles. Awareness of vision difficulties was associated with older child age, greater visual impairment, and higher parental education. The purchase of spectacles was associated with greater visual impairment; the child's age, gender, parental education, and family income were not significant factors. Undercorrection by two lines or more in the better eye was found in 30% of those already with spectacles; undercorrection was associated with greater visual impairment and less frequent refraction checkups. *Conclusions.* Half of the children in need of first-time or updated spectacles are without them, an unacceptably high proportion. Younger children with moderate visual impairment are at particular risk for uncorrected refractive error. Parental education and enhanced school-based screening programs may be necessary to address the unfilled need for refractive correction among school-aged children. (Optom Vis Sci 2005; 82:E229)

Key Words: visual acuity, eyeglasses, ocular refraction, children, urban population, Chinese

Beginning in 1998, a series of Refractive Error Study in Children (RESC) surveys were carried out in several geographic areas: a rural district in eastern Nepal,[1] the semirural Shunyi district near Beijing, China,[2] the urban La Florida area of Santiago, Chile,[3] a rural area near Hyderabad in southern India,[4] an urban area of New Delhi, India,[5] a semirural/urban area of Durban, South Africa,[6] and most recently in Guangzhou, China.[7] These population-based surveys of school-aged children document the wide variation in visual impairment across different ethnicities and geographic settings. Visual impairment (visual acuity 0.50 or worse in both eyes with presenting vision) was 1.2% in both Nepal and South Africa, 2.6% in Southern India, 4.9% in New Delhi, 6.1% in Shunyi, 7.3% in Santiago, and 10.3% in Guangzhou. Essentially all of the impairment was attributable to *uncorrected* refractive error; with best correction, the prevalence of visual impairment was generally <1%.

The problem of uncorrected refractive error is particularly common in Chinese populations, in which the underlying prevalence of refractive error is high. The RESC prevalence of myopia in 15 year olds in Guangzhou was 73%,[7] consistent with other recent studies among urban Chinese children in Hong Kong,[8] Singapore,[9] and Taiwan.[10]

Although correction with negative-diopter lenses is an easy, safe, and effective treatment for children with myopia, barriers to refractive correction can stand in the way. Except for a recent community focus group study to identify potential barriers to eye care after the finding of an abnormal school screening test result, this topic has received little attention.[11] A thorough understanding of barriers to correction of refractive error in school-aged children remains important for the formulation of action plans. Vision impairing refractive error can have far-reaching implications for the affected child, including being at a

disadvantage with respect to school performance. The problem of uncorrected refractive error should not be ignored.

This article reports on information obtained from an awareness and spectacle use questionnaire administered to parents in the Guangzhou RESC survey. The aim was to characterize parental awareness and other barriers to spectacle use among children considered in need of refractive correction and to determine the proportion of children undercorrected with current spectacles.

METHODS

Study Population

The population-based survey of refractive error and visual impairment in Guangzhou was carried out in Liwan district in the western part of the metropolitan area. Liwan district was identified for the survey because of its relatively stable population and representative demographic and socioeconomic characteristics. Residents are of Chinese Han ethnicity and represent a wide socioeconomic spectrum.[12]

Enumeration and Clinical Examination Procedures

Random selection of geographically defined clusters, created using the 2000 Census, was used to identify a population-based sample of children 5–15 years of age.[7] Eligible subjects were enumerated by name, gender, age, and current school through house-to-house visits. The educational level of each parent was also obtained. After an explanation of the study, including the possible side effects of pupil dilation, written informed consent for each child was obtained from a parent or guardian.

Eye examinations took place on weekdays in temporary stations set up in 71 schools and in 19 community halls on weekends. Distance visual acuity (both with and without spectacles for those wearing them) was measured with an illuminated LogMAR (logarithm of the minimal angle of resolution) tumbling E chart at 4 m. Cycloplegia was induced by two drops of 1% cyclopentolate, administered 5 minutes apart, with a third drop after 20 minutes if necessary. Refraction under cycloplegia was performed first with a streak retinoscope and then, independently, with a handheld autorefractor. Subjective refraction (retinoscopic refraction with subjective refinement) was performed on children with uncorrected visual acuity 0.50 or worse in either eye. In nine schools and two community facilities, children with reduced vision and a 10% sample of others were subjected to repeat, independent testing of uncorrected visual acuity, retinoscopy, and autorefraction for quality assurance monitoring.

The RESC protocol has been described elsewhere,[12] as have further details regarding the specific sampling and examination methods used in Guangzhou.[7]

Human subject approval for the original study protocol was obtained from the World Health Organization Secretariat Committee on Research Involving Human Subjects. The ethics committee of the Zhongshan Ophthalmic Center and the Liwan District Bureaus of Education and Health approved implementation of the study in Guangzhou. The protocol adhered to the provisions of the Declaration of Helsinki for research involving human subjects.

Spectacle-Use Questionnaire

After an informational session hosted in schools before the eye examinations, parents or guardians living closely with the child were asked to fill out a questionnaire. The questionnaire asked whether they thought their child currently had a refractive problem (nearsightedness, farsightedness, or astigmatism), whether their child had eyeglasses, about the frequency of vision checkups, details regarding the purchase of spectacles, about the frequency of spectacle use, and about alternative treatment methods. (See the Appendix.) General family information was also collected, including total monthly family income. A member of the study team attended each of the informational sessions and provided one-on-one assistance to those who could not understand the questionnaire or had difficulty completing it.

Definitions and Statistical Analysis

Children were considered in *need* of refractive correction if uncorrected visual acuity was 0.50 or worse in the better eye, which improved by at least two lines with refractive correction. The 0.50 visual acuity threshold used in defining need coincided with the definition of visual impairment used in RESC studies. Children with vision not fully correctable because of amblyopia or pathologic changes were not excluded from those considered to be in need of refractive correction so long as visual acuity improvement of two or more lines could be achieved.

Among those in need of refractive correction, based on uncorrected visual acuity, some already had spectacle correction. Children with spectacles were considered *undercorrected* if visual acuity in the better eye with the presenting correction could be improved by an additional two lines or more. The further two-line improvement with best correction mirrored the requirement in the definition of need itself.

Myopia was defined as spherical equivalent refractive error -0.50 D or more and hyperopia as +2.00 D or more. Children were classified as myopic if one or both eyes were myopic (includes antimetropic children), hyperopic if one or both eyes were hyperopic, so long as neither eye was myopic, and emmetropic if neither eye was myopic or hyperopic.[13]

Using both examination and questionnaire data, those in need of refractive correction as defined here were categorized into four groups: 1) children already with spectacles at the time of the examination; 2) children reported as wearing spectacles most or all of the time, but without them at the examination; 3) children reported as never or seldom wearing spectacles (and without them at examination); and 4) children for whom corrective spectacles were never purchased. Those with spectacles at examination (group 1) were subcategorized as to whether undercorrected.

From questionnaire data, the place of spectacle purchase and purchase cost were tabulated for groups 1, 2, and 3. Reasons why purchased spectacles were never or seldom worn were tabulated for group 3. For those without spectacles (group 4), questionnaire data were used to determine whether lack of awareness precluded the purchase of spectacles. If awareness was not the issue, other reasons why corrective spectacles were not purchased were tabulated.

Multiple logistic regression modeling was used to examine the association of child age, gender, visual acuity status, and parental education with parental awareness of a vision problem. In a regression model for the purchase of spectacles among parents aware of a vision problem, family income was also included. In regression modeling of undercorrection with current spectacles, place of purchase and frequency of vision checkups were included as covariates. Vision status

was represented as lines of visual acuity in the better eye in all regression models. Parental education, taken as the highest level of schooling in either parent, was categorized as: 1) primary schooling or less, 2) junior secondary schooling, 3) senior secondary schooling, and 4) college or more. Total monthly family income was, similarly, represented by ordinal categories: 1) <2000 Yuan; 2) 2000–5000 Yuan, and 3) more than 5000 Yuan. (1 U.S. dollar = 8.26 Chinese Yuan.)

Statistical analyses were performed using Stata Statistical Software, release 8.0.[14] Confidence intervals and p values were calculated (significant at the $p < 0.05$ level) with adjustment for clustering effects associated with the sampling design. Pairwise interactions between regression model variables were assessed simultaneously using a Wald F test and considered significant at the $p < 0.10$ level.

RESULTS

Examined Population

Between September 2002 and January 2003, a total of 5053 children between the ages of 5 and 15 years were enumerated; 4359 (86.3%) of these had visual acuity testing and ocular examination as described here. The study population was divided essentially uniformly between males and females (Table 1). The prevalence of uncorrected visual acuity ≤0.50 in both eyes was 22.3%. On the basis of presenting vision, the prevalence was 10.3% and with best correction 0.62%. Visual impairment was primarily because of refractive error in one or both eyes (95.6%).[7]

Questionnaire information was available for 3612 (82.9%) of those examined (Table 1). The absence of parents and/or guardians at the informational sessions was the primary reason for missing questionnaires. There were also some refusals.

Among those completing the questionnaire, a vision problem was reported in 1210 (33.5%) cases. Based on subsequent examination findings, visual impairment was minimal for 334 (27.6%) of these: uncorrected visual acuity ≥0.625 in both eyes. (Visual acuity was 1.0 in both eyes for 69 children.) The reporting of a vision problem was associated with older child age ($p < 0.001$), female gender ($p = 0.002$), more parental education ($p = 0.014$), and greater visual impairment ($p < 0.001$).

Eyeglasses were purchased for 859 (71.0%) children in whom parents perceived a vision problem. Purchases were associated with greater visual impairment ($p < 0.001$) and higher family income ($p = 0.026$). The child's age and gender and parental education were not statistically significant. Eyeglasses were purchased primarily in commercial optical shops (55%) and hospital-based facilities (43%). The distribution of cost was: <100 Yuan, 6%; 100–300 Yuan, 56%; 300–500 Yuan, 29%; and more than 500 Yuan, 9%. The interval between refraction checkups for children with spectacles was: less then 6 months, 19%; 6 months to almost 1 year, 23%; 1 year, 34%; and greater than 1 year, 24%.

Treatment other than ordinary spectacles was reported in 280 cases. A wide variety of treatments were mentioned: bifocals (14 cases), progressive lenses (13 cases), Ortho-K therapy (16 cases), contact lenses (5 cases), various other treatments (83 cases), with eye drops the most common (149 cases).

TABLE 1.
Guangzhou study population

	No. (%) examined	No. (%) with questionnaire data
Age		
5–7	888 (20.4)	643 (17.8)
8–10	1,207 (27.7)	1,038 (28.7)
11–13	1,378 (31.6)	1,184 (32.8)
14–15	886 (20.3)	747 (20.7)
Sex		
Male	2,245 (51.5)	1,840 (50.9)
Female	2,114 (48.5)	1,772 (49.1)
Uncorrected visual acuity		
≥0.625 both eyes	2,995 (68.7)	2,475 (68.5)
≥0.625 one eye only	393 (9.0)	330 (9.1)
≤0.50–≥0.32 better eye	572 (13.1)	471 (13.0)
≤0.25 better eye	399 (9.2)	336 (9.3)
Spherical equivalent refractive error*		
Myopia	1,533 (35.2)	1,301 (36.0)
Emmetropia	2,573 (59.0)	2,118 (58.6)
Hyperopia	253 (5.8)	193 (5.3)
Parental education†		
Primary	96 (2.2)	74 (2.1)
Junior high	962 (22.1)	763 (21.1)
Senior high	2,747 (63.0)	2,323 (64.3)
College	553 (12.7)	451 (12.5)
ALL	4,359 (100.0)	3,612 (100.0)

* As measured with retinoscopy, including 17 cases without successful cycloplegia in one or both eyes.
† Parental education is missing for one case.

Children Needing Refractive Correction

Based on the study definition, 919 (21.1%) of the examined population were in need of refractive correction (Table 2). The distribution of age, gender, and parental education were different between those in need and the examined population as a whole, as were definition-created differences in the distribution of visual acuity and refractive error. Children in need of refractive correction were more likely to be older ($p < 0.001$), female ($p = 0.002$), and to have parents with more education ($p = 0.040$). Emmetropia cases in need of refractive correction were classified as emmetropic only because refractive error was expressed in equivalent spheres. With few exceptions, these cases were astigmatic–negative cylinders but with offsetting positive spheres.

Questionnaire data were available for 779 (84.8%) of those in need of refractive correction (Table 2).

Parents were apparently aware of the vision problem in at least 778 (84.7%) of those needing refractive correction (Table 3). This includes cases without questionnaire data if the child was with spectacles on the day of the examination. Parental awareness was associated with older child age ($p = 0.001$; odds ratio [OR] = 1.15; 95% confidence interval [CI] = 1.07–1.24), more parental education ($p = 0.004$; OR = 1.87; 95% CI = 1.26–2.78), and greater visual impairment ($p < 0.001$; OR = 1.69; 95% CI = 1.38–2.06). Gender was not statistically significant.

Considering both examination and questionnaire information, spectacles were purchased for 684 (74.4%) of those in need (Table 3). The purchase of spectacles for 684 children represented 87.9% of the 778 parents who were aware of the vision problem. The purchase of spectacles was associated with greater visual impairment ($p < 0.001$; OR = 1.77; 95% CI = 1.49–2.11). The child's age and gender, parental education, or family income was not statistically significant.

In 94 cases, parents reported awareness of the child's vision problem but spectacles were not purchased. The stated reasons were: not wanting their child to wear eyeglasses, 49%; eyeglasses were too expensive, 24%; not knowing how to obtain eyeglasses, 14%; and other reasons, 12%. For an additional 92 cases, spectacles were not purchased because parents were, reportedly, unaware of the child's vision difficulties.

For 40 cases, eyeglasses were purchased, but it was reported that the child never or seldom used them. Reasons were: uncomfortable, 29%; cause progression of refractive error, 21%; unnecessary, 16%; other reasons, 24%; and do not know, 11%. Because these children were without spectacles at the examination, it was not possible to determine whether they were coping with inappropriate or undercorrection.

Aside from the issue of children not having or wearing corrective spectacles is the question of whether the current correction is adequate. Of the 635 children with spectacles at the examination, 190 (29.9%) were undercorrected. Twenty-eight were undercorrected by four or more lines in the better eye. Undercorrection was associated with greater visual impairment ($p = 0.006$; OR = 1.20; 95% CI = 1.06–1.35) and less frequent refraction checkups ($p = 0.002$; OR = 1.45; 95% CI = 1.17–1.79). Family income was not significant, nor were the child's age or gender, parental education, or place of purchase.

DISCUSSION

This study is the first to explicitly address the need for, and use of, refractive correction in a large cohort of school-aged Chinese children. Because the study sample was population-based, selection biases associated with school-based or other convenience samples were avoided.

Overall, 465 (50.6%) of the 919 children in need of refractive correction did not have the necessary or appropriate correction.

TABLE 2.
Children in need of refractive correction

	Cases (%)	Prevalence; 95% C.I.	No. (%) with questionnaire
Age			
5–7	48 (5.2)	5.4; 4.0–6.8	31 (4.0)
8–10	139 (15.1)	11.5; 10.0–13.1	122 (15.7)
11–13	361 (39.3)	26.2; 23.6–28.8	315 (40.4)
14–15	371 (40.4)	41.9; 38.4–45.4	311 (39.9)
Sex			
Male	422 (45.9)	18.8; 17.1–20.5	343 (44.0)
Female	497 (54.1)	23.5; 21.3–25.7	436 (56.0)
Uncorrected visual acuity			
≤0.50–≥0.32 better eye	523 (56.9)	91.4; 89.3–93.5	445 (57.1)
≤0.25 better eye	396 (43.1)	99.2; 97.8–99.8	334 (42.9)
Spherical equivalent refractive error			
Myopia	841 (91.5)	54.9; 52.4–57.4	720 (92.4)
Emmetropia	57 (6.2)	2.2; 1.6–2.9	46 (5.9)
Hyperopia	21 (2.3)	8.3; 4.2–12.4	13 (1.7)
Parental education			
Primary	15 (1.6)	15.6; 10.3–21.0	11 (1.4)
Junior high	179 (19.5)	18.6; 15.8–21.4	151 (19.4)
Senior high	618 (67.2)	22.5; 20.9–24.1	529 (67.9)
College	107 (11.6)	19.3; 14.1–24.6	88 (11.3)
ALL	919 (100.0)	21.1; 19.7–22.4	779 (100.0)

TABLE 3.
Parental awareness and spectacle usage among children in need of refractive correction

Total needing refractive correction			919 (100.0)
Wearing eyeglasses at examination (aware)		635 (69.1)	
Adequately corrected	445 (70.1)		
Under corrected	190 (29.9)		
Without eyeglasses at examination		235 (25.6)	
Purchased and regular use (aware)	9 (3.8)		
Purchased but seldom/no use (aware)	40 (17.0)		
Never purchased	186 (79.1)		
Aware of vision problem	94 (50.5)		
Not aware	92 (49.5)		
Without eyeglasses at exam and no questionnaire data		49 (5.3)	

Data are number of children with percentages in parentheses.

Cases remaining in need of refractive correction (Table 3) include: the 190 children with spectacles at examination but undercorrected; the 40 children reported as having spectacles but with little or no use; the 186 children for whom spectacles had never been purchased; and the 49 children without spectacles at examination and no questionnaire (purchase or use) information. These latter cases are included among those still requiring refractive correction; if these children had spectacles, and wore them on a regular basis, they would have been wearing them at the examination.

Not included in the tabulation of those remaining in need of refractive correction, although they could have been, are the nine cases without eyeglasses at the examination but, reportedly, using them on a regular basis. It is unclear why regular users would not be wearing spectacles on the day of the examination. It is possible that these nine children were with inappropriate or undercorrection.

For the 186 cases in whom corrective spectacles were never purchased, lack of parental awareness accounted for half. Awareness was less likely to be a problem among parents with more education, for children with increased visual impairment, and for children of older age. Younger children with relatively mild impairment may be less capable of reporting a vision difficulty, and parents with lower educational backgrounds may be less able to recognize such difficulty. For cases in which parental awareness was not the problem, half simply did not want their child wearing spectacles. In another one-fourth, cost was the issue.

Although 70% of those in need of refractive correction were with spectacles on the day of the examination, 30% were undercorrected. Increased visual impairment and a decreased frequency of refraction checkups were associated with undercorrection. This is consistent with undercorrection being more likely in cases with rapid refractive error progression. Place of purchase, as a possible indicator of quality of care, and family income, as an indicator of ability to pay, were not significant factors.

Visual acuity was used in defining those in need of refractive correction rather than refractive error itself. It is visual impairment, not the refractive error that underlies it, that becomes evident to the child and the child's parents. A less conservative visual acuity threshold, or requiring impairment in only one eye, would, of course, have resulted in classifying a greater number of children in need of refractive correction and a disproportionately greater percentage without appropriate correction. Need may have been underestimated to the extent that additional children might have improved by the required two or more lines had subjective refraction been done 2 or 3 days later, after the effect of cycloplegia was gone. Requiring only a one-line improvement as evidence of benefit with refractive correction was never considered because it falls within measurement error.[7]

The findings suggest a community deficit in the correction of refractive error among urban school-aged Chinese children. Although spectacle coverage was close to 75% among those considered in need, this is far from satisfactory considering the conservativeness of the definition of need. Also troubling is the 30% of refractive error that was undercorrected with current spectacles. Parental awareness was implicated as a risk factor for uncorrected refractive error, implying that efforts to improve parental awareness of vision difficulties might be indicated, particularly among young children with moderate visual impairment. Without parental awareness, it is obvious that visual impairment because of refractive error will go uncorrected, even when affordability or other socioeconomic factors are not the issue.

Currently, visual acuity screening is one of the components in the annual physical examination required of school children conducted in schools by community health workers. Children identified as having visual impairment are advised to seek spectacle correction from optical shops or hospital-based facilities. Payment for spectacles is the responsibility of the family. Free-of-charge optometric services do not exist. Although socioeconomic factors may stand in the way of the child actually obtaining spectacles, it is not evident why parental awareness remains an issue. Evaluation of the current vision screening program may help clarify deficiencies.

Parental education coupled with enhanced school-based screening may be needed to help identify children with visual impairment, perhaps not severe enough for parents to easily recognize, but serious enough to affect classroom performance. Additionally, robust scientific evidence regarding any association between refractive correction and myopic progression may be influential for some parents in deciding whether to encourage their child to wear ordinary eyeglasses vs. encouraging the use of bifocals, progressive lenses, or attempts with various unproven alternatives.

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APPENDIX

Appendix is available online only at www.optvissci.com.

Awareness and Spectacle Usage Questions

1. According to what you know, does your child currently have refractive error, such as nearsighted, farsighted, or astigmatism?
   a) No
   b) Yes
   c) Don't Know
2. Did you obtain eyeglasses for your child to correct the current refractive error?
   a) No
   b) Yes
3. If you did not obtain eyeglasses, what were the reasons?
   a) Don't want child to wear eyeglasses
   b) No optic shop near by
   c) Too expensive
   d) Don't know how to obtain eyeglasses
   e) Other
4. If you obtained eyeglasses for your child, where did you buy the ones your child is currently wearing?
   a) Optic shop
   b) Hospital eye service
   c) Other
5. If you obtained eyeglasses for your child, how often did you bring your child for a vision check-up and eyeglasses updating?
   a) Less than 6 months
   b) Six months to almost one year
   c) One year
   d) More than 1 year
6. If you did purchase eyeglasses for your child, how much did the current ones cost?
   a) Less than 100 yuan
   b) 100 to 300 yuan
   c) 300 to 500 yuan
   d) More than 500 yuan
7. What kind of alternative treatment has your child ever received, besides wearing ordinary eyeglasses?
   a) Bifocal lenses
   b) Progressive lenses
   c) Ortho-K therapy
   d) Contact lenses
   e) Eye drops
   f) Other
8. If your child has eyeglasses, how frequent does he/she wear them?
   a) Never
   b) Sometimes
   c) Most of time
   d) Always
9. If your child does not wear eyeglasses most of time, what are the reasons?
   a) Not necessary, can still see without eyeglasses
   b) Cannot see even with eyeglasses
   c) Not comfortable with eyeglasses
   d) Eyeglasses will lead to progression
   e) Child doesn't look good with eyeglasses
   f) Other
   g) Don't know

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