Prevalence and Causes of Visual Impairment in Low–Middle Income School Children in São Paulo, Brazil

Solange R. Salomão,[1] Rafael W. Cinoto,[1] Adriana Berezovsky,[1] Luana Mendieta,[1] Célia R. Nakanami,[1] César Lipener,[1] Emílio de Haro Muñoz,[1] Fabio Ejzenbaum,[1] Rubens Belfort, Jr,[1] Gopal P. Pokharel,[2] and Leon B. Ellwein[3]

Purpose. Assess prevalence and causes of vision impairment among low–middle income school children in São Paulo.

Methods. Cluster sampling was used to obtain a random sample of children ages 11 to 14 years from public schools (grades 5–8) in three districts from June to November 2005. The examination included visual acuity testing, ocular motility, and examination of the external eye, anterior segment, and media. Cycloplegic refraction and fundus examination were performed in children with uncorrected visual acuity 20/40 or worse in either eye. A principal cause of visual impairment was determined for eyes with uncorrected visual acuity of 20/40 or worse.

Results. A total of 2825 children were enumerated and 2441 (86.4%) were examined. The prevalence of uncorrected, presenting, and best-corrected visual acuity 20/40 or worse in the better eye was 4.82%, 2.67%, and 0.41%, respectively. Spectacles were used by 144 (5.9%) children. Refractive error was a cause in 76.8% of children with visual impairment in one or both eyes; amblyopia, 11.4%; retinal disorders, 5.9%; other causes, 2.7%; and unexplained causes, 7.7%. Myopic visual impairment (spherical equivalent −0.50 D in one or both eyes) was not associated with age or grade level, but female sex was marginally significant ($P = 0.070$). Hyperopic visual impairment (+2.00 D or more) was not associated with age, grade level, or sex.

Conclusions. The prevalence of reduced vision in low–middle income urban São Paulo school children was low, most of it because of uncorrected refractive error. Cost-effective strategies are needed to address this easily treated cause of vision impairment. (*Invest Ophthalmol Vis Sci.* 2008;49:4308–4313) DOI:10.1167/iovs.08-2073

Visual impairment because of uncorrected refractive error is increasingly being recognized worldwide as a significant cause of avoidable visual disability. This recognition is evidenced by its inclusion in the priority areas of Vision 2020: The Right to Sight—a global initiative launched by a coalition of nongovernmental organizations and the World Health Organization (WHO).[1] In addressing the widespread need for population-based data on childhood refractive error, the Refractive Error Study in Children (RESC) protocol was developed to assess the prevalence of visual impairment and refractive error in children of different ethnic origins and cultural settings, by using consistent definitions and methods.[2] Between 1998 and 2003, eight RESC surveys were conducted in Nepal,[3] China,[4,5] Chile,[6] India,[7,8] South Africa,[9] and Malaysia.[10]

These surveys showed that visual impairment because of refractive error is uncommon among children not attending school.[3,7,9] On the basis of these findings, a subsequent RESC survey in rural Yangxi, China, was designed with logistically less cumbersome, school-based sampling.[11] Further, because of resistance among parents in providing consent for cycloplegia, a recent survey among private secondary schools in Kathmandu, Nepal, only children with visual impairment were evaluated with cycloplegic refraction.[12] The current emphasis in RESC surveys is thus not on evaluating the prevalence of refractive errors, but on visual impairment *with* refractive error.

Among the 96 districts in São Paulo city, three districts representative of low–middle income populations, Ermelino Matarazzo, Vila Jacuí, and São Miguel, were chosen for an RESC survey. The purpose was to estimate the prevalence of visual impairment with refractive error in middle school children between the ages of 11 and 14 years. Based on the 2000 Census,[13] the estimated population of these three districts was 346,170, with 7.8% 11 to 14 years of age. The population of Brazil as a whole was 169,799,170, with 8.23% between 11 and 14 years of age. Literacy was 89.8% in the three districts, compared with 92.0% in São Paulo city and 83.3% throughout Brazil. Households with incomes of five times the minimum wage or less (approximately 600 U.S. dollars/mo) represented 71.3% of households in the three study districts, compared with 58.0% for São Paulo city and 77.5% throughout Brazil.

The data presented are the first on the prevalence of vision impairment and causes among low–middle income school children in Brazil. Adopting the RESC protocol makes it possible to compare these findings in a straightforward fashion with those from the earlier RESC surveys.[3–12] A subsequent article will deal with the prevalence of ocular abnormalities.

From the [1]Vision Institute, Department of Ophthalmology, Federal University of São Paulo (UNIFESP), Paulista School of Medicine, São Paulo, Brazil; [2]Nepal Netra Jyoti Sangh, Kathmandu, Nepal; and the [3]National Eye Institute, National Institutes of Health, Bethesda, Maryland.

Presented in part at the annual meeting of the Association for Research in Vision and Ophthalmology, Fort Lauderdale, Florida, May 2007.

Supported by the World Health Organization, Geneva, Switzerland (under National Institutes of Health [Bethesda, MD] contract N01-EY2103) to the Vision Institute, Federal University of São Paulo (UNIFESP); Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) Grant 04/06670-9 (SRS); Conselho Nacional de Desenvolvimento Científico e Tecnológico-CNPq (Brasília, DF, Brazil) research fellowships (SRS, AB, RB); and Fundo de Apoio aos Docentes e Alunos da UNIFESP-FADA research fellowships (SRS, AB, RB).

Submitted for publication March 25, 2008; revised May 15, 2008; accepted August 11, 2008.

Disclosure: **S.R. Salomão**, None; **R.W. Cinoto**, None; **A. Berezovsky**, None; **L. Mendieta**, None; **C.R. Nakanami**, None; **C. Lipener**, None; **E. de Haro Muñoz**, None; **F. Ejzenbaum**, None; **R. Belfort, Jr**, None; **G.P. Pokharel**, None; **L.B. Ellwein**, None

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be marked "*advertisement*" in accordance with 18 U.S.C. §1734 solely to indicate this fact.

Corresponding author: Solange R. Salomão, Department of Ophthalmology, Federal University of São Paulo—UNIFESP, Rua Botucatu 822, São Paulo, SP 04023-062, Brazil; ssalomao@oftalmo.epm.br.

Investigative Ophthalmology & Visual Science, October 2008, Vol. 49, No. 10

METHODS

Sample Selection

Based on Ministry of Education data for 2003, the city of São Paulo has 5137 middle schools: 2322 public (1216 supported by the city government and 1106 by the state government) and 2815 private. Within the three study districts, there are 187 middle schools: 76 public (26 city and 50 state) and 111 private.

Originally, the study sampling plan was to include both public and socioeconomically higher private middle schools from districts outside the study area. However, after a pilot study, it was found essentially impossible to obtain informed consent and a satisfactory examination response rate among children in the private schools. The sampling plan was therefore modified to include only public schools from the Ermelino Matarazzo, Vila Jacuí, and São Miguel districts.

Cluster sampling was used to obtain a random sample of children ages 11 to 14 years (grades 5–8) from the 76 public schools in the three districts. The sampling frame was formulated on the basis of using an entire school in defining the sampling units (clusters). Large schools were subdivided, and small ones were grouped such that each cluster contained as estimated 215 to 430 children within the 11- to 14-year age range. Classrooms in public schools are of a reasonably uniform size throughout São Paulo city with approximately 30 to 50 children; thus, with two classes for each grade, children in grades 5 through 8 would represent approximately 320 children—80 children in each grade level (i.e., each year of age).

The sampling frame consisted of 81 clusters. Nine were randomly selected (with equal probability) in producing an expected study sample of 720 children for each year of age. This number exceeds the originally calculated sample size of 640, which was based on estimating a prevalence of 20%, within a 20% error bound with 95% confidence and adjustment to accommodate nonparticipation (10%) and cluster sampling design (50%) effects.

Field Operations

School authorities at each of the selected schools were contacted either by phone or through a prescheduled personal interview from April to October 2005 for an explanation of the project objectives and procedures. This contact was followed by the enumeration of eligible children performed by two field workers from the Vision Institute of Federal University of São Paulo (UNIFESP). Lists of the registered students (name, age, and sex) for each class/grade were obtained, along with the parents' names and their respective addresses. Children who would fall within the 11- to 14-year age range at the prescheduled date of examination were included in the enumerated sample. Children absent from the school at the time of the enumeration (e.g., illness, unauthorized absence) were not included.

School authorities contacted the parents or guardian of each child to obtain informed consent. Prescheduled meetings with parents or guardians, teachers, and students were offered by the project staff, to explain details of the eye examination. Examinations were conducted during school hours, mostly between June and November 2005. Children without written informed consent before the examination date were reminded by their teachers to bring a signed consent form to the school. Those without signed consent forms were not examined. Teachers also reminded children who usually wore glasses to bring and wear them on the day of the examination.

Clinical Examination

The clinical team was composed of five ophthalmologists, four ophthalmic technologists, a field assistant, a field team coordinator, and a study manager.

Visual acuity was measured at 4 m by an ophthalmic technologist who used a retroilluminated logarithm of the minimum angle of resolution (logMAR) chart with tumbling-E optotypes. For children with glasses, visual acuity was measured both with and without them. Ocular motility was evaluated by cover test for near and distance, and prism and cover were used for the tropic component measurement. Tropia was categorized as esotropia, exotropia, and/or vertical deviation. A team ophthalmologist evaluated the external eye and anterior segment (eyelid, conjunctiva, cornea, iris, and pupil) with a handheld slit lamp (SLP-15; Kowa, Tokyo, Japan).

For children with unaided (uncorrected) visual acuity of 20/40 or worse in either eye, cycloplegia was induced with 2 drops of 1% cyclopentolate, administered 5 minutes apart, with a third drop administered after 15 minutes. Cycloplegia and pupil dilation were evaluated after an additional 20 minutes. Pupillary dilation of 6 mm or more with absence of light reflex was considered complete cycloplegia.

Autorefraction was performed with a handheld refractor (Retinomax Plus; Nikon, Tokyo, Japan) by an ophthalmic technologist. Subjective cycloplegic refraction and indirect ophthalmoscopic examination of the media and fundus were performed by an ophthalmologist. The examining ophthalmologist assigned a principal cause for eyes with uncorrected visual acuity 20/40 or worse. (Refractive error was assigned routinely if acuity improved to at least 20/32 with refractive correction). Examination details have been described elsewhere.[2]

For children with visual impairment that improved with refraction, free spectacles were prescribed and provided, and local medical advice was given for minor disorders. Children needing tertiary medical treatment were referred to the eye clinic at the local UNIFESP units of Ermelino Matarazzo Hospital or São Paulo Hospital.

Review Board Approval

Human subject research approval for the study protocol was obtained from the WHO Secretariat Committee on Research Involving Human Subjects. The UNIFESP Committee on Ethics in Research approved the implementation of the study. The research protocol adhered to the provisions of the Declaration of Helsinki for research involving human subjects.

Data Management and Analysis

Data forms were reviewed for accuracy and completeness in the field before computer data entry at UNIFESP. Data ranges, frequency distributions, and consistency among related measurements were checked with computerized data-cleaning programs. Statistical analyses were performed with commercial software.[14]

The prevalence of visual impairment based on uncorrected visual acuity, presenting visual acuity, and best corrected visual acuity was calculated. Visual acuity categories were defined as normal/near normal vision (20/32 or better in both eyes), unilateral visual impairment (20/32 or better in one eye only), mild impairment in the better eye (20/40–20/63 in the better eye), moderate impairment in the better eye (20/80–20/160 in the better eye), and blindness (20/200 or worse in both eyes).

Estimates of refractive error were based on measurement with cycloplegic autorefraction. Myopia was defined as spherical equivalent (SE) refractive error of at least −0.50 D and hyperopia as +2.00 D or more. Children were considered myopic if one or both eyes were myopic and hyperopic if one or both eyes were hyperopic, so long as neither eye was myopic. Astigmatism was investigated at cylinder values of <0.75, ≥ 0.75 to <1.50, ≥ 1.50 to <2.00, and ≥ 2.00 D. The prevalence of refractive error was calculated with the presumption that eyes with normal or near-normal vision were emmetropic. (The emmetropic assumption was used to account for the fact that refraction data were not available for eyes with normal or near-normal vision.)

The association between visual impairment and age (or grade level) and sex was explored with logistic regression. Confidence intervals (CIs) and probabilities (significance at ≤ 0.05) for prevalence estimates and regression models were calculated, with adjustment for clustering effects associated with the sampling design. Sampling design effects were represented by a ratio (deff) that compared the estimate of variance actually obtained with the generally smaller variance that would have been obtained had simple random sampling been used.[14]

TABLE 1. Distribution of Enumerated and Examined Population by Age, Sex, and Grade

	Enumerated Population		Examined Population*
	n (%)	Percent Examined	*n* (%)
Age (y)			
11	673 (23.8)	90.8	611 (25.0)
12	685 (24.3)	87.4	599 (24.5)
13	722 (25.6)	85.8	619 (25.4)
14	745 (26.4)	82.1	612 (25.1)
Sex			
Male	1362 (48.2)	83.5	1137 (46.6)
Female	1463 (51.8)	89.1	1304 (53.4)
Grade			
5th†	814 (28.8)	90.7	738 (30.2)
6th	704 (24.9)	84.9	598 (24.5)
7th	782 (27.7)	85.7	670 (27.5)
8th	525 (18.6)	82.9	435 (17.8)
All	2825 (100.0)	86.4	2441 (100.0)

* Includes one 11-year-old fifth grade girl with unreliable visual acuity measurements.

† Sixty-eight enumerated 11-year-old grade 4 children are grouped with grade 5 children; 65 of those were examined.

RESULTS

Study Population

A total of 2825 children were enumerated—ranging from 195 to 377 per cluster across the nine study clusters (schools). Age, sex, and grade distributions of the enumerated sample are shown in Table 1. (When age at enumeration and examination differed, age at the time of examination was used). One of the schools had only 20 children in grade 6 because of registration problems in the preceding year; thus, the total number of grade 6 children is disproportionately lower than expected. Two of the schools had both primary- and middle-school grade levels (grades 1–8) in which the enumeration included 43 11-year-old children in one school in grade 4 and 25 in another. Because of the relatively small number, these children were grouped with grade 5 children, rather than analyzed separately.

A total of 2441 children were examined, representing an examination response rate of 86.4%. Examination rates exceeded 75% in all clusters. The age, sex, and grade distributions of the examined population are shown in Table 1.

Visual Acuity

Visual acuity findings are presented in Table 2. Uncorrected visual acuity of 20/32 or better in at least one eye was found in 2322 (95.2%) children. One-hundred-eighteen (4.8%) children had visual impairment (20/40 or worse) in both eyes, with three (0.12%) of these blind (20/200 or worse) in both eyes.

A total of 144 (6.0%) children were wearing spectacles, and among the 118 with visual impairment in both eyes based on uncorrected vision, 63 (53.3%) had spectacles (Table 2). With their presenting refractive correction, 52 of the 63 had normal or near-normal vision in one or both eyes, and 11 remained impaired. Including the 55 visually impaired children without spectacles, 66 (2.7%) presented with bilateral visual impairment—a 44.1% reduction in visual impairment compared with that with uncorrected visual acuity (52 ÷ 118). No child was bilaterally blind at initial presentation.

With testing of best corrected visual acuity, it was possible to reduce the bilateral visual impairment to 10 (0.41%) children, with none blind (Table 2). (Presenting visual acuity [20/80 in one eye and 20/63 in the other] was used in place of best corrected vision for one child where the best corrected visual acuity measurement was not available). Accordingly, a total of 108 (91.5%) of the 118 children with bilateral visual impairment could achieve normal to near-normal vision in at least one eye with best corrected refraction, including six children who were wearing inadequate spectacles. Stated another way, 51.9% (56) of the 108 children who could achieve

TABLE 2. Distribution of Uncorrected, Presenting, and Best Corrected Visual Acuity

Visual Acuity Category	Uncorrected Visual Acuity *n* (%; 95% CI)	Wearing Glasses* *n* (%)	Presenting Visual Acuity *n* (%; 95% CI)	Best Visual Acuity *n* (%; 95% CI)
≥20/32 both eyes	2,220 (91.0; 89.9–92.1)	58 (2.6)	2,284 (93.6; 92.3–94.9)	2,379 (97.5; 96.7–98.3)
≥20/32 one eye only	102 (4.2; 3.3–5.0)	23 (22.5)	90 (3.7; 2.7–4.6)	51 (2.1; 1.5–2.7)
≤20/40 to ≥20/63 better eye	76 (3.1; 2.2–4.0)	29 (38.2)	57 (2.3; 1.6–3.1)	9‡ (0.37; 0.17–0.70)†
≤20/80 to ≥20/160 better eye	39 (1.6; 1.0–2.2)	31 (79.5)	9 (0.37; 0.17–0.70)†	1 (0.04; 0.001–0.23)†
≤20/200 better eye	3 (0.12; 0.03–0.36)†	3 (100.0)	0	0
All	2,440 (100.0)	144 (5.9)	2,440 (100.0)	2,440 (100.0)

* Percentage of the number within each visual acuity category based on uncorrected vision.

† CIs were calculated by using the exact binomial distribution instead of the normal approximation. Cluster design effects of 0.754, 0.996, 1.158, and 1.828 are not reflected in the confidence intervals for exact binomial estimates. (Design effects ranging from 0.715 to 1.332 were taken into account in calculating confidence intervals for estimates based on the normal approximation.)

‡ Includes one child in whom missing best corrected visual acuity was replaced with presenting visual acuity (20/63).

Table 3. Prevalence of Visual Impairment with Refractive Error (One or Both Eyes) by Age, Sex, and Grade

	Children with Visual Impairment*			Children without Visual Impairment	All Children
	Hyperopia *n* (%; 95% CI)†	Myopia *n* (%; 95% CI)‡	Emmetropia *n* (%)	*n* (%)	
Age (y)					
11	11 (1.8; 0.90–3.20)	33 (5.40; 3.72–7.08)	5 (0.82)	561 (92.0)	610 (100.0)
12	19 (3.18; 1.92–4.92)	27 (4.52; 2.53–6.50)	15 (2.51)	537 (89.8)	598 (100.0)
13	7 (1.13; 0.46–2.32)	36 (5.83; 4.57–7.08)	8 (1.29)	567 (91.7)	618 (100.0)
14	13 (2.12; 1.14–3.61)	37 (6.05; 4.20–7.89)	7 (1.14)	555 (90.7)	612 (100.0)
Sex					
Male	22 (1.93; 1.22–2.91)	53 (4.66; 3.40–5.93)	17 (1.50)	1045 (91.9)	1137 (100.0)
Female	28 (2.15; 1.43–3.10)	80 (6.14; 5.08–7.20)	18 (1.38)	1175 (90.3)	1301 (100.0)
Grade					
5§	16 (2.17; 1.25–3.50)	39 (5.29; 3.67–6.92)	9 (1.22)	673 (91.3)	737 (100.0)
6	13 (2.18; 1.16–3.69)	29 (4.86; 2.13–7.59)	14 (2.35)	541 (90.6)	597 (100.0)
7	11 (1.64; 0.82–2.92)	33 (4.93; 4.00–5.82)	7 (1.05)	618 (92.4)	669 (100.0)
8	10 (2.30; 1.11–4.19)	32 (7.36; 4.55–10.2)	5 (1.15)	388 (89.2)	435 (100.0)
All	50 (2.05; 1.40–2.70)	133 (5.46; 4.56–6.35)	35 (1.44)	2220 (91.1)	2438 (100.0)

* Refraction data were not available for two children with visual impairment: a 12-year-old girl in grade 6 whose parents did not consent to cycloplegia and a 13-year-old girl in grade 7 with severe acute conjunctivitis.

† Confidence intervals for all hyperopia age-, sex-, and grade-specific estimates were calculated by using an exact binomial distribution, instead of the normal approximation, with adjustments for sampling design effects ranging from 0.539 to 1.714.

‡ Design effects were taken into account in the calculation of confidence intervals for myopia estimates based on the normal approximation. Design effects ranged from 0.331 to 1.030 for age-specific estimates, 0.770 and 0.469 for sex specific estimates, and 0.212 to 1.812 for grade-specific estimates.

§ Sixty-five 11-year-old grade 4 children were grouped with grade 5 children.

normal or near-normal vision in at least one eye were without the necessary correction.

The girls had poorer vision in the better eye with uncorrected, presenting, and best corrected measurements (Kolmogorov-Smirnov test; $P = 0.044$, $P = 0.026$, and $P = 0.055$, respectively).

Pupillary Dilation and Cycloplegia

Based on uncorrected visual acuity of 20/40 or worse in at least one eye, cycloplegic dilation and refraction should have been performed in 220 (9.0%) children. Cycloplegic dilation was not attempted in two children: a 12-year-old girl in grade 6 whose parents did not consent to cycloplegia and a 13-year-old girl in grade 7 with severe acute conjunctivitis (the same child as the one with a missing best corrected visual acuity measurement). Pupillary dilation and cycloplegia (dilation of at least 6 mm and the absence of light reflex) were possible in both eyes in 216 children; in 2 others light reflex was absent but pupil diameter was less than 6 mm.

Refractive Error

Cycloplegic autorefraction measurements were not available for two right and three left eyes of four of the 218 children with cycloplegia. For these children, the measurement of refractive error was based on subjective refraction.

The prevalence of visual impairment with hyperopia was approximately 2.0% across age, sex, and grade subgroups (Table 3). The prevalence of visual impairment with myopia was roughly 5% to 6% across age and sex subgroups and 5% to 7% across grade levels.

Multivariate logistic regression was used to quantify the association of hyperopic and myopic visual impairment with age or grade level and sex. Neither age ($P = 0.634$) nor sex ($P = 0.750$) was significant in modeling for hyperopic visual impairment. Results were essentially the same when grade level ($P = 0.876$) was used in place of age. For myopic vision impairment, age and grade were not significant ($P = 0.449$ and $P = 0.348$, respectively), whereas female sex was marginally significant ($P = 0.070$) in both age and grade level models.

Astigmatism

Visual impairment with astigmatism of 0.75 D or greater was found in 118 (4.84%) right eyes and in 113 (4.63%) left eyes (Table 4). Visual impairment with astigmatism in either eye was present in 164 (6.73%) children. In multiple logistic regression modeling, astigmatism was not associated with age ($P = 0.951$), grade level ($P = 0.713$), or sex ($P = 0.145$).

Table 4. Prevalence of Visual Impairment with Astigmatism

	Cylinder Diopters in Eyes of Children with Visual Impairment					Eyes of Children without Impairment	All
	≤0.75	≥0.75; <1.50	≥1.50; <2.00	≥2.00	All		
Right eyes	53 (2.17)	49 (2.01)	19 (0.78)	50 (2.05)	171 (7.01)	2267 (93.0)	2438 (100.0)
Left eyes	50 (2.05)	42 (1.72)	19 (0.78)	52 (2.13)	163 (6.69)	2275 (93.3)	2438 (100.0)
Children*	54 (2.21)	62 (2.54)	27 (1.11)	75 (3.08)	218 (8.94)	2220 (91.1)	2438 (100.0)

Data are the number (%) of cases.

* Astigmatism in children is categorized according to the worse eye.

Table 5. Causes of Visual Impairment

Cause	Eyes with Visual Impairment *n* (%) Right Eye	Eyes with Visual Impairment *n* (%) Left Eye	Children with Visual Impairment *n* (%) (One or Both Eyes)*	Percent Prevalence in the Population (One or Both Eyes)*
Refractive error†	138 (79.8)	129 (78.2)	169 (76.8)	6.93
Amblyopia‡	10 (5.8)	15 (9.1)	25 (11.4)	1.02
Retinal disorder	9 (5.2)	7 (4.2)	13 (5.9)	0.53
Other causes	5 (2.9)	3 (1.8)	6 (2.7)	0.25
Unexplained cause§	11 (6.4)	11 (6.7)	17 (7.7)	0.70
Any cause	173 (100.0)	165 (100.0)	220 (100.0)	9.02

Data are the number (%) of cases.

* Children with visual acuity ≤ 20/40 in both eyes may represent two causes of reduced vision, one in each eye. Accordingly, the total of 230 children across all specific causes exceeds the 220 with any cause of impairment. Similarly, the total for the cause-specific prevalences exceeds the any-cause prevalence.

† Refractive error was assigned as the cause of reduced vision for all eyes correcting to ≥20/32 with subjective refraction, even if other contributing disease was present.

‡ Includes only cases meeting the defined tropia, anisometropia, or hyperopia criteria for amblyopia.

§ Includes 13 eyes of 12 children where the examining ophthalmologist concluded that amblyopia was the principal cause of impairment, even though the amblyopia criteria were not met.

Ocular Motility

Tropia, mostly esotropia, at both near and distance fixations was present in 26 (1.07%) children, with 17 (0.70%) having both near and distant esotropias. With near fixation, 54% of tropia was ≤30 prism diopters and with distant fixation, 46%.

Cause of Visual Impairment

Of the 220 children with visual impairment, 55 had impairment in only the right eye, 47 in only the left eye, and 118 in both eyes. Refractive error was the cause of most of the visual impairment: 159 (72.3%) of the 220 attained normal or near-normal acuity in both eyes with refractive correction (Table 2). Another 10 children had correctable refractive error in one eye, with an uncorrectable cause in the fellow eye, for a total of 169 (76.8%) with refractive error as the cause of impairment in one or both eyes (Table 5).

Amblyopia, satisfying the predefined criteria, was the cause of uncorrectable visual impairment in 25 (11.4%) children: 7 with tropia; 3 with hyperopia ≥ 6.00 SE diopters; and 16 with anisometropia ≥ 2.00 SE diopters, including 1 with hyperopia ≥ 6.00 SE diopters. Retinal disorders were the principal cause in 16 eyes of 13 children. Other causes were found in 6 children: uveitis in two and albinism, nystagmus, keratoconus, and optic neuritis in one each. The cause of visual impairment was undetermined in 22 eyes of 17 children, including 13 eyes of 12 children in whom amblyopia was considered the principal cause, even though none of the explicit criteria were met.

Discussion

This survey provides reliable information on the prevalence of visual impairment among middle school children in low–middle income areas of urban São Paulo, Brazil. (These are the first population-based data on the prevalence and causes of vision impairment in school-age children from anywhere in Brazil.) With uncorrected vision, 4.8% of children had visual acuity 20/40 or worse in the better eye. Over three fourths (76.8%) of this impairment was attributable to refractive error; amblyopia was implicated in 16.8% of children, and retinal disorders were a principal cause in 5.9%. With presenting visual acuity, 2.7% remained visually impaired and 0.41% with best correction. Accordingly, more than half (51.9%) of the children who could achieve normal/near normal vision, in at least one eye, were without the necessary spectacles.

As in previous RESC surveys, cluster sampling was used to simplify sampling and examination logistics. Because the study sample in the Ermelino Matarazzo, Vila Jacuí, and São Miguel districts was chosen randomly, rather than in an arbitrary fashion, self-selection biases should have been minimal. Further, because school enrollment rates throughout Brazil are reportedly high, 97.8% for children 7 to 14 years of age,[13] biases introduced because of school-based, rather than population-based, sampling are likely to be insignificant.

Despite attempts to include children from high socioeconomic private schools to compare those from low socioeconomic public schools, as originally anticipated, we were unable to achieve a satisfactory response rate in the children of high socioeconomic status. It is unfortunate that private schools could not be included in the study, in that they represent more than half of the middle schools in the three districts. (Typical tuition fees in private schools within the three districts are equivalent to one minimum wage, which could correspond to 1 or 2 months of household income). Accordingly, a deficiency of the study is that the sample of public school children was not necessarily representative of all children living in the study area.

After completion of the survey, we visited the previously identified sample of private schools to make a simple count of the number of children wearing glasses or contact lenses. This disclosed a dramatic difference in the prevalence of optical correction between the two populations: 22% in private schools versus the 5.9% in the public school sample. This difference suggests a higher prevalence of refractive error among children in private schools. The more intense academic programs in private schools, coupled with parents' having high expectations for educational achievement, may contribute to a greater risk of myopia associated with increased amounts of near work and less time for outdoor activities (Saw SM, et al. *IOVS* 2008;49:ARVO E-Abstract 1551).[15,16] The discrepancy in spectacle usage between the two groups may also be reflective of lower access to and affordability of eye care services among children living in low-income settings (Half of those in need of spectacles were without them.).

The prevalence of visual impairment with myopia and visual impairment with hyperopia was 5.46% and 2.05%, respectively. This low prevalence of vision-impairing refractive error is consistent with findings from surveys in other developing countries in both urban[8,9] and rural settings.[3,7] It is also noteworthy that the RESC survey in urban Santiago (La Florida), Chile, produced a comparable result: Visual impairment with myopia among 11- to 14-year-olds was 5.18% versus 5.46%, and visual impairment with hyperopia was 4.05% versus 2.05% (additional analyses provided by LBE). With low-middle income children in São Paulo and Santiago having a nearly identical prevalence of myopia (despite environmental and genetic differences), it is possible that the findings from these two RESC studies are representative of low–middle income children throughout South America.

The unmet need for refractive correction is widespread among both urban and rural children, as found in all the previous RESC surveys.[3–12] Barriers to spectacle use include factors such as parental unawareness of the vision problem, attitudes regarding the need for spectacles, high cost, and concern that wearing spectacles may cause progression of refractive error.[17]

Considering that a significant number of children are without appropriate refractive correction, the relatively low prevalence of visual impairment with myopia or hyperopia should not be taken to suggest that refractive errors are an insignificant contributor to visual disability in Brazil. Because visual impairment can have a detrimental impact on social and educational development in a child's life, exploration of cost-effective strategies to eliminate this easily treatable cause of visual impairment are warranted. These data are of potential importance to school and public health authorities in augmenting middle school health programs to incorporate vision testing. Strategies to detect children in need of glasses, to improve access to good-quality refractive services, and to provide availability of low-cost glasses should be pursued, to decrease avoidable visual impairment due to correctable refractive error.

Although health services research dealing with the delivery of eye care services is not envisioned, a follow-up project to examine refractive error progression and risk factors is planned. The assessment of risk factors will be based on parental, school, and child questionnaires. The emphasis will be on evaluating the amount of near work and outdoor activities before, during, and after the school period, as well as during weekends.

References

1. WHO. Global initiative for the elimination of avoidable blindness. Geneva, World Health Organization; 2000 (WHO/PBL/97.61 Rev. 2).
2. Negrel AD, Maul E, Pokharel GP, et al. Refractive error study in children: sampling and measurement methods for a multi-country survey. *Am J Ophthalmol*. 2000;129:421–426.
3. Pokharel GP, Negrel AD, Munoz SR, Ellwein LB. Refractive error study in children: results from Mechi Zone, Nepal. *Am J Ophthalmol*. 2000;129:436–444.
4. Zhao J, Pan X, Sui R, et al. Refractive error study in children: results from Shunyi District, China. *Am J Ophthalmol*. 2000;129:427–435.
5. He M, Zeng J, Liu Y, et al. Refractive error and visual impairment in urban children in southern China. *Invest Ophthalmol Vis Sci*. 2004;45:793–799.
6. Maul E, Barroso S, Munoz SR, et al. Refractive Error Study in Children: results from La Florida, Chile. *Am J Ophthalmol*. 2000;129:445–454.
7. Dandona R, Dandona L, Srinivas M, et al. Refractive error in children in a rural population in India. *Invest Ophthalmol Vis Sci*. 2002;43:615–622.
8. Murthy GV, Gupta SK, Ellwein LB, et al. Refractive error in children in an urban population in New Delhi. *Invest Ophthalmol Vis Sci*. 2002;43:623–631.
9. Naidoo KS, Raghunandan A, Mashige KP, et al. Refractive error and visual impairment in African children in South Africa. *Invest Ophthalmol Vis Sci*. 2003;44:3764–3770.
10. Goh PP, Abqariyah Y, Pokharel GP, Ellwein LB. Refractive error and visual impairment in school-age children in Gombak District, Malaysia. *Ophthalmology*. 2005;112:678–685.
11. He M, Huang W, Zheng Y, et al. Refractive error and visual impairment in school children in rural southern China. *Ophthalmology*. 2007;114:374–382.
12. Sapkota YD, Adhikari BN, Pokharel GP, et al. The prevalence of visual impairment attributable to refractive error and other causes in school children of upper-middle socioeconomic status in Kathmandu. *Ophthalmic Epidemiol*. 2008;15(1):17–23.
13. Instituto Brasileiro de Geografia e Estatística. *Estatcart: Sistema de Recuperação de Informações Georreferenciais*. Versão 2.0. Rio de Janeiro: IBGE; 2003.
14. StataCorp. *Stata Statistical Software*: Release 8.0. College Station, TX: Stata Corp.; 2003.
15. Saw SM, Chua WH, Hong CY, et al. Nearwork in early-onset myopia. *Invest Ophthalmol Vis Sci*. 2002;43:332–339.
16. Jones LA, Sinnot LT, Mutti DO, et al. Parental history of myopia, sports and outdoor activities, and future myopia. *Invest Ophthalmol Vis Sci*. 2007;48:3524–3532.
17. He M, Xu J, Yin W, Ellwein LB. Need and challenges of refractive correction in urban Chinese school children. *Optom Vis Sci*. 2005;82:229–234.