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The Prevalence of Visual Impairment in School Children of Upper-Middle Socioeconomic Status in Kathmandu

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Abstract

Purpose—Assess visual impairment in school children of upper-middle socioeconomic status in Kathmandu for comparison with rural Jhapa District.

Methods—Random selection of classes from secondary private schools in Kathmandu was used to identify the study sample. Children in 130 classes at 43 schools were enumerated using school records and examined between January–May 2006. Examinations included visual acuity testing, ocular motility evaluation, cycloplegic refraction, and examination of the external eye, anterior segment, media, and fundus. The principal cause was determined for eyes with uncorrected visual acuity ≤20/40.

Results—A total of 4,501 children in grades 5–9 were enumerated; 4282 (95.1%) were examined. The prevalence of uncorrected, presenting, and best-corrected visual impairment (≤20/40) in the better eye was 18.6%, 9.1%, and 0.86%, respectively. Refractive error was a cause in 93.3% of children with uncorrected visual impairment, amblyopia 1.8%, retinal disorders 1.3%, other causes 0.3%, and unexplained causes 4.4%. Among children correctable in at least one eye, 46.3% presented without the necessary spectacles. Visual impairment with myopia (−0.50 diopters) ranged from 10.9% in 10 year-olds to 27.3% in 15 year-olds, compared to 0.5%–3.0% in rural Jhapa District. Myopic visual impairment was associated with grade level, female gender, parental education, parental spectacle usage, and Mongol ethnicity.

Conclusions—Visual impairment with myopia among upper-middle socioeconomic school children in Kathmandu is higher than that in rural Nepal, and a public health problem because nearly half are without corrective spectacles. Effective strategies are needed to eliminate this easily treatable cause of visual impairment.

Keywords

Myopia; Nepal; school children; spectacles; visual impairment

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INTRODUCTION

In the global initiative "VISION 2020 The Right to Sight," childhood visual impairment and refractive error are highlighted as a priority area.[1] However, because of the requirement for additional resources and expertise, along with a general lack of authentic prevalence information, visual impairment among children in Nepal is currently not a priority in the planning of eye care services.

Uncorrected refractive error as the leading cause of visual impairment among school-age children has been documented in a series of population-based, multi-country Refractive Error Study in Children (RESC) surveys. Using standardized clinical methods and definitions.[2] surveys were conducted in rural Jhapa District in the eastern Mechi Zone of Nepal;[3] Shunyi District, a semi-rural area outside of Beijing in northern China;[4] La Florida, an urban area of Santiago, Chile;[5] rural Mahabubnagar District near Hyderabad in southern India;[6] an urban area within metropolitan New Delhi, India;[7] a semi-urban area of Durban, South Africa;[8] Guangzhou, a large metropolis in southern China;[9] Gombak District in metropolitan Kuala Lumpur, Malaysia;[10] and Yangxi County, in rural southern China.[11] This series of studies show that myopic refractive error is associated with the educational and socioeconomic status of the family, related possibly to reading and other near vision tasks pertaining to school performance.[12–14]

The RESC survey conducted in the Jhapa District of rural Mechi zone in 1988 was the only population-based survey of visual impairment and refractive error targeting school-age children (ages 5–15 years) in Nepal. The prevalence of uncorrected (unaided) visual acuity ≤20/40 in one or both eyes in Jhapa District was 2.9%, and the prevalence of refractive error measured with cycloplegic retinoscopy was 2.6%, or 3.3% with cycloplegic autorefraction. Another RESC study with low refractive error rates (children 7–15 years of age) was in Mahabubnagar District in Southern India.[6] In this rural area, with low school attendance rates as in Jhapa District, 5.0% of the children had visual impairment (≤20/40 in one or both eyes), and refractive error was found in 4.9% with cycloplegic retinscopy, or 6.3% with cycloplegic autorefraction. A third RESC survey in the Indian subcontinent was carried out in the Trilokpuri segment of New Delhi, among children 5–15 years, where the prevalence of visual impairment was 9.0%, and the refractive error prevalence was 15% based on cycloplegic retinoscopy, or 14.8% with cycloplegic autorefraction.[7]

An earlier school-based study of Nepalese school children ages 7–18 years found a myopia prevalence of 2.9% among Sherpa children in the Khumjung School in rural Solukhumbu region, and 21.7% for Tibetan children in the Srongtsen Bhrikuti boarding school in Kathmandu.[15] Similarly, a recent study of students 5–16 years of age from two private schools in Kathmandu found a refractive error prevalence of 21.9%.[16] Finally, initial data from a screening program to promote eye health among children attending poor schools in Kathmandu show a refractive error prevalence among children 5–16 years of 8.1 %.[17]

Although differences in measurement methods and definitions preclude direct comparisons between these Nepalese studies, it is apparent that the prevalence of refractive error in rural areas is substantially lower than that in the more urban settings of the country. Accordingly, the present study was motivated by an interest in investigating further the importance of these urban-rural differences and associated differences in socioeconomic status (SES). The focus was on examining children from families of upper-middle SES in urban schooling environments for direct comparison with findings from the low SES rural RESC survey in Jhapa District.

Because children in high SES families are likely to be attending school—at least through the high secondary level-a school-based sampling scheme was used, rather than logistically cumbersome, population-based sampling as in the previous RESC surveys. Further, to maximize contrast with Jhapa findings, the study was concentrated on children in the 10–15 year age range.

Clinical methods for the ocular examination, as well as definitions and analyses, were consistent with the RESC protocol ensuring straightforward comparisons with the Jhapa District data.

MATERIALS AND METHODS

Study population

The target population was children ages 10–15 years (grades 5 to 9) attending competitive, private schools in Kathmandu. The Nepal government categorizes private schools into A, B, C, and D level strata, where "A" level schools have the liberty to meet the highest fee structure ceiling. Accordingly, the study population was drawn from these secondary and higher secondary A-level schools in the Kathmandu valley. (Children begin secondary school at grade 5, usually between 10–11 years of age, with completion of higher secondary schooling five years later at grade 9.)

Sample selection

Stratified cluster sampling was used in selecting the study sample from the 60 secondary and higher secondary A-level schools in the Kathmandu valley. The sampling frame was constructed by listing grade-specific classes within each of the 60 schools. Based on Ministry of Education data, 4439 students were enrolled in 131 classes at the 5th grade level, 4665 were in 146 classes at the 6th grade level, 4826 were in 148 classes at the 7th grade level, 5152 were in 151 classes at the 8th grade level, and 4985 were in 151 classes at the 9th grade level. Thus, the sampling frame comprised 727 classes (clusters) with a total of 24,067 students. Stratification of clusters based on grade level was used to ensure that the 10–15 age range would have a reasonably uniform distribution within the selected sample.

Because the study population was being drawn from the most elite secondary schools in Kathmandu, it was anticipated that the prevalence of myopia would be higher than that found in the earlier studies in Kathmandu. Accordingly, the sample size was based on estimating a prevalence of 30% with a 15% error bound (30% ± 4.5%). With simple random sampling, 398 children would be required for each grade level. Assuming a 10% nonparticipation rate increases the required sample size to 438, and accounting for a two-fold increase in the sample because of inefficiencies associated with the cluster sampling design increases the sample size further to 876. With an average of 34 students per class (schools generally have anywhere from 20–50 students in each class), the sample size requirement is 26 classes for each of the five grade levels, for a total sample size of 130 classes with an expected 4420 students.

Enumeration and informed consent

Enumeration of students within each of the selected classes (child name, age, sex, parent/guardian name, caste and home address) was completed two or more days prior to the scheduled examination date. (Students absent from the school for more than one month were not included in the enumeration.) An invitation for the free eye examination at the school and an informed consent form for the parents/guardians were sent home with each enumerated child by school authorities. The communication included information on the objectives of the study, details regarding the eye examination, and a questionnaire requesting information on parental education and spectacle use for distance viewing.

Field operations

The study director identified appropriate field personnel for each study component, with intensive training to explain the purpose of the study, clinical methods and procedures, completion of data forms, and quality assurance procedures. Data management staff was trained in the use of data entry, data cleaning, and statistical analysis software. Pre-pilot and pilot exercises were conducted to ensure familiarity with all aspects of the protocol and measurement methods in a field setting. Monitoring and supervision was conducted throughout the period of fieldwork to circumvent unintentional protocol deviations.

Ocular examinations

The clinical team comprised one senior ophthalmologist and two ophthalmic assistants. Clinical examinations were conducted during the weekday while school was in session in temporary stations set-up in each school. Ophthalmic assistants tested visual acuity at 4 meters using a retro-illuminated log-MAR chart with tumbling-E optotypes (Precision Vision. Villa Park, Illinois). Children unable to read top line at four meters were moved to a one meter distance. Visual acuity was measured with the right eye and then the left eye, with and without glasses for those wearing them—representing presenting and uncorrected vision.

Binocular motor function was assessed with cover testing at both 0.5 and 4.0 meters. Corneal light reflex was used to quantify the degree of tropia. The anterior segment (eyelid, conjunctiva, cornea, iris, and pupil) was examined by the ophthalmologist with a torch light and slit lamp (SL-15. Kowa, Toyko, Japan).

For children with unaided visual acuity 20/40 or worse in either eye, pupillary dilation and cycloplegia was induced with 2 drops of 1% cyclopentolate, administered 5 minutes apart to each eye. After an additional 15 minutes if a pupillary light reflex was still present when observed with a bright torch light without magnification, a third drop was administered. Cycloplegia and pupillary dilation were evaluated after an additional 15 minutes. Pupils were considered fully dilated if 6 mm or greater, and cycloplegia was considered complete if pupillary light reflex was absent.

Cycloplegic refraction was performed with an autorefractor (Retinomax K Plus. Nikon. Japan) with daily calibration. Autorefraction was followed by subjective refraction and measurement of best corrected acuity. For those not consenting to the instillation of cycloplegic eye drops, and for those with incomplete cycloplegia, streak retinoscopy was used as the starting point for subjective refraction. Retinoscopy was carried out in a semi-dark room with the examiner at a distance of 0.75 meters and a +1.5 diopter lens in the trial frame.

Examination of the lens, vitreous and fundus was performed by the ophthalmologist, after cycloplegic dilation, with a slit lamp and direct/indirect ophthalmoscope. Recording of abnormal findings provided documentary evidence to support the subsequent assignment of a principal cause of impairment for eyes with uncorrected visual acuity of ≤20/40. Refractive error was routinely assigned as the cause for eyes improving to ≥20/32 with subjective refractive correction.

Children with vision ≤20/40 in both eyes improving with refractive correction were given prescription glasses free of charge. Those requiring medical treatment beyond what could be provided on-site were referred to nearest eye hospital.

Human subject approval for the original study protocol was obtained from the World Health Organization (WHO) Secretariat Committee on Research Involving Human Subjects. The Ethics Review Committee of Nepal Netra Jyoti Sangh in Kathmandu (the Nepalese society for comprehensive eye care) approved implementation of the study. The research protocol adhered to the provision of the Declaration of Helsinki for research involving human subjects.

Data management and analysis

Clinical examination data forms were reviewed for accuracy and completeness prior to computer data entry. Data ranges, frequency distributions, and consistency among related measurements were checked with cleaning programs. Statistical analyses were performed using Stata Statistical Software, Release 8.0.[18]

Normal/near-normal visual acuity was defined as acuity ≥20/32, with visual impairment categories defined as ≤20/40 to ≥20/63, ≤20/80 to ≥20/160, and ≤20/200. The later category was taken as blindness. The prevalence of visual impairment was calculated on the basis of uncorrected, presenting, and best corrected visual acuity measurements.

Myopia was defined as spherical equivalent (SE) refractive error of at least −0.50 diopter (D) and hyperopia as +2.00 D or more. Visually impaired 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. The prevalence of visual impairment *with* hyperopia and the prevalence of visual impairment *with* myopia were calculated by assuming that eyes with normal/near-normal vision were emmetropic. (This emmetropic assumption was needed to account for the fact that refraction data were generally not available for eyes with normal/near-normal vision.)

The association between myopic visual impairment and grade level (age), gender, parental education, parental spectacle usage, and ethnicity was explored with logistic regression. Parental education, based on the parent with the highest level of schooling, was categorized as none (no formal schooling), primary (1–5 years), secondary (6–10 years), higher secondary (11–13 years), and graduate (≥14 years). Ethnicity was grouped into Aryan, Mongol, Tibetan, and “Other” using parental surname/caste.

Confidence intervals and P values (significant at the $P < 0.05$ level) for prevalence estimates and regression were calculated with adjustment for clustering effects associated with the sampling design.[18] Sampling design effects are represented by a ratio (termed, deff) comparing the estimate of variance actually obtained with the generally smaller variance that would have been obtained had simple random sampling been used. Pair-wise interactions between regression model variables were assessed simultaneously using a Wald F test[18] and considered significant at the $P < 0.10$ level.

RESULTS

Study population

The random selection of 130 classes resulted in 43 of the 60 A-level schools in Kathmandu valley being included in the study. Field work was carried out between January 2006 and May 2006. A total of 4282 children were examined, representing 95.1% of the 4501 enumerated. Distributions of age, gender, and grade level of the enumerated and examined populations are shown in Table 1. (Because of relatively small numbers of 9 and 16 year old children, those 9 years of age were grouped with 10-year olds and children 16 years of age were grouped with 15 year olds.)

Visual acuity

Visual acuity findings are presented in Table 2. Uncorrected normal/near-normal visual acuity (≥20/32) in at least one eye was found in 3484 (81.4%) children. Seven hundred ninety-eight children (18.6%) had visual impairment (≤20/40) in both eyes, with 184 (4.3%) of these blind (≤20/200).

At the examination, 615 (14.4%) children were wearing spectacles (Table 2). Among the 798 with uncorrected visual acuity impairment in both eyes, 494 (61.9%) were with spectacles. With presenting vision, 409 of the 798 had normal/near-normal vision in at least one eye, leaving 389 (9.1% of those examined) with bilateral visual impairment—a 51.3% reduction over uncorrected vision. None were bilaterally blind with presenting vision.

With best measured vision, it was possible to further reduce bilateral visual impairment to 37 children (0.86% of those examined). Accordingly, 761 (95.4%) of the 798 children with bilateral visual impairment based on uncorrected visual acuity could achieve nonnal/near-normal vision in at least one eye with best correction. Stated another way, 46.3% (352 [389 minus 37]) of the 761 children who could achieve normal/near-normal vision in at least one eye were without the necessary correction.

Better eye visual acuity in females was poorer than that in males for uncorrected, presenting and best corrected measurements (Kolmogorov-Smirnov test; P < 0.001, P < 0.001. and P < 0.008, respectively).

Pupillary dilation and cycloplegia

Cycloplegic dilation should have been performed in 958 (22.4%) children, based on uncorrected visual acuity ≤20/40 in at least one eye. However, in 23 children the parents did not agree with cycloplegia, and in one child cycloplegic dilation was not attempted because of posterior synaechia. Among the 934 who were administered cycloplegic drops, pupillary dilation and cycloplegia (pupil diameter ≥6 mm and the absence of light reflex) was achieved in both eyes of 887 (95.0%) children. Another 40 children had complete cyloplegia but dilation <6 mm in both eyes, and four had complete cycloplegia in both eyes with dilation <6 mm in one eye. Three children had dilation ≥6 mm and incomplete cycloplegia in both eyes.

Refractive error

Autorefraction measurements were available for 853 of the 877 right eyes with visual impairment and for 856 of the 878 left eyes. Refractive error evaluation in the other 24 right eyes and 22 left eyes was based on subjective refraction measurements.

The prevalence of visual impairment with hyperopia was less than 1.0% within each grade level (and generally within each age group), for both boys and girls (Table 3). The prevalence of visual impairment with myopia increased from 9.5% among 5th graders to 26.8% in 9th graders. Prevalence was 16.8% in boys and 21.5% in girls.

Visual impairment with myopia was associated with increasing grade level (age), female gender, higher parental education, parental spectacle usage, and Mongol ethnicity (Table 4).

Astigmatism

Astigmatism ≥0.75 D was found in 209 (4.9%) right eyes and 224 (5.2%) left eyes (Table 5). Astigmatism in *either* eye was present in 319 (7.4%) children. In multiple logistic regression modeling with age and gender as covariates, astigmatism was associated with older age (OR. 1.15; 95% CI: 1.04–1.26) but not gender (P = 0.132).

Binocular motor function

Tropia was observed in three (0.07%) children: Two had esotropia, 15 to 30 degrees, at both near and distance fixation, and the third child had esotropia, <15 degrees, at near fixation only.

Causes of visual impairment

Among the 958 children with visual impairment. 798 were impaired in both eyes. Eighty were impaired in only the right eye and 80 in only the left eye. Refractive error was the cause of almost all visual impairment—884 (92.3%) of the 958 attaining normal/near-normal acuity in both eyes with refractive correction (Table 2). Ten additional children had correctable refractive error in one eye with an uncorrectable cause in the fellow eye, for a total of 894 (93.3%) with refractive error as the cause of impairment in at least one eye (Table 6).

Amblyopia, satisfying explicit criteria,[2] was the cause of visual impairment in 17 (1.8%) children: three with hyperopia ≥6.00 SE diopters; and 14 with anisometropia ≥2.00 SE diopters, including three with hyperopia ≥6.00 SE diopters. Retinal abnormalities were the cause in 12 children, including six children with high myopia and three with macular abnormalities. Lens opacity (cataract) was a cause of impairment in one child. Other causes of vision loss were uncommon: Traumatic aphakia with posterior synaechia was the cause in one child and sensory deprivation associated with bilateral congenital cataract operated late was the cause in another child. Seventy-three eyes of 42 children, generally with mild visual impairment, had no explanation for the impairment, including 22 eyes of 13 children where amblyopia was considered the principal cause by the examiner even though none of the explicit criteria were met.

DISCUSSION

In a sample of high socioeconomic status secondary school children in Kathmandu, we estimated the prevalence of visual impairment in 5th to 9th graders ages 9 to 16 years. These estimates pertain to children likely to be at highest risk for myopia; thus, they are not representative of the urban Kathmandu population as a whole. A relatively high prevalence of refractive error among children attending private Kathmandu schools was reported by others,[15,16] while lower rates were reported for school children from public schools in poor Kathmandu neighborhoods.[17]

The prevalence of visual impairment with myopia ranged from 10.9% in 9–10 year-olds to 27.3% in 15–16 year-olds, far above the myopia prevalence found in rural Jhapa District (which ranged from 0.5%–3.0%, respectively). Given the similar ethnic origins of the two populations, these comparisons underscore the significance of environmental influences on myopia development. The urban-rural differentials may be related to a combination of more time spent on near-work in top urban schools (associated with a greater emphasis on academic performance and intensity of schooling), less time on outdoor activities outside school hours, and low attendance rates for schooling beyond the primary level in rural areas. Outdoor activity in children has been shown to be negatively associated with myopia development, [20] and school attendance at the secondary level for ages 10–15 years is 28.4% in Jhapa district compared to 75.0% in Kathmandu valley.[21]

Urban-rural differences are also apparent in India by contrasting the 7.0%–10.8% prevalence of myopia (with cycloplegic retinoscopy) for children of ages 10–15 years in the urban New Delhi RESC survey with the 2.5%–6.7% prevalence for children of similar ages in the rural India survey.[6–7] The three RESC surveys conducted in China are also illustrative of urban-rural differences.[4,9,11]

Female gender was also a significant risk factor for myopia, paralleling what was found in RESC surveys conducted in Shunyi District, Guangzhou, Yangxi, and among Malay children in Kuala Lumpur.[4,9–11] It is possible that the gender differences in myopia prevalence are attributable, at least in part, to differences between boys and girls in the extent of involvement in (protective) outdoor leisure activities.[20]

The study also documents that, even among the upper SES families of Nepal, nearly half of children who could achieve normal/near normal vision with refractive correction are likely to be without the necessary spectacles. This unmet need for refractive correction is widespread, as previously reported.[3–11] Barriers to the use of corrective spectacles include: parental awareness of the vision problem, attitudes regarding the need for spectacles, spectacle cost, cosmetic appearance, and concerns that wearing glasses may cause progression of refractive error.[19] There is an apparent need for parental education programs along with effective strategies for providing school-based vision screening, quality optométrie services, and affordable spectacles, in Nepal as elsewhere.

With growing evidence that the type and years of schooling are important factors in myopia risk, it is also apparent that vision impairing myopia among school-age children in rural areas of Nepal will be on the increase as a consequence of increasing economic development and greater emphasis on schooling in rural settings. Similarly, even though the rate of myopic vision impairment was found to be relatively high among urban children in top Nepalese schools, it was considerably lower than that found in urban Guangzhou children,[9] and other East Asian populations.[22] Accordingly, Nepalese urban children are also likely to face an increasing risk of myopia in the years to come.

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Table 1

Distribution of Enumerated and Examined Populations by Age, Gender, Grade, Parental Education and Ethnicity

	Enumerated Population		
Age (yrs)*	**No. (%)**	**Percent Examined**	**Examined Population No. (%)**
10	431 (9.6)	94.0	405 (9.5)
11	634 (14.1)	95.7	607 (14.2)
12	917 (20.4)	94.7	868 (20.3)
13	1023 (22.7)	96.3	985 (23.0)
14	920 (20.4)	95.4	878 (20.5)
15	576 (12.8)	93.6	539 (12.6)
Gender			
Male	2409 (53.5)	94.6	2278 (53.2)
Female	2092 (46.5)	95.8	2004 (46.8)
Grade			
5th	886 (19.7)	93.9	832 (19.4)
6th	853 (19.0)	95.0	810 (18.9)
7th	896 (19.9)	96.0	860 (20.1)
8th	946 (21.0)	96.0	908 (21.2)
9th	920 (20.4)	94.8	872 (20.4)
Parental Education			
None	100 (2.2)	90.0	90 (2.1)
Primary	142 (3.2)	91.6	130 (3.0)
Secondary	300 (6.7)	95.3	286 (6.7)
Higher Secondary	1732 (38.5)	95.2	1649 (38.5)
Graduate	2224 (49.4)	95.5	2124 (49.6)
Missing	3 (0.1)	100.0	3 (0.1)
Ethnicity			
Aryan	2247 (49.9)	94.7	2128 (49.7)
Mongol	2016 (44.8)	95.6	1927 (45.0)
Tibetan	197 (4.4)	95.4	188 (4.4)
Other	41 (0.9)	95.1	39 (0.9)
All	4501 (100.0)	95.1	4282 (100.0)

* Twenty-five children of age 9 were grouped with age 10, and 78 children of age 16 were grouped with age 15.

Table 2

Distribution of Uncorrected, Presenting, and Best-Corrected Visual Acuity

Visual Acuity Category	Uncorrected Visual Acuity No. (%; 95% CI)	Wearing Glasses No. (%)*	Presenting Visual Acuity No. (%; 95% CI)	Best Visual Acuity No. (%; 95% CI)
≥ 20/32	3324	79 (2.4)	3704	4208
both eyes	(77.6; 75.7–79.6)	(86.5; 85.1–87.9)	(98.3; 97.9–98.7)	
≥ 20/32	160	42 (26.3)	189	37
one eye only	(3.7; 3.1–4.3)	(4.4; 3.7–5.1)	(0.86; 0.56–1.16)	
≤ 20/40 to ≥20/63	273	94 (34.4)	246	32
better eye	(6.4; 5.5–7.2)	(5.7; 4.9–6.6)	(0.75; 0.51–1.05)†	
≤ 20/80 to ≥20/160	341	224 (65.7)	135	5
better eye	(8.0; 6.9–9.0)	(3.2; 2.6–3.7)	(0.12; 0.04–0.27)†	
≤ 20/200	184	176 (95.7)	8	0
better eye	(4.3; 3.6–5.0)	(0.19; 0.08–0.37)†		
All	4282 (100.0)	615 (14.4)	4282 (100.0)	4282 (100.0)

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

†Confidence intervals were calculated using an exact binomial distribution instead of the normal approximation. Cluster design effects of 0.941, 0.976, and 0.997 are not reflected in the confidence intervals for exact binomial estimates. (Design effects ranging from 1.093 to 2.432 were taken into account in calculating confidence intervals for estimates based on the normal approximation.

Table 3

Prevalence of Visual Impairment with Refractive Error (One or Both Eyes) by Age, Grade, and Gender

	Children with Visual Impairment				
Children Age (yrs)‡	Hyperopia No. (%; 95% CI)*	Myopia No. (%; 95% CI)†	Emmetropia No. (%)	Children Without Visual Impairment No. (%)	Total No. Examined
10	4 (0.99; 0.27–2.51)	44 (10.9; 7.00–14.7)	11 (2.7)	346 (85.4)	405
11	5 (0.82; 0.27–1.91)	84 (13.8; 10.5–17.2)	20 (3.3)	498 (82.0)	607
12	5 (0.58; 0.19–1.34)	143 (16.5; 13.2–19.8)	23 (2.6)	697 (80.3)	868
13	12 (1.21; 0.63–2.12)	191 (19.4; 16.7–22.1)	32 (3.2)	750 (76.1)	985
14	3 (0.34; 0.07–1.00)	205 (23.3; 20.0–26.7)	16 (1.8)	654 (74.5)	878
15	3 (0.56; 0.11–1.62)	147 (27.3; 22.6–32.0)	10 (1.9)	379 (70.3)	539
Gender					
Male	20 (0.88; 0.54–1.35)	383 (16.8; 14.9–18.7)	53 (2.3)	1822 (80.0)	2278
Female	12 (0.60; 0.31–1.04)	431 (21.5; 19.0–24.0)	59 (2.9)	1502 (75.0)	2004
Grade					
5th	6 (0.72; 0.27–1.56)	79 (9.50; 6.94–12.1)	22 (2.6)	725 (87.1)	832
6th	7 (0.86; 0.35–1.77)	133 (16.4; 12.6–20.3)	24 (3.0)	646 (79.8)	810
7th	2 (0.23; 0.03–0.84)	168 (19.5; 15.0–24.1)	27 (3.1)	663 (77.1)	860
8th	9 (0.99; 0.45–1.87)	200 (22.0; 17.4–26.7)	27 (3.0)	672 (74.0)	908
9th	8 (0.92; 0.40–1.80)	234 (26.8; 23.4–30.3)	12 (1.4)	618 (70.9)	872
All	32 (0.74; 0.51–1.05)	814 (19.0; 17.8–20.2)	112 (2.6)	3324 (77.6)	4282

*Confidence intervals for all hyperopia estimates were calculated using an exact binomial distribution instead of the normal approximation with adjustments for sampling design effects, which ranged from 0.710 to 1.090.

†Design effects were taken into account in the calculation of confidence intervals for myopia estimates based on the normal approximation. Design effects ranged from 1.201 to 1.765 for age-specific estimates, 1.522 and 1.917 for gender-specific estimates, and 1.375 to 2.943 for grade-specific estimates.

‡Twenty-five children of age 9 were grouped with age 10, and 78 children of age 16 were grouped with age 15.

Table 4

Logistic Regression Models for Myopic Visual Impairment with Grade (Age), Gender, Parental Education, Parent With Glasses, and Ethnicity as Covariates

	Model with Grade	**Model with Age**
Grade	1.28; 1.19–1.38	—
Age	—	1.24; 1.16–1.33
Gender		
Male	reference	reference
Female	1.30; 1.10–1.54	1.38; 1.16–1.63
Parental Education	1.08; 0.97–1.20	1.14; 1.02–1.27
Parent Spectacle Usage	1.92; 1.60–2.30	1.92; 1.60–2.30
Ethnicity		
Aryan	reference	reference
Mongol	1.58; 1.31–1.92	1.54; 1.28–1.86
Tibetan	0.96; 0.60–1.53	0.85; 0.53–1.35
Other	0.78; 0.30–2.00	0.73; 0.29–1.84

Data are odds ratios with 95% confidence intervals adjusted for sampling design effects.

Table 5

Prevalence of Visual Impairment with Astigmatism

Cylinder Value (Diopters)	Right eye	Left eye	No. (%) Children*
< 0.75	4073 (95.1)	4057 (94.8)	3963 (92.6)
≥ 0.75 to < 1.50	150 (3.5)	156 (3.6)	230 (5.4)
≥ 1.50 to < 2.00	23 (0.6)	23 (0.5)	33 (0.8)
≥ 2.00	36 (0.8)	45 (1.1)	56 (1.3)
All	4282 (100.0)	4281 (100.0)	4282 (100.0)

*Astigmatism in children is categorized using the worse eye.

Table 6

Causes of Visual Impairment

Cause	Eyes with Uncorrected Visual Acuity 20/40 or Worse, No. (%) Right Eye	Left Eye	Children with Visual Acuity 20/40 or Worse, No. (%) (One or Both Eyes)*	Percent Prevalence in the Population (One or Both Eyes)*
Refractive error†	822 (93.6)	823 (93.7)	894 (93.3)	20.9
Amblyopia‡	6 (0.68)	12 (1.37)	17 (1.77)	0.40
Cataract/lens opacity	1 (0.11)	0 (0.0)	1 (0.10)	0.02
Retinal disorder	8 (0.91)	8 (0.91)	12 (1.25)	0.28
Other causes	2 (0.23)	1 (0.11)	2 (0.21)	0.05
Unexplained cause	39 (4.44)	34 (3.87)	42 (4.38)	0.98
Any cause	878 (100.0)	878 (100.0)	958 (100.0)	22.4

*Children with visual acuity ≤ 20/40 in both eyes may represent two different causes of reduced vision a different cause for each eye. Accordingly, the total of 968 children across all specific causes exceeds the 958 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 pathology was present.

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

§Includes 22 eyes of 13 children where the examining ophthalmologist concluded that amblyopia was the principal cause of impairment even though the amblyopia criteria were not met.