Refractive Error and Visual Impairment in Private School Children in Ghana


ABSTRACT

Purpose. To assess the prevalence of refractive error and visual impairment in private school children in Ghana.

Methods. A random selection of geographically defined classes in clusters was used to identify a sample of school children aged 12 to 15 years in the Ashanti Region. Children in 60 clusters were enumerated and examined in classrooms. The examination included visual acuity, retinoscopy, autorefraction under cycloplegia, and examination of anterior segment, media, and fundus. For quality assurance, a random sample of children with reduced and normal vision were selected and re-examined independently.

Results. A total of 2454 children attending 53 private schools were enumerated, and of these, 2435 (99.2%) were examined. Prevalence of uncorrected, presenting, and best visual acuity of 20/40 or worse in the better eye was 3.7, 3.5, and 0.4%, respectively. Refractive error was the cause of reduced vision in 71.7% of 152 eyes, amblyopia in 9.9%, retinal disorders in 5.9%, and corneal opacity in 4.6%. Exterior and anterior segment abnormalities occurred in 43 (1.8%) children. Myopia (at least −0.50 D) in one or both eyes was present in 3.2% of children when measured with retinoscopy and in 3.4% measured with autorefraction. Myopia was not significantly associated with gender (P = 0.82). Hyperopia (+2.00 D or more) in at least one eye was present in 0.3% of children with retinoscopy and autorefraction.

Conclusions. The prevalence of reduced vision in Ghanaian private school children due to uncorrected refractive error was low. However, the prevalence of amblyopia, retinal disorders, and corneal opacities indicate the need for early interventions.

Key Words: Ghana, myopia, refractive error, school children, visual impairment

Refractive error is one of the priority components of the VISION 2020 global initiative. Globally, 1.8 billion out of 2.3 billion people with refractive errors have access to an eye examination and affordable correction.1 The outstanding 500 million people who do not have access live in developing countries and nearly a third of this number live in Africa, many being children.3 Uncorrected refractive error is of widespread public health importance, affecting all ages. In children, uncorrected refractive error can impact on academic performance, career choice, or job opportunities. Refractive error, especially myopia, can have a negative impact on learning capability and educational potential. Despite the importance of correcting refractive problems in children, there is very limited information on the type and prevalence in Ghana. Data on refractive error prevalence and the utilization of corrective spectacles among school-aged children is necessary for eye health planning.

The Refractive Error Study in Children (RESC) protocol2—a population-based survey—was developed for school-aged children and has been utilized in Nepal,3 China,4 Chile,5 India,6,7 and South Africa.8 However, this study, utilizing the modified school-based version of RESC protocol developed by World Health Organization,9 reports on the assessment of refractive error and visual impairment in private and faith-based school attendees in Ashanti region of Ghana.

METHODS

Sample Selection

The Ashanti region is a centrally located area of Ghana with 21 administrative districts. It is the economic and cultural center
of Ghana, with a population of 3.6 million (2000 Census).\textsuperscript{10} Approximately 51.3\% of its people live in urban settlements and 47\% in rural areas. There are 530 health facilities in the region: 178 run by government, 71 by missions, and 281 which are privately owned. Primary school attendance rate is 88\%,\textsuperscript{11} and 80.0\% for junior secondary aged 12–15 years.\textsuperscript{12} Random cluster sampling was used to select the study population mapping a geographical corridor of Ashanti region. Using Kumasi as the center, seven districts were included taking into consideration the various geographical sub-regions of the Ashanti region and socioeconomic characteristics of the districts.

The modified standardized RESC protocol\textsuperscript{2} used in this study provides the minimum items required on the protocol that have direct relevance to study area, in line with available and affordable technology as in many developing parts of the world. The revisions are defining sampling clusters on the basis of schools/classes rather than geographic areas and requiring cycloplegic refraction only in children with reduced vision. The protocol is aimed at obtaining valid, core information for planning, implementation, and monitoring of refractions and other eye care services.

In this study, a cluster was defined on the basis of individual classes within each grade, and all children within a cluster were enumerated and included in the study sample. Cluster numbers were then assigned to each class in the schools listed in the seven districts. Thus there were 693 clusters in 160 private schools.

The main study was carried out following a random selection of 60 clusters from 53 private schools. The sample size was calculated as follows:

\[
N = \left( \frac{Z}{2} \right)^2 \left( 1.0 - P \right)P / \left( B \right) \left( P \right)^2,
\]

where \( P \) is the anticipated prevalence of myopia, \( B \) is the desired error bound, and \( Z = 1.96 \) for a 95\% confidence interval. In addition, a 10\% increment for non-response and Design Effect of 2 was considered, and the total number of participants was 2454.

**Field Operations**

Fieldwork for the main study occurred from January to September 2009. Cooperation from the Ministry of Education and Parents Teachers’ Association was solicited. Four enumerators were involved in the study. Two of them worked in advance of the team to seek support and consent from parents and headmasters of schools. Selected schools were individually visited by trained enumerators up to three times to verify name, gender, and date of birth. During these visits, the head of the school was informed about the details of the study including side effects of dilations during testing.

Children aged 12 to 15 years were enumerated by name, age (complete years), and gender. In addition, the children were given an identification slip for presentation at the examination. Eligible children were also given consent forms to take to their parents or guardians for approval. Detailed information regarding clinical examinations was included. Teachers of enumerated classes were also informed prior to the examination date. Enumeration of all children within each class (cluster) took approximately 2 hours.

**Clinical Examination**

Clinical examinations were conducted by four optometrists and one ophthalmologist in 37 temporary stations in school classrooms, community clinics, or community halls. Examination procedures followed the modified version of Refractive Error Study in Children (RESC) protocol.\textsuperscript{9} Only children with signed consent forms by parents were examined. However, children with signed consent forms who refused cycloplegic dilations were allowed to go and return later only if they consented to be examined.

Distance visual acuity was measured at 4 m using a retro-illuminated LogMar chart with tumbling-E optotypes and was recorded as the smallest line read with one or no errors. First, the right eye was tested and then the left eye—both without (uncorrected visual acuity) and with spectacle refractions (presenting visual acuity) only if the child brought them. A lensometer was used in measuring the lens power.

Cover test was evaluated by an optometrist at both 0.5 and 4 m. Heterotropias were categorized as exotropia, estrabismus, and vertical tropia. Examination of the anterior segment was performed by the team’s ophthalmologist with a magnifying loupe. In children with unaided visual acuity of 20/40 or worse in either eye, cycloplegic drops were used: two drops of 1% cyclopentolate eye-drops administered 5 minutes apart. After 20 minutes, if a pupilary light reflex was still present, a third drop was administered. The light reflex and pupil dilation were checked after an additional 15 minutes. Cycloglpa was considered complete if the pupil dilated to 6 mm or greater and a light reflex was absent (RESC).\textsuperscript{9} Cycloplegic refraction was performed first with a streak retinoscope (Welch-Allyn, Skaneateles, NY, USA) in a semi-darkened room at 67.0 cm and with a +1.5 D lens in the trial frame. The spherical and cylindrical power and axis necessary to neutralize the shadow movement were noted. The cycloplegic autorefraction was carried out using a handheld autorefractor (Retinomax K-Plus; Nikon, Tokyo, Japan). Calibration of the autorefractor was performed at the beginning of each working day. Using refraction measurement, best-corrected visual acuity with subjective refraction was determined. Refractive error was considered the cause of impairment in all eyes improving to better than 20/40 with refractive correction.

The eye examination was completed with slit lamp and direct ophthalmoscope examination of the lens, vitreous, and fundus. Eyes with best-corrected visual acuity of 20/40 or worse were assigned a principal cause of visual impairment. The cause of impairment was assigned according to the protocol.\textsuperscript{3} Treatment of minor ailments and corrective spectacles were provided at the examination centers free of charge. Children requiring additional medication and follow-ups were referred to the Teaching Hospital.

The approval of the study protocol was obtained from the WHO Secretariat Committee on Research Involving Human Subjects, and the ethics committee of the Kwame Nkrumah University of Science and Technology in Ghana. The research protocol adhered to the provisions of the Declaration of Helsinki for research involving human subjects.

**Pilot Study**

Fieldwork was preceded by training and a pilot exercise was conducted in three schools not included in the study. A total of 320 children were examined in the pilot study. Additional training was necessary because of the long period between the pilot study and the main study.

**Data Management and Analysis**

Class enumeration and clinical examination data forms were reviewed for completeness in the field before they were sent for data entry. Verification included checks on measurement data.
ranges, frequency distribution, and consistency between related measurements. Cleaned data was analyzed using statistical software (Stata Statistics Software, release 10).13 Confidence interval estimates were calculated using exact binomial distribution for very low prevalences.

Prevalence of visual impairment and blindness of uncorrected (unaided), presenting, and best-corrected visual acuity were calculated. The latter was based on subjective refraction for those with reduced uncorrected visual acuity. Thresholds of 20/40 or less, than 20/63, and 20/200 or less were used in defining visual categories. Myopia was defined as spherical equivalent refractive error of at least −0.50 D and hyperopia as +2.00 D or more. Age-specific prevalence of myopia and hyperopia were estimated in children with cycloplegia in both eyes. The association between myopia or hyperopia and the child’s age and gender were calculated. Confidence intervals were also calculated.

Quality Assurance

Children with uncorrected visual acuity of 20/40 or less and approximately 10% of those with normal vision or near normal vision selected in seven clusters were subjected to quality assurance by independent re-evaluation. The evaluation included visual acuity, retinoscopy, and autorefraction. Visual acuity was obtained from 141 children. Right eye measurements showed that 132 subjects had line-by-line agreement, nine differed by one line, and two differed by two lines. The left eyes showed that 124 subjects had line-by-line agreement, 14 differed by one line, and three differed by two lines.

Mean retest difference (the first measurements minus the second one) for cycloplegic retinoscopy were −0.01 ± 0.05 D (SD) in 141 right eyes and −0.01 ± 0.05 D (SD) in 141 left eyes. Neither difference was statistically significant from zero (paired t test, P = 0.86). The 95% upper and lower limits of agreement around mean difference were −0.01 to + 0.01 D. Similarly, reproducibility for autorefraction was comparable with mean test retest differences of +0.03 ± 0.12 D (SD) and +0.02 ± 0.12 D (SD) of 141 right and left eyes, respectively. Also, neither of these differences was significantly different from zero (paired t test, P = 0.52 and P = 0.72). The 95% limits of agreement for cycloplegic autorefraction were −0.03 to −0.05 D and −0.02 to +0.03 D.

RESULTS

Study Population

A total of 2454 children aged 12 to 15 years were identified within 60 clusters in 53 private schools. The age distribution of the enumerated population is shown in Table 1. Approximately 46.6% (1143) of the total were males. Examinations were possible in 99.2% of enumerated children.

Visual Acuity

Reliable visual acuity testing was possible in all but one child, and findings are presented in Table 2. Nine children wore glasses to the examination and six of them had normal vision without glasses. Uncorrected visual acuity of 20/32 or better in the better eye was found in 2346 (96.3%) children. According to the study definition, 119 children had vision impairment in one or both eyes and 89 (3.7%) children had vision impairment (uncorrected vision of 20/40 or worse in the better eye). Of the 89 children with vision impairment, only three (3.4%) were wearing glasses and achieved normal vision. Out of the remaining 86 children, 79 achieved normal vision after correction. There were two children; each of them had a blind eye. The blind eyes remained blind, even with best correction.

Cycloplegic Dilation

Using the criteria given in the protocol,9 cycloplegia was considered complete if pupillary dilation of at least 6 mm and absence of light reflex were achieved. Four hundred twenty (420) children who had visual acuity of 20/40 or worse in either eye underwent cycloplegic examination. Complete cycloplegia occurred in 174 right eyes and 164 left eyes. However, pupil dilation with light reflex present was achieved in 164 right eyes and 148 left eyes, while absence of light reflex without full pupil dilation was achieved in 22 right eyes and 32 left eyes. Hence, a total of 360 right eyes and 344 left eyes satisfied one or both criteria for “cycloplegia dilation.”

Refractive Error

Autorefraction measurements were obtained in 360 right eyes and 344 left eyes. Retinoscopy was possible in 339 right eyes and 338 left eyes. Retinoscopy result could not be obtained in the remaining eyes due to poor reflex in eyes with media opacities. Spherical equivalents (SE) refractive error measured with retinoscopy decreased with age from a median of +0.63 D in the right eyes of 12-year-olds to plano in 15-year-olds. Across all ages, the median SE refractive error was +0.13 D in boys and girls. Mean values were −1.1 ± 2.9 D (SD) in boys and −0.21 ± 1.71 D in girls. With autorefraction, median SE refractive error decreased from +0.83 D in 12-year-olds to 0.13 D in 15-year-olds. Median SE refractive error was 0.12 D in both boys and girls with mean values being −1.1 ± 2.9 and −0.21 ± 1.71 D, respectively. Findings were similar in the left eye. The prevalence of hyperopia ranged between 0.1 and 0.4% when measured with retinoscopy and autorefraction (Table 3). With retinoscopy, the prevalence of myopia ranged from 1.7% in 13-year-olds to 5.4% in 15-year-olds. With autorefraction, the prevalence of myopia was approximately 3.4%.

Myopia with retinoscopy and autorefraction was not significantly associated with gender (P = 0.82, chi-square). Statistical association was also not found with hyperopia. Significant

<table>
<thead>
<tr>
<th>Age</th>
<th>Enumerated n (%)</th>
<th>Undergone full examination n (%)</th>
<th>Undergone full examination within age group, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>282 (11.5)</td>
<td>281 (11.6)</td>
<td>99.6</td>
</tr>
<tr>
<td>13</td>
<td>667 (27.2)</td>
<td>660 (27.1)</td>
<td>98.9</td>
</tr>
<tr>
<td>14</td>
<td>751 (30.6)</td>
<td>746 (30.6)</td>
<td>99.3</td>
</tr>
<tr>
<td>15</td>
<td>754 (30.7)</td>
<td>748 (30.6)</td>
<td>99.2</td>
</tr>
<tr>
<td>All</td>
<td>2454 (100)</td>
<td>2435 (100)</td>
<td>99.2</td>
</tr>
</tbody>
</table>

Reliable visual acuity could not be obtained from one child in age group 15 years old.

VA indicates visual acuity
TABLE 2.
Distribution of uncorrected, presenting, and best-corrected visual acuity among participants

<table>
<thead>
<tr>
<th>Visual acuity category</th>
<th>Uncorrected VA n (%; 95% CI)</th>
<th>Wearing glasses n (%)</th>
<th>Presenting VA n (%; 95% CI)</th>
<th>Best VA n (%; 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/32 or better in the better eye</td>
<td>2346 (96.4; 94.18–97.94)</td>
<td>6 (0.3)</td>
<td>2350 (96.5; 94.18–85.90)</td>
<td>2427 (99.7; 98.89–99.96)</td>
</tr>
<tr>
<td>20/40 or worse in one eye only</td>
<td>30 (1.2; 0.83–1.75)</td>
<td>0 (0)</td>
<td>35 (1.4; 1.00–1.99)</td>
<td>9 (0.37; 0.17–0.70)</td>
</tr>
<tr>
<td>20/40 to 20/63 or better in the better eye</td>
<td>53 (2.17; 1.63–2.84)</td>
<td>3 (5.7)</td>
<td>50 (2.05; 1.43–2.58)</td>
<td>5 (0.21; 0.17–0.56)</td>
</tr>
<tr>
<td>20/80 to 20/160 or better in the better eye</td>
<td>29 (1.20; 0.78–1.71)</td>
<td>0 (0.00)</td>
<td>29 (1.19; 0.83–1.65)</td>
<td>3 (0.12; 0.02–0.36)</td>
</tr>
<tr>
<td>20/200 or worse in the better eye</td>
<td>7 (0.29; 0.12–0.60)</td>
<td>0 (0.00)</td>
<td>7 (0.29; 0.12–0.60)</td>
<td>2 (0.08; 0.01–0.30)</td>
</tr>
<tr>
<td>All</td>
<td>2435 (100.00)</td>
<td>9 (0.37)</td>
<td>2435 (100.00)</td>
<td>2435 (100.00)</td>
</tr>
</tbody>
</table>

VA indicates visual acuity.

astigmatism (0.75 D or more) was found in 15% of the right eyes and 13% of left eyes with retinoscopy, and in 12.8 and 14.3%, respectively, measured with autorefraction (Table 4). Therefore, significant astigmatism in either eye was present in 9.8% of children with retinoscopy and in 13.7% of children with autorefraction.

Measurement Agreement

Among the hyperopes, the retinoscopy and autorefraction measurements were consistent. In the younger age group, autorefraction produced more negative readings.

Ocular Abnormalities

Exotropia accounts for the higher proportion of tropia. Exotropia was present in 43 cases with near fixation and nine cases with distant fixation. Exterior and anterior segment abnormalities were observed in 42 (1.7%) of the 2435 children examined. Eyelid abnormalities were present in nine eyes of five (0.2%) children. Conjunctival abnormalities were present in 56 eyes of 28 (1.1%) children. Corneal abnormalities—mainly opacity—were found in seven eyes of five (0.2%) children. Pupillary abnormalities were present in three eyes of three (0.1%) children. Other segment abnormalities were observed in 11 eyes of 12 (0.5%) children. Abnormal lens was observed in one child. Fundus abnormalities, including optic atrophy and macular and retinal degenerations, were present in five eyes of five (0.2%) children.

Cause of Visual Impairment

Out of the 89 children with vision impairment, 79 were due to uncorrected refractive error and four were due amblyopia (best-corrected and pinhole visual acuity 20/40 or worse without any apparent cause). Two children each had vision impairment as a result of corneal opacity and retinal disorders (Table 5). Hence, the prevalence of children with vision impairment in the population was 3.66%.

Vision impairment due to refractive error was found in 89 children and amblyopia was found in 11 children. Four of the children had amblyopia in both eyes and seven children had vision 20/32 or better in one eye while amblyopic in the other eye. These seven children were considered to have normal vision according to the study definition (best-corrected VA of 20/40 or worse in the better eye).

DISCUSSION

A total of 2454 children were enumerated in this study of semi-rural and urban school-going children attending private and faith-based schools in Ghana. The age distribution was uniform except for 12-year-olds. The discrepancy in 12-year-olds was attributed to the endorsement by Ministry of Education, Parent Teachers Association, and perhaps older age groups in the study. However, the study observed that achieving adequate cycloplegia with cyclopentolate and tropicamide may have been more effective as reported by a few studies. Combining cyclopentolate and tropicamide may have been more effective as reported by a few studies.

While it is important to achieve complete cycloplegia for refraction, the

TABLE 3.
Prevalence of ametropia in children with cycloplegic dilatation in both eyes

<table>
<thead>
<tr>
<th>Age, yr</th>
<th>Number of children</th>
<th>Hyperopia Retinoscopy n (%); CI</th>
<th>Autorefraction n (%); CI</th>
<th>Myopia Retinoscopy n (%); CI</th>
<th>Autorefraction n (%); CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>281</td>
<td>1 (0.4); 0.1–0.8</td>
<td>1 (0.4); 0.1–0.8</td>
<td>6 (2.1); 0.8–4.6</td>
<td>13 (4.6); 2.5–7.8</td>
</tr>
<tr>
<td>13</td>
<td>660</td>
<td>1 (0.1); 0.0–0.3</td>
<td>1 (0.1); 0.0–0.3</td>
<td>11 (1.7); 0.8–3.0</td>
<td>15 (2.3); 1.3–3.7</td>
</tr>
<tr>
<td>14</td>
<td>746</td>
<td>2 (0.3); 0.03–1.0</td>
<td>3 (0.4); 0.1–1.2</td>
<td>20 (2.7); 1.7–4.1</td>
<td>27 (3.6); 2.4–5.2</td>
</tr>
<tr>
<td>15</td>
<td>748</td>
<td>2 (0.3); 0.03–1.0</td>
<td>2 (0.3); 0.03–1.0</td>
<td>41 (5.4); 3.9–7.2</td>
<td>27 (3.6); 2.4–5.2</td>
</tr>
<tr>
<td>All ages</td>
<td>2435</td>
<td>7 (0.3); 0.12–0.6</td>
<td>7 (0.3); 0.12–0.6</td>
<td>78 (3.2); 2.5–3.9</td>
<td>82 (3.4); 2.7–4.2</td>
</tr>
</tbody>
</table>

Myopia is defined as −0.50 D or less and hyperopia is defined as +2.00 D or greater.

CI indicates confidence interval.
study results reflect routine practice circumstance in which cyclopentolate is the drug of choice. Right and left eyes were assessed individually by autorefraction, retinoscopy, and subjective methods. The difference in values between methods was not statistically significant.

The prevalence of refractive error in the population was 3.25%. This is comparatively lower than the values reported for private schools in Nepal\textsuperscript{19,20} and in India.\textsuperscript{21} These values are also lower than the previously reported values of 7% and 11% for public schools conducted in Ghana.\textsuperscript{22,23} The difference may be due to methodological differences as the previous studies enrolled older children and did not use cyclopentolate. Non-cycloplegic refractions tend to produce more myopia and less hyperopia. In addition, both studies did not take into account random sampling method. Another study conducted in public school settings in rural Tanzania found the prevalence was even much lower at 1%.\textsuperscript{24}

Myopia has been associated with increased near work, higher socioeconomic group, and parental education.\textsuperscript{7,25-28} The results have demonstrated a higher prevalence of myopia among children of higher age group, which may be due to increase in near work activities. The prevalence of refractive error causing vision impairment in children (one or both eyes) was 3.7%, which is higher when compared to the population-based RESC study conducted in South Africa (1.8%). The difference might be due to the study population, whereby the Ghanaian study included older children in private schools as compared to the South African study with younger population.

The age range (12 to 15 years), though limited, showed a noticeable upward trend in the prevalence of myopia, beginning at ages 13 and 14 years as observed in other surveys—South Africa,\textsuperscript{8} Chile,\textsuperscript{5} and India.\textsuperscript{6} Cross-sectional surveys in older cohorts may be required to determine the extent to which age-related increase in myopia continues beyond 15 years of age.

Refractive error is the main cause of vision impairment among school-going children in several studies.\textsuperscript{21,23,29,30} Similarly, this study found refractive error to be the major cause of vision impairment in 69.4% of 157 eyes, and the difference in prevalence was not significant between males and females.

Only three out of 89 (3.37%) children with significant refractive errors and who needed glasses were wearing them. Lack of services and inappropriate refractive correction could account for the larger percentage needing spectacles but not having access to them. The high number of children with amblyopia and unexplained causes of vision impairment indicates the need for accessible interventions for children. The prevalence of corneal opacities and anterior segment abnormalities further emphasizes the need for primary eye care services, including health education and health promotion. Low vision services may be beneficial to those children who were still visually impaired after best correction. The dearth of refractive error data, the cost effectiveness, and potential high response rate were motivating factors for the study. Ghana; like most parts of Africa, has too few optometrists in the public service.\textsuperscript{31} Most qualified optometrists are in the private sector. These factors and the lack of awareness have contributed to huge unmet need for those who require spectacle corrections.\textsuperscript{22} The study also observed a high number of children with exotropia at near fixation. Further investigation may be required for better understanding of this observation.

The strength of the study lies in the adequate sample size, appropriate study method, and the high school-attendance rate. Also, the study provides reliable information for planning eye care services for school-going children in Ghana. The limitation of the study, however, is its inability to generalize the results to the entire population as it was confined to the private school settings with sample from limited age groups.

**Conclusion**

These data support the concept that vision screening of school children in developing countries can be useful in detecting avoidable causes of vision impairment and will make a significant public health contribution.
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