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Prevalence of vision impairment and refractive error in school learners in Calabar, Nigeria

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Background: Uncorrected refractive error could negatively affect learning and academic performance, there is still inadequate information for planning school health.

Aim: To determine the proportion of students with vision impairment because of uncorrected refractive error, and prevalent types among learners aged 10–18 years.

Setting: The study site included two of 18 local government areas of the Cross River State in Nigeria, with 23 public and mission secondary schools.

Methods: A two-stage cluster sampling method was used to enrol 4241 study participants from eight selected secondary schools.

Results: The prevalence of vision impairment (presenting visual acuity worse than 6/12) was 7.9% (95% confidence interval [CI]: 7.17% – 8.6%). The prevalence of vision impairment because of refractive error was 7.2% (95% CI: 6.41% – 7.96%) in the better eye. Astigmatism was the predominant type of refractive error with a prevalence of 4.2% (95% CI: 3.6% – 4.8%), followed by myopia (1.72%; 95% CI: 1.3% – 2.1%) and hyperopia (1.3%; 95% CI: 0.9% – 1.6%). There were statistically significant differences in proportions of female participants who presented with myopic astigmatism (30.8%; $p < 0.012$). Statistically significant difference in proportions was found in older (33.3%; $p < 0.0004$) and male (29.6%; $p < 0.0003$) participants who presented with hyperopic astigmatism compared to younger and female participants, respectively. Myopia accounted for 4.8% (95% CI: 4.2% – 5.5%) and was significantly higher in female participants (5.5%; $p < 0.033$).

Conclusion: Refractive error was the major cause of vision impairment and myopic astigmatism was the predominant type of refractive error among secondary school children in Calabar.

Keywords: vision impairment; school refractive errors; school myopia; school astigmatism; school children.

Introduction

Uncorrected refractive error (URE) is the leading cause of vision impairment (VI) across geographical settings around the world[1,2,3,4,5,6,7,8] and the second most common cause of blindness.[2] The World Health Organization (WHO 2008) estimates that 153 million people worldwide live with uncorrected distance vision, causing VI because of refractive errors (REs). Of these, 12.8 million are children aged 5–15 years.[3] In some countries where the standard protocol for the Refractive Error Study in Children (RESC)[4] aged 5–15 years was used, comparison between settings showed that the prevalence of RE varied across geographical settings,[1,2,3,4,5,6,7] and between urban or rural populations,[5,6] gender[1,5,7,8] and age groups.[1,6,8,9] Myopia (near sightedness) is the most common type of RE reported among school children.[6,7,8,9,10,11,12,13,14,15,16] In Asian children, myopia is the leading cause of VI in 80% of children.[1,5,10,11] Prevalence of RE though lower in children of African descent (ranging from 1.7% to 8.5%),[7,11,12] myopia still accounts for 35% – 65% of VI in African children.[13,14] Older children become more myopic, which is attributable to increasing near work demand in higher education.[5,7,8,10,11]

Hyperopia (or farsightedness) and astigmatism (distorted vision) are common REs in African children.[13,15] These forms of RE are associated with near vision difficulties and can impact negatively on learning, academic performance and even career prospects.[16,17] If left uncorrected, RE can lead to poor academic performance and increase school dropout rates.[18] The long-term educational and socio-economic implications of VI because of uncorrected RE may include poverty, limited career choices and poor social interaction.[19,20] A critical factor is that children will develop amblyopia if intervention to correct RE is not performed early enough, before the age of 12 or 13 years,[21,22] after which amblyopia cannot be corrected with spectacles.

School-based studies are less expensive in that a large number of children can be more easily included in a structured environment as compared to other population-based studies. Also, in Cross River State (Nigeria), as the school attendance in the urban and semi-urban areas has improved since 2010,[23] school-based studies can reach the majority of students.

To estimate the prevalence of visual impairment in school children and RE types, the Refractive Error Study in School Children (RESSC) protocol[24] recommends the following tests: visual acuity (VA), cycloplegic refraction and dilated fundus examinations.[11,25] Visual acuity tests measure central vision, that is the eye's ability to discriminate shapes and objects at a specified distance.[26] As part of a comprehensive eye examination, VA tests were used for diagnosis of eye condition, REs and to assess change in vision.[27] Cycloplegic refractions produced refractive states of greater validity. In younger populations, cycloplegic refraction is recommended best practice.[24] Studies have shown that without the use of cycloplegic agents, refraction outcomes have a tendency towards myopic shift, overcorrection of myopia and under-correction of hyperopia.[28] The advantage of the dilated pupils is that it permits wider viewing of the internal structures of the eye.

Table 1 shows school-based prevalence studies in Nigeria by study age groups, methods used and results obtained.

Among South African children, myopia prevalence increased from 6.3% in 14-year-olds to 9.6% in 15-year-olds.[7] Other risk factors associated with developing myopia included reading for more than 4 h per day, or playing computer, video or mobile games for more than 2 h per day,[32] parental myopia[25] and living in urban areas.[32,33] Myopia is a public health concern, yet there has been no evidence for planning RE services targeting 10–18-year-olds who are at higher risk of developing myopia and other forms of RE. Planning effective RE services require age-specific information on types of RE, and thus, this study was conducted to determine the prevalence of VI and RE in learners aged 10–18 years in Calabar, South-South region of Nigeria.

Methodology

Study area

Two out of 18 local government areas (LGA), Calabar Municipal and Calabar South, LGAs of Cross River State in Nigeria with a total population of 800 000 people,[34] were selected because of their proximity to each other. Both LGAs share similar ethnicities and occupation, although as the capital city, Calabar municipality is urban and Calabar south is semi-urban. In total, there are 23 public and mission secondary schools in the 21 administrative wards of the study area.

Study design

This was a cross-sectional, school-based descriptive study of secondary school learners aged 10–18 years from two LGAs of Cross River State in the South-South region of Nigeria.

Sample selection

The study sample was obtained through a two-stage cluster sampling: The sampling design firstly included a simple random sampling from a sampling frame of 21 wards to select eight wards and a second-stage random sampling to select one school from each selected ward. A total of eight (39%) government and mission schools were selected; five in urban and three in semi-urban areas. Private schools were excluded as they were not under full control of government. All learners in the selected schools (excluding final-year students) aged 10–18 years were eligible to participate in the study.

The sample size was based on an estimated prevalence of RE of 5% from a previous study,[30] which had used cycloplegia to determine RE. The significance level was 5%, an allowance of 0.05 alpha error and a study power of 80%. The calculated sample size was 1900. Taking into consideration cluster sampling design effect of 2, the sample size was doubled to 3800. The sample size was increased by 10% for non-response rate resulting in the final minimum sample size of 4180 children.

Informed consent and ethical approval

The Cross River State Ministry of Education granted permission and informed all principals of the selected schools prior to commencement of the field work. Informed consents were obtained from parents of the child in addition to verbal assent from children prior to data collection.

Ophthalmic examinations and management

Each learner was registered with a participant number and demographic information was obtained by two trained

TABLE 1: Findings of school-based prevalence studies conducted in various regions in Nigeria.

Author	Year	Sample size	Age group (years)	Cycloplegia Yes or No	Prevalence RE (%)	Percentage corrected vision with spectacles	Regions
Faderin et al.[15]	2001	919	6–15	No	7.3	No data	Lagos, SW
Chuka-Okosa[29]	2005	355	12–22	No	1.97	No data	Enugu, SE
Ajaiyeoba et al.[13]	2007	1144	4–24	Yes	5.8	3%	Ilesha, SW
Abah et al.[14]	2011	327	5–17	No	8	3.10%	Zaria, NC
Ayanniyi et al.[30]	2013	1393	4–15	No	6.9	No data	Ilorin, SW
Baralabe et al.[31]	2015	614	11–20	No	4.8%	10%	Birin-Kebbi, NW

Note: All the studies in Nigeria except that of Faderin et al.[14] found myopia to be the most common type of refractive error, accounting for 35% – 60%[14,30,31] of vision impairment in childhood. The risk of developing myopia increases at age 10–12.[8,10,25]

RE, refractive error; SE, South East; SW, South West; NW, North West; NC, North Central.

personnel, including learner names, dates of birth, gender and current or previous spectacle use. Four trained ophthalmic assistants conducted vision screening tests on eligible participants at 4 m, using a tumbling E Log-MAR chart (Precision Vision, Villa Park, IL, United States [US]). The results for the VA were converted and reported in 6 m equivalents. Vision was checked at the 6/9 line. If the child correctly read the 6/9 line, a 2 D (dioptre) sphere lens was used to re-test vision using the 6/24 line. A participant who failed the 6/9 line or passed the 6/24 line was included for the full eye examination. Participants who failed the screening tests were requested to obtain signed consent letters from their parents to permit the use of cycloplegic eye drops for full eye examination. Refractive Error in School Children Protocol and Manual of Procedures[24] was used as a guide to conduct the visual assessments. Also, in the study team, there were four experienced optometrists and each performed specific tasks. Study optometrist 1 examined the anterior segment (eyelids, cornea, conjunctiva and pupil) using a flashlight. Study optometrist 2 performed cycloplegic refraction using the following regimen: two drops of 1% cyclopentolate eye drops administered 5 min apart onto each eye, followed by two drops 0.5% tropicamide eye drops. The combination is known to be effective for the dark irises of African eyes.[35] Cycloplegic autorefraction was then performed with an NIDEK autorefractor. Prior to use, calibration checks were performed according to the manufacturer's manual – the steel ball is installed on the chin rest and set to refractor mode, while keeping autofocus on to focus correctly, and then removed and using the joystick to take three measurements for each eye. The right eye is measured first, and next the left eye.[36] A third optometrist conducted a subjective refraction the next day to determine the best corrected visual acuity (BCVA) using the autorefraction measurement as the starting point.[37] The prescription dispensed was that which produced the BCVA. Visual acuity for each eye was measured as the lowest line on which four of five optotypes were read correctly on the Log-MAR chart. Dilated fundus examination was performed by the paediatric optometrist and principal investigator. The principal cause of VI was recorded as per the results obtained. Refractive error was assigned as the cause if acuity improved to 6/9 or better with subjective refractive correction with or without pinhole. Medical treatment for minor ophthalmic problems was provided at no cost and participants who required further management were referred to the University Teaching Hospital, or other eye clinics. Participants were instructed to report to the school's health teachers if they experienced any visual problems. Uncorrected RE causing VI was defined as: hyperopia if spectacle prescription was 2 D or worse, myopia as -0.50 D or worse and astigmatism as -0.75 D or worse.[1,3,38] All participants who met the criteria were provided spectacles free of charge. World Health Organization International Classification of Disease II (2018) for distance VI was used to define the following: mild visual impairment (MVI) as VA < 6/12–6/18, moderate vision impairment (MVI) as VA < 6/18–6/60, severe visual impairment (SVI) as VA < 6/60–6/120 and blindness as VA < 3/60 or 6/120.[39,40] Refractive errors were classified in terms of types and severity: myopia was mild (0.75–3.00 D), moderate (> 3–6 D) and high (> 6 D).[41] Hyperopia was mild (≤ 1.75 D), moderate (2–3.75 D) and high (> 4 D),[24] and astigmatism was mild (0.75 D), moderate (1–2 D) and high (> 2 D).[11]

Data management

Data forms were reviewed in the field for completeness before submitting for data entry. The data were entered into a Microsoft Excel 2007 spreadsheet by a data clerk and validated by re-checks for possible data entry errors. The IBM SPSS Statistical Package for Windows, version 24.0 (IBM Corp, Armonk, New York, US)[42] was used for analysis. The calculations were based on subjective refraction for those with reduced uncorrected VA. Thresholds of 6/12 or worse, worse than 6/18 and 6/120 or worse were used in defining VA categories. Descriptive statistics were used to report prevalence, frequency distributions and demographic categories. Refractive errors were analysed by types and spherical equivalents: firstly, in categories of myopia, hyperopia and astigmatism and sub-categorised as myopia, myopic astigmatism, hyperopic and hyperopic astigmatism and simple astigmatism. Secondly, myopia was defined as spherical equivalent RE of at least 0.50 D and hyperopia as 2 D or greater. Age- and gender-specific prevalences of myopia and hyperopia were estimated. Ninety-five per cent confidence interval (CI) estimates were calculated using exact binomial distribution for very low prevalence. Logistic regression was conducted to explore association of demography and characteristics such as age and gender with REs (myopia, hyperopia and astigmatism). The principal cause of ocular morbidity was categorised using the criteria set out in the RESC protocol.[4] Confidence intervals and *p*-values (significant at $p < 0.05$) were used for the interpretation of findings. The cause of VI was assigned as RE if vision was corrected to 6/9 or better with best subjective refraction with or without disease condition. Amblyopia was assigned if an isometropia (unequal powers of RE in the two eyes) or bilateral ametropia (RE present in the two eyes) was present and contributing to reduced vision of two or more lines. Cataract was assigned if a lens opacity was present without underlying co-morbidity and no improvement in VA with pinhole. Cases of uncorrectable vision loss in the absence of any organic lesion were assigned as being of unexplained causes if they did not meet any of the criteria.

Ethical considerations

The ethical clearance to conduct this study was obtained from Cross River State Ministry of Health (ethical clearance number: CRS/MH/HREC/017/Vol.V1/020).

Results

A total of 4241 participants from eight secondary schools were screened in October and November 2018. The majority of the learners (49.7%; 95% CI: 48.2% – 51.2%) were aged between 13 and 15 years with a mean age of 13.26 years [standard deviation (s.d.) ±1.9 years]. There were more female participants (51.3%) and a higher proportion (59.0%) were in junior classes (Table 2).

Visual acuity

Of the number screened, 3904 (92.1%) learners had normal vision (6/9 or better) in the better eye. Although 10 learners reported to have used spectacles before, none of them were wearing them at the time of the examination. Table 3 shows the distribution of uncorrected VA and best corrected acuity. The prevalence of VI (presenting vision worse than VA 6/12) was 7.9% (95% CI: 7.17% – 8.6%), of which 6.2% (95% CI: 5.5% – 6.9%) had MVI, low vision was 1.5% (95% CI: 1.2% – 1.9%) and blind was 0.2% (95% CI: 0.07% – 0.3%). With the best correction, no learner remained blind, the number of participants with MVI was reduced from 263 to 21 (0.5%; 95% CI: 0.2% – 0.7%) and the number of participants with low vision was reduced from 65 to 8 (0.2%; 95% CI: 0.05% – 0.3%).

Causes of visual impairment

In participants with impaired vision, RE was the main cause in 91.3% (95% CI: 88.4% – 94.3%), followed by amblyopia in 4.1% (Table 4).

Refractive error

Subjective findings following cycloplegic autorefraction[37] were used as final refraction results. Prevalence of VI because of RE was 7.2% (95% CI: 6.41% – 7.96%). Astigmatism was the predominant type of RE with a prevalence of 4.2% (95% CI: 3.6% – 4.8%), followed by myopia (1.72%; CI: 1.3% – 2.1%) and hyperopia (1.3%; 95% CI: 0.9% – 1.6%). More female than male participants presented with myopic astigmatism (30.8%, $p = 0.012$), while older participants (33.3%, $p < 0.0004$) and male participants (29.6%, $p < 0.0003$) presented with hyperopic astigmatism (Table 5).

In terms of magnitude, 85% of participants with VI had astigmatism greater than 1.0 D, and 41.55% presented with moderate astigmatism (1.0–2.0 D, $p = 0.017$), as shown in Table 6. Mild astigmatism was associated with younger female participants (19.6%, $p < 0.03$), while moderate astigmatism defined as 0.75 D was predominantly found in male participants (80.8%, $p < 0.017$).

As shown in Table 7, reusing spherical equivalent (calculated by adding the sum of the sphere power with half of the cylinder power)[43] showed myopia accounted for 4.8% (95% CI: 4.2% – 5.5%) and was significantly higher in female participants (5.5%; $p < 0.033$) than in male participants, and in urban (70%, CI: 63.1% – 76.2%) than in semi-urban (30%; 95% CI: 23.8% – 36.9%) schools. Myopia did not increase with age, although the myopia rate was higher in children aged 13–16 years, with a spike at age 11 (6.5%; 95% CI: 4.6% – 8.9%). The prevalence of hyperopia was 2.4% and the highest proportions (3.1%) were the same for both ages 14 years (95% CI: 2.0% – 4.1%) and 17 years (95% CI: 0.9% – 7.9%). The gender difference was found to be statistically insignificant for hyperopia in the study participants ($p = 0.44$).

TABLE 2: Demographic distribution of learners.

Characteristic	Examined children		95% confidence interval	Mean (years)
	N	%		
Age in years				13.26 ± 1.90
10–12	1580	37.3	35.8–38.7	
13–15	2108	49.7	48.2–51.2	
16–18	553	13.0	12.0–14.1	
Sex				-
Male	2064	48.7	47.2–50.2	
Female	2177	51.3	49.8–52.8	
Class level				-
Junior	2502	59.0	58.5–60.5	
Senior	1739	41.0	39.5–42.5	
Location				-
Semi-urban	2090	49.3	47.8–50.8	
Urban	2151	50.7	49.2–52.2	

TABLE 3: Distribution of uncorrected visual acuity and best corrected visual acuity.

VA category	UCVA	BCVA	*p*
Normal (6/9 or better in both eyes)	3904 (92.1)	4212 (99.3)	< 0.0001
Mild VI (< 6/12–6/18)	263 (6.2)	21 (0.5)	< 0.0001
Low vision† (< 6/18–6/120)	65 (1.5)	8 (0.2)	< 0.0001
Blind (< 6/120 better eye)	9 (0.2)	0 (0.0)	< 0.0017

Log-MAR conversion to Snellen (in metres) were: 0.2 (6/9), 0.3 (6/12), 0.5 (6/18), 1.3 (6/120 or 3/60).

UCVA, uncorrected visual acuity; BCVA, best corrected visual acuity; VA, visual acuity; VI, vision impairment.

†, Low vision defined as combination of moderate VI and severe VI: MVI (VA worse than 6/18–6/60), SVI (VA worse than 6/60–6/120) and blind (VA < 6/120 or 3/60).

Discussion

The study assessed the RE and visual impairment of school-going children aged 10–18 years in two LGAs of Cross River State, Nigeria. The findings of the study showed that the prevalence of VI was 7.9% higher than reported by other studies conducted in Africa, Tanzania[12] and Ghana.[11] The difference may be attributed to, firstly, the use of the 2 D lens in screening, and may have identified more participants with hyperopia which otherwise may have been missed, and secondly, the combined regimen for cycloplegia may have also contributed to more REs identified – although the prevalence was lower compared to the findings of related studies in Vietnam,[44] rural southern China[5,45] and Saudi Arabia.[46] Studies have suggested that these differences may be as a result of genetic,[25] environmental[32] and lifestyle factors.[33] The study also found 0.2% of the children who were

TABLE 4: Causes of vision impairment (visual acuity < 6/12 in better eye).

Causes	Best corrected VA	
	n	%
Refractive error	308	91.3
Amblyopia	14	4.1
Cataract	1	0.3
Retinal disorder	4	1.2
Other causes	5	1.5
Unexplained causes	5	1.5
Any cause	337	99.9

VA, visual acuity.

TABLE 5: Distribution of refractive error by type, age and gender.

RE type	Age (years)				*p*	Sex				*p*
	10–14		15–18			Male		Female		
	N	%	*N*	%		*N*	%	*N*	%	
Myopia	53	25	20	20.8	0.4258	39	25.7	34	21.8	0.4254
MA	57	26.9	19	19.9	0.181	28	18.4	48	30.8	0.012
Hyperopia	39	18.4	16	16.7	0.7136	28	18.4	27	17.3	0.7987
HA	33	15.6	32	33.3	0.0004	45	29.6	20	12.8	0.0003
SA	30	14.2	9	9.4	0.243	12	7.9	27	17.3	0.013
Total	212	100	96	100	-	152	100	156	100	-

MA, myopic astigmatism; HA, hyperopic astigmatism; SA, simple astigmatism (astigmatism in which one of the meridians is plano); RE, refractive error.

TABLE 6: Distribution of refractive errors by age and gender.

Refractive error type	Age (years)				*p*	Sex				*p*	Total
	10–14		15–18			Male		Female			
	n	%	*n*	%		*n*	%	*n*	%		
Myopia†											
0.75–3 D	46	86.8	18	90.0	0.7101	32	82.1	32	94.1	0.1178	64
> 3–6 D	5	9.4	1	5.0	0.5384	4	10.3	2	5.9	0.4973	6
> 6 D	2	3.8	1	5.0	0.8139	3	7.6	0	0.0	0.0986	3
Total	53	100.0	20	100.0	-	39	100.0	34	100.0	-	73
Hyperopia‡											
≤ 1.75 D	21	53.8	10	62.5	0.5567	16	57.1	15	55.6	0.9055	31
2–3.75 D	16	41.0	5	31.3	0.4979	11	39.3	10	37.0	0.8638	21
> 4.00 D	2	5.1	1	6.3	0.8679	1	3.6	2	7.4	0.5311	3
Total	39	100.0	16	100.0	-	28	100.0	27	100.0	-	55
Astigmatism¶											
0.75 D	24	18.2	3	6.2	0.0474	6	8.2	21	19.6	0.0353	27
1–2 D	92	69.7	36	75.0	0.4876	59	80.8	69	64.5	0.0176	128
> 2 D	16	12.1	9	18.8	0.2554	8	11.0	17	15.9	0.348	25
Total	132	100.0	48	100.0	-	73	100.0	107	100.0	-	180

D, dioptre.
†, Mild (0.75–3.00 D), Moderate (>3.00–6.00 D), High (> 6.00 D).
‡, Hyperopia = Mild (≤ 1.75 D), Moderate (2.00–3.75 D), High (> 4.00 D),
¶, Astigmatism = Mild (0.75 D), Moderate (1.00–2.00 D), High (> 2.00 D).

TABLE 7a: Proportion of participants with refractive error by age by spherical equivalents.

Age (years)	Total screened	Myopia		95% CI	Hyperopia†		95% CI	Spectacle need†	
		n	%		*n*	%		*n*	%
10	327	13	4.0	2.1–6.7	6	1.8	0.7–4.7	19	5.8
11	550	36	6.5	4.6–8.9	13	2.4	1.3–4.0	50	9.1
12	703	26	3.7	2.4–5.4	18	2.6	1.5–4.0	44	6.3
13	793	36	4.5	3.2–6.2	15	1.9	1.0–2.1	52	6.6
14	699	37	5.3	3.8–7.2	22	3.1	2.0–4.1	59	8.4
15	616	24	3.9	2.5–5.7	13	2.1	1.1–3.6	37	6.0
16	391	23	5.9	3.8–8.1	11	2.8	1.4–5.0	34	8.7
17	127	7	5.4	2.2–11	4	3.1	0.9–7.9	11	8.7
18	35	1	2.9	0.07–14	1	2.9	0.07–4.9	2	5.7
Total	**4241**	**203**	**4.8**	**4.2–5.5**	**103**	**2.4**	**2.0–3.0**	**308**	**-**

Myopia and hyperopia with astigmatism were converted into spherical equivalent.
CI, confidence interval; RE, refractive error.
†, Total need for spectacle correction per age.

TABLE 7b: Proportion of participants with refractive error by location by spherical equivalents.

Location	Myopia		95% CI	Hyperopia†		95% CI	Spectacle need†	
	n	%		*n*	%		*n*	%
Urban	142	70.0	63.1–76.2	57	55.3	45.2–65.1	-	-
Semi-urban	61	30.0	23.8–36.9	46	44.7	34.9–54.8	-	-

Myopia and hyperopia with astigmatism were converted into spherical equivalent.
CI, confidence interval; RE, refractive error.
†, Total need for spectacle correction per age.

blind (as defined by WHO 2018, VA < 3/60 in better eye)[40] similar to the findings reported by Isawumi et al.[47] In this current study, none of the participants remained legally blind after refraction, which indicates the need for organised school eye health activities to identify children with vision problems for timely intervention.

Refractive error was the main cause of VI at 91.3% of study participants, similar to the findings in other studies.[5,10,25,44] Uncorrected refractive error prevalence was 7.2%, similar to the findings of other studies conducted in urban schools in Nigeria by Abah et al., (8.0%) [14] and Faderin et al. (7.3%)[15] carried out in Zaria and Lagos, respectively. Although Ayanniyi et al.[30] reported a slightly lower prevalence of RE (6.7%), the study population was younger primary school children in South West Nigeria. Much lower URE prevalences of 1.7%[29] and 2.2%[48] have also been reported in Southern Nigeria, which could be because of the subjects in their studies being younger and from a rural setting, respectively. Lower RE prevalences have been associated with rural compared with urban areas in India,[49,50] China[5] and Cambodia.[6] The URE prevalence found in this study was higher than those reported in Ghana (3.4%),[11] Tanzania (1.8%)[12] and Cambodia.[6]

The prevalence of astigmatism in the study population was 4.2%, while that of moderate astigmatism (1.0 DC or greater) was 3.6%. Over half of the children with VI presented with astigmatism. This finding suggests that there is a predominance of significant astigmatism (0.75 DC) as a cause of VI in the study population. Myopic astigmatism was the most common (24.7%) and more females than males had this type of astigmatism. Czepita et al.[51] also found more women than men with astigmatism in their study that investigated the role of gender in the occurrence of REs.[52] Perhaps, the higher myopic astigmatism may be a consequence of higher myopia prevalence in women. Our study also found older male participants to have hyperopic astigmatism, which may be as a result of the significantly higher moderate astigmatism found among the male participants.

In terms of magnitude of RE, moderate astigmatism was predominantly in male participants and mild astigmatism was predominantly in younger female participants. Astigmatism greater than 1.0 D constituted almost half (49.7%) of the children who required spectacle correction. These findings suggest the need to incorporate the use of astigmatic lenses into RE service delivery plans for learners to fully address the visual needs of a large proportion of children who need spectacles. In this study, 10 participants reported that they had spectacles but were not wearing them at the time of examination. Other school-based studies conducted in Nigeria had reported low spectacle correction of 3% – 10%[13,14,31] among participants examined. There is urgent need to develop strategies to improve access to refractive services and spectacles including dispensing of custom-made spectacles incorporating required astigmatic corrections for improved spectacle uptake.

The prevalence of myopia in this study was 4.8% (5.9% at 16 years), similar to findings reported in a global myopia trends publication which estimated myopia prevalence of 5.5% among African children.[33] However, our finding was higher than reports from school-based studies in Nigeria,[15] Africa[11] and Cambodia.[6] The prevalence of myopia was significantly higher in urban (70%, CI: 63.1–76.2) than in rural (30%, CI: 23.8–36.9) schools, a result similar to other studies.[6,25,44] We speculate that this finding may be associated with the difference in urban lifestyle and environment of Calabar municipality compared with semi-urban Calabar South. The risk of developing myopia among urban dwellers includes sedentary lifestyle, increased near work and fewer hours spent outdoors.[52,53] Our study also found higher prevalence of myopia in female participants compared to male participants (5.5% vs. 4.1%, $p < 0.033$) which is similar to other studies.[5,25,46,54] This could possibly suggest that female participants in this study may be more exposed to activities associated with increased risk of developing myopia.

Hyperopia was found in 2.4% of the study population, and 3.1% of 14- and 17-year-olds. This is contrary to findings of O'Donoghue et al.,[55] who reported a decrease in hyperopia with age. In our study, there was no statistically significant association between the prevalence of hyperopia and age or gender, unlike the findings of Czepita et al.,[51] who reported that hyperopia occurred more frequently in boys. We speculate that the sample size of this current study may not have had adequate power to observe the trends in age or gender.

Amblyopia (4.1%) was the second most important cause of VI, a result that is markedly different from other studies.[6,10,25,44,56] This finding suggests the need for early intervention to reduce the high rate of amblyopia. Many (93.5%) with VI had never had an eye examination, and 3.25% had previously received spectacles, but were not wearing them at the time of the eye examination. This further strengthens the need to improve access to eye examinations and spectacles.

The strengths of the study were in the high participation rate (98.1%) and the use of cycloplegia. These were achieved through support of the Ministry of Education and by providing adequate information and notices to parents prior to commencement of the study.

The main limitation of the study was that it is school-based and not population-based. As a result, the sample may not be fully representative of the Calabar population. Another limitation was that final-year students were excluded as they were leaving school earlier than the end of session and this may be the reason for a comparatively smaller number of children in the senior classes and may have reduced the prevalence of myopia among older children.

Conclusion

Refractive error was a major cause of VI among secondary school children in Calabar, Nigeria. The majority of the learners had significant astigmatism, of which myopic astigmatism was the predominant type. The majority of learners who needed a pair of spectacles did not have them. Amblyopia was the second most important cause of VI, suggesting the need for early identification and intervention. Therefore, an effective approach for school eye health programmes that best meets the visual needs of the children is important. This study provides evidence for spectacle needs of the majority of the children and useful information for planning school eye health programmes.

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Competing interests

The authors have declared that no competing interests exist.

Authors' contributions

A.E.E. was responsible for student project work, initiation, proposal writing, project implementation and manuscript writing. P.G. provided inputs into article writing. K.S.N. was involved with project supervision and input into methodology and content of the article.

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Data sharing is not applicable to this article.

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