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Prevalence of refractive error among secondary school students in Katagum Local Government Area, Bauchi State, Nigeria

Maji Attah[1], Shahir Umar Bello[2], Hajara Isah Faridah[2], Amina Hassan Wali[3], Adamu Mohammed Dantani[4], Funmilayo Jane Oyediji[2], Hauwa Batah[1], Ugochukwu Anthony Eze[5,6,7]

[1]*Department of Ophthalmology, Federal University of Health Sciences, Azare, Nigeria*
[2]*Department of Ophthalmology, Abubakar Tafawa Balewa Teaching Hospital, Bauchi, Nigeria.*
[3]*Department of Paediatrics and Strabismus, National Eye Centre, Kaduna, Nigeria.*
[4]*Department of Ophthalmology, Usman Dan Fodio, Teaching Hospital Sokoto, Nigeria.*
[5]*Department of Ophthalmology, Federal Medical Centre, Asaba, Nigeria*
[6]*Centre for Disease Control and Prevention, Cephas Research Initiative Inc. Ibadan, Nigeria*
[7]*Department of Research, University of Putisasthra, Phnon Penh, Cambodia*

Abstract

Background: Uncorrected refractive error is the most common cause of childhood visual impairment and the second leading cause of treatable blindness. It significantly impacts overall socio-economic development and is particularly common in low- and middle-income countries.
Aim: To assess the prevalence and patterns of refractive errors among public and private secondary school students in Katagum LGA, Bauchi State.
Method: A descriptive cross-sectional study was conducted among secondary school students selected from 10 schools across 7 wards of the LGA, using a multistage random sampling method. Ocular examinations were performed according to the modified Refractive Error Study in Children (RESC) protocol, which included visual acuity assessment, pinhole testing, and subjective refraction ± cycloplegia. Data analysis was conducted with SPSS v24. Descriptive and inferential statistics were done. The level of significance was set at $p<0.05$.
Results: The study included 701 students, aged 12–22 years (mean 15.7 ± 1.97), with a female: male ratio of 1:1.1. The prevalence of refractive error was 11.7% (95% CI: 4.0% to 8.8%). Myopia, hypermetropia, and astigmatism accounted for 63.4%, 26.8%, and 9.8% of the errors, respectively. Females and students aged 15–16 years had the highest burden. Low-grade myopia (−0.50 to −1.75 DS), hypermetropia (+0.5 to +1.75DS); astigmatism in that order were the most common. Spectacle correction significantly improved visual acuity, with 96.9% achieving 6/6 vision after refraction.
Conclusion: This study reports a high prevalence of refractive errors among secondary school students in Katagum LGA, with low-grade myopia, hyperopia, and astigmatism being the most frequent, especially among females, it significantly improved with spectacles. Regular routine school eye screening and provision of affordable spectacles will reduce the burden of avoidable visual impairment among students.

Keywords - Refractive error; Visual impairment; Secondary school students; Prevalence; Bauchi State; Nigeria.

Corresponding Author:

Dr Ugochukwu A Eze
Department of Ophthalmology, Federal Medical Centre, Asaba, Nigeria

ugorexeze@gmail.com

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Introduction

Refractive error occurs when the eye can't focus light rays from distant objects onto the retina, resulting in blurred vision. It needs correction for clear vision. There are three types: myopia (near-sightedness), hypermetropia (far sightedness), and astigmatism.[1]
Childhood visual impairment caused by refractive errors is the second leading cause of treatable

blindness and is common among school-age children.[2] Approximately 1.4 million children are blind worldwide; of these, 300,000 are in Africa. This results in 75 million years of blindness, making it the second leading cause after age-related cataracts.[3] Refractive errors can cause visual disability, especially when combined with other visual disorders. Early detection and treatment of refractive errors are vital to prevent amblyopia, which can impede learning.[4]

Visual impairments and blindness in children can significantly impact their academic performance, social skills, and future opportunities, potentially leading to lifelong challenges.[3]

Providing appropriate spectacles effectively improves vision in individuals with refractive errors.[5] Uncorrected refractive errors are responsible for most moderate visual impairments worldwide. The Vision 2020: Right to Sight Initiative, which aimed to eliminate blindness, prioritised correcting refractive errors and included it as a category of "childhood blind ness".[2]

The asymptomatic nature of uncorrected refractive errors in many children underscores the importance of screening to identify and address them. To support this, school eye screening programmes are often combined with assessments for other health concerns in countries with high school attendance. Additionally, these screening programmes sometimes provide spectacles to enhance their use. Studies have shown that spectacle use among schoolchildren varies considerably, ranging from 15% to 50% across countries.[3]

In Low- and Middle-Income Countries like Nigeria, routine eye examination, especially for children, are rare.[6] Nigeria apparently lacks a afunctional National School Eye Health Programme, except in Lagos.[7] Contributing factors include low awareness, a shortage of eye care professionals, limited access to spectacles, lack of political will, and cultural barriers.[8]

To reduce avoidable visual impairment caused by refractive errors, it is vital to gather baseline data on refractive errors and spectacle use among secondary school pupils.

Several studies have investigated the prevalence and patterns of refractive errors among secondary school students in various regions of Nigeria.[9,10] However, there has been little research on the subject in North East Nigeria, particularly in Bauchi State. This emphasises the importance of conducting a study in this area to provide valuable information for health planning and treatment.

This study assesses the prevalence and patterns of refractive errors among public and private secondary schools in Katagum LGA, Bauchi State. The baseline data obtained will support advocacy with the government and NGOs to develop a school eye health programme as part of comprehensive eye care.

Materials and Methods

Study Area:

This study was a cross-sectional survey conducted in Katagum Local Government Area (LGA) in Bauchi State, Nigeria, with an estimated population of 347,367.[11] Bauchi State is in the northeast geopolitical zone of Nigeria. The study took place from March 2018 to February 2019.

The LGA comprises three districts that have 40 public schools, including 24 junior secondary schools (Upper Basic schools),[12] senior secondary schools, and 4 private secondary schools. The registered secondary school student population in the Local Government Area was 2007[8] during the year of the study.

The Ethical approval for the study was given by the Ethical Committee of the National Eye Centre, Kaduna. The research adhered to the tenets of the Helsinki Declaration.

All participating students provided written consent or assent. Permissions were also secured from the Bauchi State Ministry of Education, the Katagum Local Government Education Department, and the inspectorate directorate. Additionally, introductory letters were presented to the principals of the schools involved.

The minimum sample size required was 723, rounded up to 750 students, based on the following:

Target population = 20,078 (This is the total number of pupils in both public and private schools in Katagum).[12]

Prevalence rate of uncorrected refractive error among school children in a previous study was 8.4%.[13] A 95% Confidence interval and 5% level of precision was used.

The minimum sample size was calculated using the Leslie-Kish statistical formula, the formula for a population greater than 10,000

$n = (z^2pq/d^2)$.[14] Where:

n = sample size

z = standard normal deviation at 95% confidence interval = 1.96

p = the proportion (prevalence) of the student population estimated to have Refractive error

$8.4\% = 0.084$[13]
q = the proportion (prevalence) of the children population estimated not to have Refractive error
(1-p) = 0.916
d = precision = 0.03
Design effect (D) = 2
Non-response rate = 10%
$1.96^2 x 0.084 x 0.916 / 0.03^2 = 329$

Therefore, using these assumptions, the minimum sample size was calculated as follows:
nxD =658
658+10%=723.8 =750
Thus, sample size n=750

Sampling Technique: The study employed a three-stage random sampling process. The first stage involved collating all schools within the three wards of the Local Government Council, then calculating the cumulative population and sampling interval using the formula below.
k = N/n where
k = Sampling interval
N = Target population
n = Number of clusters to be studied (public and private schools).
K = 20078/10=2007.8 = 2007
In the second stage of the selection process, schools were chosen by drawing random numbers between 0.1 and 0.9. When the number 0.7 was drawn, it was multiplied by the sampling interval (0.7 x 2007 = 1404.9) to identify the school at that cumulative population point. This process was repeated to select nine additional schools.
In the third stage, students were selected by randomly drawing classes from a list of classes written and puy into a cap. The first 75 students from the chosen class were selected based on the class register. If there were fewer than 75 students in the class, the process was repeated until the required number was reached. The researcher conducted all sampling procedures.
All registered students, whose parents or guardians gave consent for them to participate in the study, and students who also consented/assented to participate.

The exclusion criteria were:
- Unwilling/ uncooperative students,
- Absentee students during the study period
- Coexisting ocular pathology that may affect refraction.

Study instrument: The basic questionnaire consisted

Table 1: Selection of wards, schools and students

S/NO	Ward	Name of School	Inspectorate Division	No. of students selected
1	Azare	UBSS Yagana Lawal	Azare	75
2	Madara	GDSS, Nasarawa	Azare	75
3	Azare	GDSS, Matsango	Azare	75
4	Chinade	UBSS, Chinade	Azare	75
5	Madara	UBSS, Tsakuwa	Azare	75
6	Azare	UBSS, Matsango	Azare	75
7	Chinade	UBSS, Bulkachuwa	Azare	75
8	Azare	GGSS, Azare	Azare	75
9	Azare	GCDSS, Azare	Azare	75
10	Azare	UBSS, Babakafinta	Azare	75

UBSS: Upper Basic Secondary school, GDSS: Government Day Secondary school, GGSS: Government Girls Secondary school, GCDSS: Government Comprehensive Day Secondary school

of closed-ended, structured questions, which were administered to each participant by an ophthalmic nurse trained for this purpose by the investigator. The questionnaire aimed to determine age, sex, class, parental occupation, parental education, Visual acuity (VA) aided and unaided, visual symptoms, and slit lamp examination findings. The questionnaire's content was a modified version of the Refractive Error Study in Children (RESC) protocol.
It was pilot-tested at Demonstration Secondary School, a non-participating school, then translated into Hausa and back into English to verify validity.
Data collection procedure: Data collection was done using a structured questionnaire to obtain information on the biodata, school, class, and spectacle use.

Stage 1- Registration:
Stage 2- Visual Acuity (VA) recording:
The visual acuity of each eye was tested separately using Snellen's tumbling E chart. The student's VA and pinhole were measured in a well-lit area during the day with the student seated 6 metres from the chart. The chart was positioned 1 metre above ground. If the letters could not be read at 6 metres, the distance was shortened until they became visible, and the VA was determined by the lowest line the student correctly read. An ophthalmic nurse trained for this task by the investigator conducted the measurements. If any uncertainties arose, the investigator rechecked and made the necessary corrections. To prevent memorisation, the researcher used the Illiterate E chart, resulting in a 90% inter-observer agreement, which was satisfactory.
For students with uncorrected visual acuity VA ≤6/9 in one or both eyes, a pinhole test was performed, and the VA was noted. They were then referred to the principal investigator for a detailed ocular examination. All the students were taken to the hospital in groups,

accompanied by their teachers.

Examination at the hospital included:

1. Reconfirmation of the visual acuity (VA) using the same procedure that was used during screening at the school.
2. Students with VA ≤6/9 in either eye were refracted with an auto-refractor, and subjective refraction was used for best correction.
3. All students ≤ 12 years and those with variable endpoints, strabismus, or suspected amblyopia were dilated with one drop of Tropicamide 1% at 5-minute intervals for 40 minutes. When accommodation was paralyzed, they were refracted manually with a streak Retinoscope, and post-cycloplegic refraction was done three days later.
4. Subjective refraction for best spectacle correction was done.
5. Slit lamp exam of anterior and posterior segments, including ophthalmoscopy and tonometry, was performed.
6. All information was recorded in the structured questionnaire.

Ocular medication was provided for minor conditions, such as allergic and bacterial conjunctivitis, during recruitment at no cost to students. Those with other pathologies needing referral were directed to the Federal Medical Centre, Azare, ophthalmology clinic after parental contact.

Examination Tools

1. Snellen tumbling E visual acuity chart
2. A 6-meter non-elastic rope
3. Trial frame
4. Trial, box containing occluder and pinhole (Khoslsa India)
5. Pen torch
6. Retinoscope. (Welch Allyn. Streak Retinoscope Inc., New York, USA)
7. Autorefractometer (Grand Seiko co, Ltd, Japan GR-3100k
8. Cycloplegic Drugs (Cyclopentolate 1% Alcon Laboratories Inc.)
9. Ophthalmoscope. (Welch Allyn. Inc., New York, USA)
10. Topical Anti-allergic medication
11. Topical Antibiotics
12. Frames and Lens
13. 90D Volk lens (Volk BIO USA)
14. Cotton wool
15. Parent/Guardian consent form
16. Questionnaires
17. HP Laptop
18. Stationary

Data Analysis: All statistical analyses were performed with commercial software SPSS 24. (SPSS Inc., Chicago, IL). The Students t-test was used to compare 2 means to determine whether they differ, while ANOVA was used to compare 3 or more sample means.

Results

Seven hundred and fifty participants were recruited for this study. Consent to participate was granted by 701 students, resulting in a response rate of 93.46%. All the consenting 701 students (100%) were examined. Demographic and subjective visual status for the 49 non-responders could not be obtained because they refused to provide consent, despite assurances that the results would be confidential.

Socio-Demographics of participants

Analysis of the sociodemographic data for students revealed an age range of 12 to 22 years, with a mean of 15.7 and a standard deviation of 1.97. The 15-16 age group was the largest at 280 (39.94%), while those aged ≤ 12 and ≥ 21 years were the fewest at 18 (2.56%), as shown in Table 2.

Three hundred and sixty-six (52.2%) of the students were males, while 335 (47.8%) were females. The

Table 2: Sociodemographic Characteristics of Respondents

Age in years	Male no (%)	Female no (%)	Total no (%)
≤12	16 (4.37)	2 (0.60)	18 (2.57)
13 - 14	109 (29.78)	86 (25.67)	
15 - 16	134 (40.00)	146 (43.58)	280 (39.94)
17 - 18	66 (18.03)	89 (26.57)	155 (22.11)
19 - 20	25 (6.83)	10 (3.00)	35 (5.00)
≥21	16 (4.37)	2 (0.60)	18 (2.57)
Years of study (Class)			
Jss II	116 (31.70)	75 (22.39)	191 (22.25)
Jss III	137 (37.43)	108 (32.24)	245 (34.95)
SS I	14 (3.83)	64 (19.11)	78 (11.13)
SS II	99 (27.05)	88 (26.27)	187 (26.68)
Father's level of education			
No formal Education	42 (12.84)	28 (8.36)	75 (10.70)
Primary Education	86 (23.49)	99 (29.55)	185 (26.40)
Secondary Education	172 (47.00)	181 (54.03)	353 (50.40)
Tertiary Education	61 (16.67)	27 (8.06)	88 (12.60)
Fathers' occupation			
Farmers	21 (5.74)	17 (5.07)	38 (5.42)
Civil servant	84 (22.95)	130 (38.81)	214 (30.53)
Businessman	145 (36.62)	105 (31.34)	250 (35.66
Others	116 (31.69)	83 (24.76)	199 (28.39)
Father's Monthly income (naira)			
1000 – 4999	116 (31.69)	76 (22.69)	195 (27.82)
5000 – 19999	24 (6.56)	18 (5.37)	42 (6.00)
20000 –49999	82 (22.40)	127 (37.91)	209 (29.82)
50000 – 25000	140 (38.25)	111 (33.13)	255 (36.38)

male-to-female ratio was 1.1:1. This ratio is not statistically significant.

Three hundred and fifty-six students (50.8%) were from low socio-economic status, 243 (34.7%) from the middle, and 102 (14.5%) were from the high socio-economic status, as seen in Figure 1.

The father's socioeconomic status was classified using the Registrar General classification based on income and education. Monthly income determined their socioeconomic status.

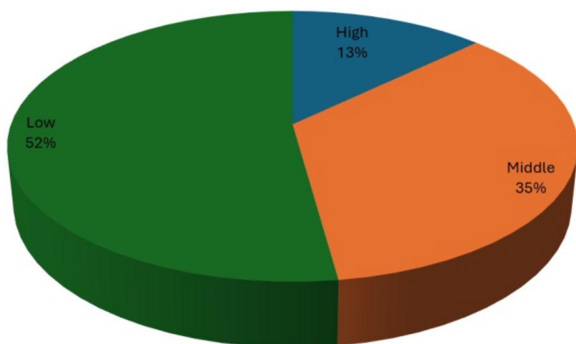

Figure 1: Students distributions according to Father's Socio-economic status

Visual acuity of the participant at presentation

Ninety four participants (13.4%) had an unaided visual acuity (VA) of ≤6/9. The pinhole visual acuity shows that 664 (94%) of participants have at least 6/6 visionin at least one eye.

Distribution of refractive errors based on age and the prevalence of refraction

Of the seven hundred and one participants, ninety-four (13.4%) who had unaided visual acuity of <6/9 were refracted. Among them, eighty-two had improved vision with their corrections, reflecting a prevalence of refractive errors at 11.7% (95% CI: 4.0% to 8.8%).

Table 3: Unaided Visual acuity of the Right eye and left eye of the participant at presentation

VA	Right Eye		Left Eye	
	Unaided (%)	Pinhole (%)	Unaided (%)	Pinhole (%)
6/6	630(90.0)	664(94.7)	612(87.3)	663(94.0)
6/9	26(3.7)	18(2.6)	42(5.8)	17(2.4)
6/12	17(2.4)	7(1.0)	22(3.1)	9(1.3)
6/18	12(1.7)	4(0.6)	11(1.6)	5(0.7)
6/24	4(0.6)	3(0.4)	3(0.3)	1(0.1)
6/36	6(0.9)	1(0.1)	8(1.1)	3(0.4)
6/60	1(0.1)	1(0.1)	3(0.4)	1(0.1)
3/60-PL	4(0.6)	3(0.4)	1(0.1)	1(0.1)
Total	701(100.0)	701(100.00)	701(100.0)	701(100.00)

Table 4: Distribution of refractive errors based on age and the prevalence of refraction

Socio-Demographic Characteristics	Refractive Errors no=82 Freq (%)	No Refractive Errors no=619 Freq (%)	Test statistics, χ^2	Df	P-Value
Age in Years					
≤12	0 (0.00)	18 (2.57)			
13 - 14	25 (3.56)	170 (24.25)			
15 - 16	41 (5.58)	239 (34.09)			
17 - 18	11 (1.57)	144 (20.54)			
19 - 20	3 (0.43)	32 (4.57)	8.48	5	0.131
≥21	2 (0.29)	16 (2.28)			

Comparison of Socio-demographic characteristics of students with refractive errors

Of these errors, fifty-two were myopic (63.4%), twenty-two were hyperopic (26.8%), and eight had astigmatism (9.8%).

The age distribution of refractive errors shows that the 15-16 age group had the highest prevalence, with 42 students (51.1%) affected. Myopia was the most common refractive error, accounting for 27 cases (32.9%), while only 2 students (2.4%) over 21 had refractive errors.

In terms of gender, 44 students (53.7%) were female and 38 (46.3%) were male. Hypermetropia and astigmatism affected an equal number of students, with 11 cases of hypermetropia and 4 of astigmatism for each gender.

Table 5: Age and sex distribution of students with refractive error

Age	Male			Female			Total
	Myopia (% of Eyes)	Hypermetropia (% of Eyes)	Astigmatism (% of Eyes)	Myopia (% of Eyes)	Hypermetropia (% of Eyes)	Astigmatism (% of Eyes)	
≤ 12yrs	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0 (0.00)	0(0.00)	0(0.00)
13-14	8(33.33)	3(27.27)	2(50.00)	8(29.63)	3 (25.00)	2(50.00)	26(31.71)
15-16	10(41.61)	4(36.36)	2(50.00)	16(59.26)	8 (66.66)	2(50.00)	42(51.22)
17-18	3(12.50)	3(27.27)	0(0.00)	3(11.11)	0(0.00)	0(0.00)	9(10.98)
19- 20	2(8.33)	0.(0.00)	0(0.00)	0(0.00)	1 (8.33)	0(0.00)	3(3.66)
>21yrs.	1(4.17)	1(9.09)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	2(2.44)
Total	**24(100.00)**	**11(100.00)**	**4(100.00)**	**27(100.00)**	**12 (100.00)**	**4(100.00)**	**82(100.00)**

Visual acuity at presentation and after refraction

The data indicate that wearing spectacles improves visual acuity by at least one line in 17.4% of participants and by four lines or more in 15.6%. This improvement is particularly notable in individuals with a presenting visual acuity of ≤6/12, and 53 (64.6%) achieved a visual acuity better than 6/18 with spectacles, while 17 (20.7%) improved beyond 6/24.

Figure 2 depicts the stratified pattern of refractive errors by lens power and by sex. The most common

Table 6: Visual acuity of all eyes at presentation and after refraction

VA	Before Refraction		After refraction	
	No of eyes	Percentage	No of eyes	Percentage
6/6	1242	88.6	1358	96.9
6/9	68	4.8	22	1.6
6/12	40	2.8	10	0.8
6/18	33	1.8	2	0.14
6/24	6	0.4	2	0.1
6/36	14	1.0	2	0.1
6/60	4	0.3	3	0.2
3/60-PL	5	0.4	4	0.3
Total	**1402**	**100.00**	**1402**	**100.00**

P<0.005, this is statistically significant.

error among male and female students was low-grade myopia (−0.50 to −1.75 DS) and hypermetropia (+0.5 to +1.75DS); the frequency was higher among females. There was a slightly higher frequency of moderate myopia among males. Low magnitude hypermetropic errors were more common in the population. The least frequent errors were cylindrical.

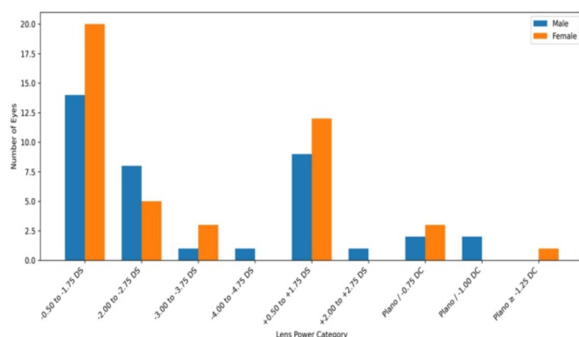

Figure 2: Showing the distribution of refractive errors by spherical and cylindrical lens power according to sex

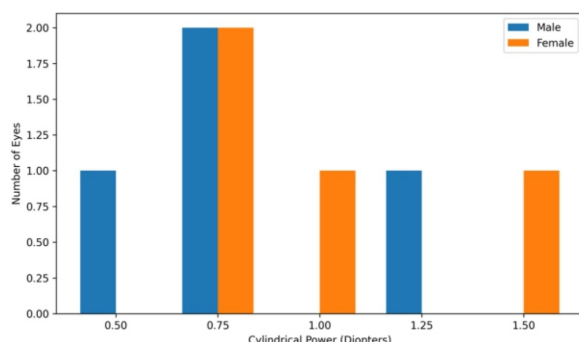

Figure 3: Showing the distribution of refractive errors by spherical and cylindrical lens power according to sex

Figure 3 further illustrates the stratified distribution of astigmatism by cylindrical power and sex. There was largely a low magnitude astigmatic error and 0.75 dioptres were the most common cylindrical prescription and was evenly spread in both sexes. Only females had had higher cylindrical powers (≥1.00 D) in the population.

Discussion

The study achieved a response rate of 93.8%. The researcher was unable to obtain detailed information about non-responders because they declined to give consent despite multiple reassurances regarding the confidentiality of the results. However, the examined sample closely resembles the demographic profile of secondary school students in Katagum Local Government Area (LGA).

Refractive errors are the biggest challenge among schoolchildren in this region and remain largely unaddressed. This situation is made worse by inadequate school eye health programmes, a shortage of eye care professionals, and barriers to spectacle use.

Prevalence of Refractive Errors

The prevalence of refractive errors in this study was reported at 11.7% (Table 4), which is higher than rates in various regions of Nigeria: 5.3% in Kano (North-West), 4.8% in Kebbi (North-West), 7.4% in Enugu (South), 6.9% in Calabar (South), and 7.3% in Lagos (South-West).[15-17] These differences may stem from varying definitions of refractive errors across studies, such as differing criteria for hypermetropia.

However, a prevalence rate was similar to that found in this study has been reported in other school-based studies across various regions of Nigeria. For instance, a survey conducted in Ile-Ife reported a prevalence rate of 13.5% for adolescent eye disease screening in high school students. Additionally, a prevalence rate of 14.3% was reported in southwestern Nigeria 18 A rate of 11.4% was observed in a comparative analysis of spectacle use among students with refractive errors in southern Nigeria.[19]

The significant differences in prevalence rates observed across various studies in Nigeria can be attributed to several factors. One key factor is the variation in study populations, which may be either community-based or hospital-based. Additionally, the choice of the cut-off for visual acuity significantly affects reported prevalence rates for refractive errors. For example, studies that use a 6/12 threshold for the better eye may report lower prevalence rates than

those using a 6/9 threshold, even if the sampling methods are similar.

Moreover, the age range of participants also plays a crucial role, as the prevalence of refractive errors tends to increase with age, particularly in children. The type of examination conducted, such as non-cycloplegic refraction, can also lead to misclassifications, further affecting the accuracy of prevalence figures.

In Africa, the prevalence of refractive errors among school children has been reported to range from 1.58% to 15%. Various studies conducted across different African countries have reported varying prevalence rates. For example, a study in Ethiopia found a prevalence of 10.2%, while another study in Uganda reported a prevalence of 11.6%.[25,26] The prevalence rate observed in this study falls within the range reported across Africa.[22,21]

Myopia was identified as the most common refractive error in this study (Figure 2), consistent with findings by Abdulsalam et al, Onakpoya et al., and Isawumi et al in Nigeria.[18,22,23] In contrast, a study by Medi Kawuma in Kampala, Uganda, found astigmatism to be the most prevalent, affecting 52% of participants, while Otutu et al. reported a prevalence of 60%.[24] Conversely, Astigmatism was the least common error in this study Figure 2 The reason for this difference is not clear, but it is important to note that many of the listed studies were clinic-based.[18,22,23] The rise in myopia during the teenage years may be due to a shift from hypermetropia to myopia, which explains its increased prevalence during this life stage.

In this study, refractive errors were found to be more prevalent among females (Figure 2). This finding aligns with previous research indicating that refractive errors are more common in females, who also tend to seek optometric consultations earlier.[18]

The 15- to 16-year-old age group had the highest number of students with refractive errors, affecting 41 eyes (50.0% of total cases). In contrast, the 21-year-and-older age group had the fewest instances, with only 2 eyes (2.4%) exhibiting refractive errors. Among these errors, myopia was the most common, occurring in 27 eyes (32.9%) within the 15 to 16-year-old age group. These findings align with other studies conducted in Nigeria.[15,18,25,26] However, they differ from the findings of Abah et al and Malu, who identified astigmatism and hypermetropia as the most prevalent refractive errors in these age groups, respectively.[13,27]

In conclusion, the prevalence of refractive error among secondary school students in Katagum Local Government Area of Bauchi State was 11.7%, with myopia as the most common refractive error, and females being most affected. Early detection and treatment through school eye health programmes will enable the students to maximise their academic potential. The role of health education on the visual benefits of refractive error correction and the safety of glasses cannot be overemphasised.

This result will help overcome long-held erroneous beliefs, such as that spectacles weaken or damage the eyes or that secondary school students are too young to wear them. Information dissemination methods like radio jingles, pamphlets, and seminars can be used to enlighten parents, emphasizing the importance of teachers prescribing glasses and the need for refractive error correction in children to ensure compliance, as children's most active visual activities take place in school.

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