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Prevalence and factors associated with visual impairment among high school students in Mbarara city, Southwestern Uganda: a cross-sectional study

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Abstract
Background In most low-income countries, including Uganda, routine screening for Visual Impairment (VI) in schools is not conducted, despite the growing global trend of VI among young people, and its negative impacts on academic performance and social integration. Data on prevalence and factors associated with VI among students in Uganda are limited. We determined the prevalence of VI and identified associated factors among high school students in Mbarara City.
Methods We conducted a cross-sectional study among high school students in sampled high schools within Mbarara City, southwestern Uganda from September 19, 2023 to October 14, 2023. Participants were selected using multi-stage stratified cluster sampling. We obtained data on socio-demographics and behaviors through interview-administered questionnaires. Visual acuity (VA) was measured using Snellen's chart at six meters. Participants were considered visually impaired if their VA in the better eye was < 6/12. Logistic regression analysis was used to identify factors associated with VI.
Results We enrolled 768 participants from four schools; most were males (56.4%), aged 18–24 years (50.3%). Median age was 18 (inter-quartile range [IQR]: 13–24) years. The prevalence of VI was 2.99% (n = 23; 95%CI 2.00–4.47%]. Age category 18–24 years (adjusted odds ratio [aOR] = 2.73, 95%CI 1.03–7.21, p = 0.043), obesity (aOR = 9.60, 95%CI 1.43–64.51, p = 0.020) and family history of VI (aOR = 7.09, 95%CI 2.87–7.51, p < 0.001), were independently associated with VI.
Conclusion The prevalence of VI among the high school students surveyed was low. However, targeted screening of older students, those with a family history of VI and obese students, could facilitate early detection and timely interventions in the region.

Keywords Visual impairment · Students · Prevalence · Visual acuity · Uganda

1 Introduction

Visual Impairment (VI) refers to decrease in sharpness or clarity of vision or visual acuity (VA) worse than 6/12 (20/40), taken using a Snellen eye chart at 6 m/ 20 feet. Despite the fact that majority of the causes of VI are preventable, [1, 2] VI continues to be a public health threat especially in the developing countries, [3–5] with uncorrected refractive errors, vitamin A deficiencies and cataracts taking the lead in causing VI [3, 6]. Globally, approximately 2.2 billion persons have

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VI, and this prevalence in developing nations is estimated to be four times higher than those in the developed ones [7]. In Sub-Saharan Africa, approximately 16–18 million individuals live with VI where almost 60% of them stay in twenty African countries, Uganda inclusive [8]. More than 18 million of the visually impaired people are children < 15 years old (1% to 10% magnitude) with a child becoming blind every minute [9]. Greater than 65% of the visually impaired cases come from the Sub-Saharan Africa [10]. In Uganda, approximately 6% of the population are visually impaired [11].

Factors associated with VI include high blood pressure, obesity, low physical activity, prolonged screen time, alcohol consumption, and exposure to smoke. High blood pressure can cause ophthalmic injury, retinal damage, leading to blurred vision, nerve damage, or even retinal stroke with complete vision loss [12]. In obesity, fatty plaques build-up within eye's minute blood vessels, compromises retinal nutrient supply leading to deterioration in VA[13]. Low physical activity time increases risk for metabolic and cardiovascular diseases which predispose to VI [14]. Longer screen time is reported to cause computer vision syndrome characterized by eye strain, fatigue, and painful headaches [12, 15]. Alcohol slows one's pupillary reaction, impairs contrast sensitivity and increases the risk for lens opacification, macular degeneration and glaucoma including and exacerbation for dry eye disease [12]. Inhaled smoke toxins in bloodstream reach the eyes causing thinning of the choroid layer, predisposing to macular damage, retinal ischemia, ischemic optic neuropathy [16, 17].

VI can negatively impact an individual's daily activities and quality of life; it can reduce learning ability, potentially compromising academic performance, social communication, and psychological development [18–20]. Even when in school, visually impaired students are more likely to be seen as different and of lower social ranks by peers and thus experience the victimization of being bullied by the colleagues [21]. Moreover, Visually impaired students need to be urgently treated as the condition is irreversible at old age [22, 23]. Despite the WHO's recommendation to prioritize vision screening for school-going children, there is limited screening uptake in most developing countries, including Uganda, often resulting in VI from uncorrected refractive errors. In Uganda, particularly in Mbarara City, there is a lack of robust data on magnitude of VI and associated factors among high school students. To address this knowledge gap, this study aimed to determine the prevalence of VI and identify associated factors among high school students in Mbarara City.

2 Material and methods

2.1 Study design, and setting

This was a cross-sectional study done in Mbarara City which is located in southwestern Uganda among high school students within the high schools found in the six divisions of the city. Mbarara City has 14 public secondary schools and 24 privately owned secondary schools. Of these 38 schools, 20 schools (public and private) participate in Universal Secondary Education (USE) and about 7 of these are single sex schools and the others are mixed schools. These have provisions for day and boarding sections and are located within the six boroughs of Mbarara City that include Kakoba, Kakiika, Nyamitanga, Kamukuzi, Biharwe and Nyakayojo divisions. Mbarara City hosts many high schools (mixed and single schools) within southwestern Uganda, with outstanding urbanization levels, that offers it a unique environmental, socioeconomic, and lifestyle factors that could influence the prevalence of visual impairment among students.

2.2 Study population

We included high school students in the selected high schools within Mbarara City. Students who were unable to comply with specific data collection procedures, such as standing unassisted for height and weight measurements or standing six meters away to read the Snellen chart, were excluded.

2.3 Sample size calculation

The sample size was calculated using Epi Info StatCalc for population surveys (version 7.2.5.0), with a 95% confidence interval (CI) and a 5% margin of error. A design effect of two was applied, considering four clusters. In the absence of prior studies on the regional prevalence of VI among high school students, a prevalence of 50% was assumed, yielding a final sample size of 768 participants.

2.4 Sampling

A multi-stage stratified cluster sampling method was employed. First, four out of the six divisions within Mbarara City were randomly selected using the lottery method. From each selected division, one mixed-gender school was chosen through simple random sampling, and these schools were coded as sites N, Z, B, and A. Students from each class in the selected schools were then randomly selected, using a random number generator, to participate in the study (Fig. 1). To ensure proportional representation, probability proportional to size sampling was applied to determine the number of students selected from each class.

2.5 Study variables, measurements and procedures

The independent variables included; categorical variables such as sex, current class, address, school status, alcohol consumption, smoking, level of physical activity and screen time. Continuous variables included age, body mass index (BMI), pulse rate, systolic and diastolic blood pressure (BP). The dependent variable was VI obtained as VA of < 6/12 in the better eye [12], based on measurements collected separately for the right and left eyes.

Research assistants were enrolled nurses and secondary school teachers. The nurses were either those who have worked in eye unit before and if no such experience, they underwent training about the study protocol and objectives to ensure accurate and precise measurement and recording of the required variables, plus administering the questionnaire. The secondary school teachers, also underwent training about study protocol and objectives. Then allowed to perform anthropometric measurements while exempted from VA or BP measurements, plus questionnaire administration to avoid bias in students' responses. Specifically, VA was measured by an ophthalmic nurse.

After obtaining ethical clearance, followed by administrative clearance from the selected schools, the principal investigator (PI) informed the school communities—students, class leaders, and teachers—about the purpose and procedures of the study. All students were encouraged to participate; however, participation remained voluntary, with informed consent/assent obtained from each participant prior to participation. Then on appropriate days granted by the school, the PI with the well-trained research assistants staged and set-up the equipment and waited for participants to come to

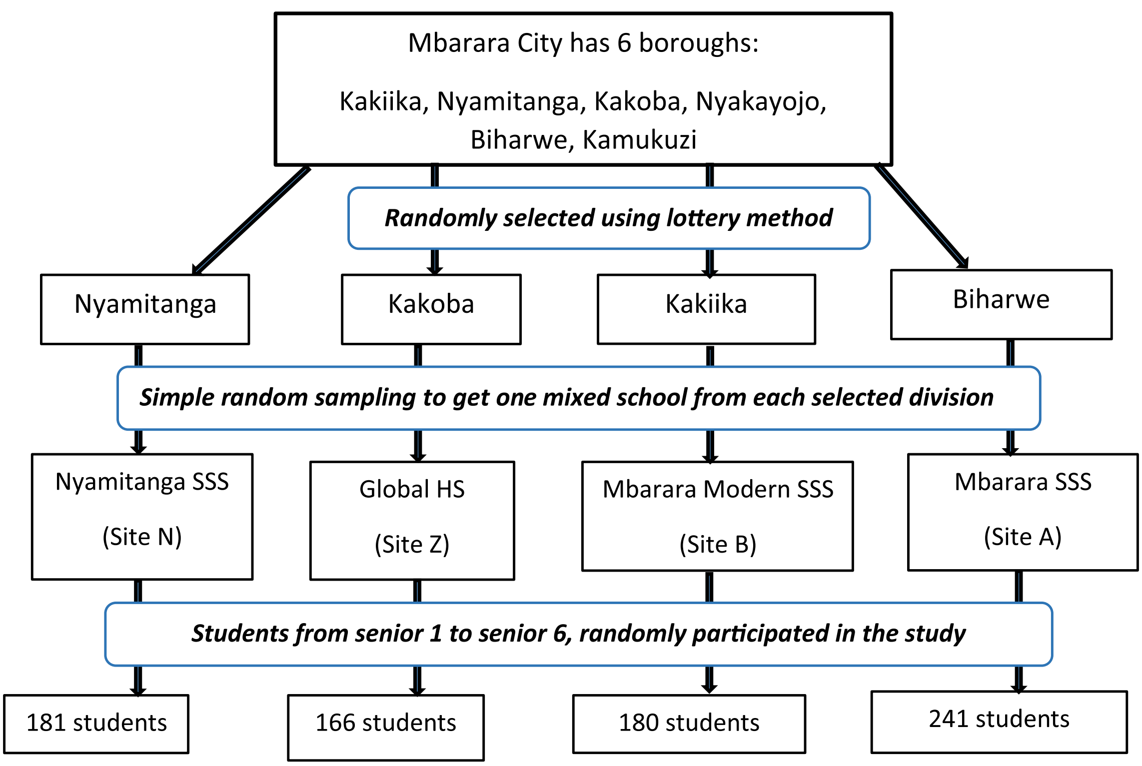

Fig. 1 Flow chart depicting sampling procedure for recruitment of students, Mbarara City, Uganda from September 19, 2023 to October 14, 2023; SSS: Senior secondary school; HS: High school

the research station. At enrolment, participants were allowed to ask more questions for any clarity about the study, then given enough time to read the consent/assent form and for those aged ≥ 18 years freely consented whereas those < 18 years were allowed to assent and consent through their teachers. Once consent had been obtained, the research team then measured the participant's visual acuity, height, weight and then allowed to rest while seated for at least five minutes, then their blood pressure was taken and finally a questionnaire was administered to capture sociodemographic, and behavioural data.

2.6 Measurement of blood pressure

Blood pressure and pulse rate was measured using an automatic digital Blood pressure machine (Scian LD 7, Digital BP monitor Honsun) with appropriate cuff size for students; cuff sizes that cover at least two-thirds of the length of the right upper arm and the entire circumference of the arm was used. Participants were seated comfortably on a chair while supporting their back, the arm reinforced at the cubital fossa, their feet on the floor, then permitted to rest for not less than five minutes before BP was measured.

The cuff was placed at an unclothed upper arm, an inch above the participant's elbow joint, ensuring the tubing at the front center of the arm, to ensure the sensor is well placed. The cuff ending was positioned tight enough to ensure only two fingertips could slip under the top edge of the cuff, so that the skin doesn't pinch when the cuff is inflated. Also, participants were requested to remain silent while the machine measured.

At the press of the start button, the cuff automatically inflated followed by a slow deflation as it took the measurement which it displayed on the monitor as BP and Pulse rate, which were taken as results for the participant.

2.7 Measurement of visual acuity

VA was measured using a 6 m Snellen chart [24]. While ensuring good illumination or natural light on the Snellen chart, the test was explained to the participant and the chart kept at his/her eye level. The participants were informed that the test is not a kind to pass but to just assess their level of VA. In addition, participants were advised not to guess if they cannot see the letters on the chart. Participant was standing six (6) meters away from the Snellen chart and was instructed to cover their left eye with their palm, ensuring not to apply pressure, as it could impact the eye's acuity. They were asked to read the Snellen chart from top to bottom and left to right. Every eye was tested distinctly starting with the right eye, then whole procedure repeated for the other eye. For participants who couldn't see the Snellen chart, we assessed their ability to count fingers (CF vision), see hand movements (HM vision), or perceive the light from a flashlight (LP vision). If the participant was unable to identify the light, we captured this as No light perception (NLP) [25–27].

2.8 Anthropometric measurements

Weight and height were measured simultaneously, using a stadiometer with weighing scale (Fazzini S7700HR, 04/2017 20,090- Vlmodrone (MI) Italy). Height was taken while the participant was standing from foot to head, as the participant's head faced forward and rear body parts touching the board and without shoes. For Weight**,** participants were encouraged to be dressed in light clothing with no materials in pockets, bags or handbags and without shoes. Then the reading read off in kilograms from the weight scale.

2.9 Data management and analysis

Data were double entered into Microsoft excel then analyzed using STATA version 17 (Stata Corp, 4905 Lakeway Drive College Station, Texas 77,845 USA) for cleaning and analysis. We compared all studied variables to the dependent variable (VI) to test if there is significant difference in the distribution of participant characteristics between the two groups. Categorical variables were summarized using frequencies and proportions, and then a Chi-square test or Fisher's exact test was used to compare the proportions in the dependent variable's categories. The prevalence of VI was determined by dividing the total number of participants with VI by the total number of study participants and was expressed as percentage. The age-adjusted prevalence was calculated using the direct method of standardization. Prevalence of VI in each age category was determined. Age-specific prevalence rates were then weighted according to the age distribution of a standard population and the weighted rates were summed to obtain the overall age-adjusted prevalence. The strength of association between VI and independent variables was measured using odds ratios together with their 95%

confidence intervals (CI), and the statistically significant crude odds ratios were indicated by a p- value less than 0.2 at the bivariate level. The variables that are biologically plausible and/or statistically significant at this level were also assessed in the multivariable model to obtain adjusted odds ratios that are free from cofounding effects. Hosmer–Lemeshow test was used to test the suitability of the final multivariable model in predicting the outcome variable. In the final model, associations were considered significant at a p-value < 0.05.

3 Results

We analyzed data for 768 participants. More than half were male students (56.4%), residing in urban (62.8%), in boarding (74.3%), and most were between 18 and 24 years (50.3%). The median (IQR) age was 18(13–24) years (Table 1). Participants with VI did not differ from those without VI.

Among the768 participants, 22.1% had a family history of VI. Three-quarters (75.0%) had normal BMI, and 1.3% were obese. Most participants (86.46%) had normal blood pressure, while 13.54% had hypertension. In terms of total screen time, nearly three-quarters (74.3%) reported > 2 h per day. The majority of participants (94.1%) reported never consuming alcohol, and never smoking (Table 2).

The proportion of students with a family history of VI was significantly higher among those with VI (65.2%) compared to those without (34.8%) (p < 0.001). Other medical and behavioral characteristics were similar between the two groups (Table 2).

3.1 Prevalence of VI among high school students in Mbarara city

Out of 768 participants recruited, 23 had VI in the better eye, giving a prevalence of 2.99% (95% CI: 2.00 – 4.47). The age-adjusted prevalence of VI was 1.96%.

Table 1 Socio-demographic characteristics of Participants

Characteristics	Overall	VI		p-value
	N = 768	Absent (N = 745)	Present (N = 23)	
	n/N (%)	n/N (%)	n/N (%)	
Age Category				0.060
12–17 years	382 (49.7)	375 (50.3)	7 (30.4)	
18–24 years	386 (50.3)	370 (49.7)	16 (69.6)	
Current class				0.350
Senior 1	204 (26.6)	200 (26.8)	4 (17.4)	
Senior 2	145 (18.9)	143 (19.2)	2 (8.7)	
Senior 3	133 (17.3)	127 (17.0)	6 (26.1)	
Senior 4	142 (18.5)	138 (18.5)	4 (17.4)	
Senior 5	69 (9.0)	66 (8.9)	3 (13.0)	
Senior 6	75 (9.8)	71 (9.5)	4 (17.4)	
Sex				0.680
Female	335 (43.6)	324 (43.5)	11 (47.8)	
Male	433 (56.4)	421 (56.5)	12 (52.2)	
Address				0.490
Rural	286 (37.2)	279 (37.4)	7 (30.4)	
Urban	482 (62.8)	466 (62.6)	16 (69.6)	
School status				0.660
Boarding	571 (74.3)	553 (74.2)	18 (78.3)	
Day scholar	197 (25.7)	192 (25.8)	5 (21.7)	

Table 2 Medical and Behavioral characteristics of Participants

Characteristics	Overall	VI		p-value
	n = 768	Absent N = 745	Present N = 23	
	n/N (%)	n/N (%)	n/N (%)	
Family history of VI				< 0.001
Yes	170 (22.1)	155 (20.8)	15 (65.2)	
No	598(77.9)	590 (79.2)	8 (34.8)	
First degree relative with VI				0.290
Father	51 (30.0)	44 (28.4)	7 (46.7)	
Mother	39 (22.9)	38 (24.5)	1 (6.7)	
Sibling(s)	69 (40.6)	63 (40.6)	6 (40.0)	
Both Parents	11 (6.5)	10 (6.5)	1 (6.7)	
Body Mass Index (BMI)				0.057
Underweight	113 (14.7)	109 (14.6)	4 (17.4)	
Normal	576 (75.0)	561 (75.3)	15 (65.2)	
Overweight	69 (9.0)	67 (9.0)	2 (8.7)	
Obesity	10 (1.3)	8 (1.1)	2 (8.7)	
Hypertension				0.171
Normal Blood pressure	664(86.46)	644 (96.99)	20 (3.01)	
Raised Blood pressure	104(13.54)	101 (97.12)	3 (2.88)	
Pulse (Median/IQR)	79 (68–89)	79 (68–89)	79 (69–92)	0.970
Physical activity time				0.350
60 min per day or more	264 (34.4)	254 (34.1)	10 (43.5)	
less than 60 min per day	504 (65.6)	491 (65.9)	13 (56.5)	
Total screen time				0.471
Less than 2 h/day	197 (25.7)	193 (25.9)	4 (17.4)	
More than 2 h/day	571 (74.3)	552 (74.1)	19 (82.6)	
Alcohol Consumption				0.789
Never taken alcohol	723 (94.1)	701 (94.1)	22 (95.7)	
Ever taken alcohol	45 (5.9)	44 (5.9)	1 (4.3)	
Smoking				1.000
Never smoked	723 (94.1)	701 (94.1)	22 (95.7)	
Ever smoked	45 (5.9)	44 (5.9)	1 (4.3)	

3.2 Factors associated with visual acuity

At multivariable analysis, three factors were independently associated with VI: age 18 years or older, obesity, and having a family history of VI. Those who were 18 years or older were 2.73 times (aOR = 2.73, 95%CI 1.03–7.21) more likely to have VI compared to their young counterparts. Those with a positive family history of VI were about 7 times more likely to have VI than those without such a family history (aOR = 7.09, 95%CI 2.87–17.51). Additionally, individuals classified as obese had tenfold higher odds of VI (aOR = 9.60, 95%CI 1.43–64.51) (Table 3).

4 Discussion

This study among high school students in Mbarara City, Uganda revealed a prevalence of VI of 3%, with age 18–24 years, obesity, and a family history of VI being significant factors associated with VI. The prevalence of VI in our study (3%) was lower than the overall prevalence of studies conducted about VI in Uganda (7%) [28]. The prevalence from this study was

Table 3 Factors associated with VI among high school students in Mbarara City, September–October 2023

Variable	Bivariate Analysis (cOR)		Multivariable analysis (aOR)	
	Odds ratio (95%CI)	p-value	Odds ratio (95%CI)	p-value
Age category				
12–17 years	1.00		1.00	
18–24 years	2.32 (0.94–5.70)	0.067	2.73 (1.03–7.21)	**0.043**
Current class				
Senior 1	1.00			
Senior 2	0.70 (0.13–3.87)	0.682		
Senior 3	2.36 (0.65–8.53)	0.190		
Senior 4	1.45 (0.36–5.89)	0.604		
Senior 5	2.27 (0.50–10.42)	0.291		
Senior 6	2.82 (0.69–11.56)	0.151		
Sex				
Female	1.00		1.00	
Male	0.84 (0.37–1.93)	0.680	0.61 (0.22–1.72)	0.349
Address				
Rural	1.00			
Urban	1.37 (0.56–3.37)	0.495		
School status				
Boarding	1.00			
Day scholar	0.80 (0.29–2.18)	0.663		
Family history of VI				
No	1.00		1.00	
Yes	**7.14 (2.97–17.14)**	**0.000**	7.09 (2.87–17.51)	**< 0.001**
First degree relative				
Both Parents	1.00			
Mother	0.26 (0.02–4.59)	0.360		
Father	1.59 (0.18–14.43)	0.680		
Sibling(s)	0.95 (0.10–8.77)	0.966		
BMI Category				
Normal	1.00		1.00	
Underweight	1.37 (0.45–4.21)	0.580	1.80 (0.53–6.05)	0.345
Overweight	1.12 (0.25–4.99)	0.885	0.73 (0.14–3.70)	0.706
Obesity	9.35 (1.83–47.82)	0.007	9.60 (1.43–64.51)	**0.020**
Hypertension				
Normal Blood pressure	1.00		1.00	
Raised Blood pressure	0.96 (0.28–3.28)	0.943	0.71 (0.18–2.72)	0.613
Pulse (Median/IQR)	1.00 (0.97–1.03)	0.976		
Physical activity time				
60 min per day or more	1.00		1.00	
less than 60 min per day	0.67 (0.29–1.55)	0.354	0.59 (0.23–1.51)	0.276
Total screen time				
Less than 2 h/day	1.00		1.00	
More than 2 h/day	1.66 (0.56–4.94)	0.362	1.74 (0.56–5.38)	0.336
Alcohol Consumption				
Never taken alcohol	1.00		1.00	
Ever taken alcohol	0.87 (0.32–2.38)	0.789	1.11 (0.36–3.47)	0.858
Smoking				
Never smoked	1.00		1.00	
Ever smoked	0.72 (0.10–5.50)	0.755	0.88 (0.09–8.12)	0.909

Bold values are for *P*-values that were found statistically significant at Bivariate and Multivariable Analysis cOR; crude Odds Ratio, aOR; adjusted Odds Ratio also lower than that in some studies conducted in other countries like Nigeria (28.9%) [1], 4.4% in South Darfur Sudan [29], 7% in Ethiopia [30], 9.1% in Nepal [31], 8.0% in North West Ethiopia [32].

The discrepancy in the results is probably due to the difference in age groups. Our study participants were strictly high school students ranging from 15 to 20 years of age, whereas, most of the above studies included pre-school going children and also primary school children. Additionally, the variation in the measurement of VA could have also contributed to the differences in the burden of VI, whereby, this study considered students whose VA was less than 6/12 in the better eye, whereas most of the above studies attributed being visually impaired to having a visual acuity of less than 6/18 in the better eye [1]. Furthermore, this study was conducted in urban areas of Mbarara City, VI is more prevalent among rural areas, this could have also contributed to the lower prevalence in our study as compared to some of the studies above which were conducted in rural areas [33]. However, our results were in agreement with some studies held in Northern Ireland and Brazil whose prevalence was 3.6% and 2.67% respectively [1, 34].

In this study, older students (18 years to 24 years) were 2.7 times at risk of being visually impaired as compared to their younger counterparts (12 years to 17 years). These findings were similar with those in other studies which have associated being older as a risk to development of VI [35, 36]. This is scientifically plausible because of known patterns of growth changes in the eye during early, middle and late adolescent stages. During adolescence, there is an observed pattern of myopia progression, characterized by axial length elongation due to scleral tissue remodeling making the eyeball too long and then, lens thinning making the crystalline lens too strong. These physiological changes occur rapidly during early and middle adolescence and stabilize during late adolescence, implying that these growth changes can lead to an increased degree of nearsightedness. Eventually, worsening myopia among the late adolescents (18–24 years), could contribute to VI [37–39].

Students with a positive family history were 7 times at risk of being visually impaired as compared to those ones who didn't have a family history of VI. Other studies conducted in Ethiopia, Amman City, Beijing and Greece are in agreement with our findings in this study [37, 40–42]. This is because myopia, a form of VI has a high genetic basis and it manifests as juvenile-onset myopia, which is inherited as a complex trait genetically but can also be modified due to environmental factors [37].

Obese students were 9 times at risk of becoming visually impaired as compared to other students who had a normal weight or even under weight. These results are in agreement with those from other studies that have proven a correlation between obesity and VI [38, 43]. It is hypothesized that myopia, a form of VI is associated with insulin resistance, which is a common manifestation among obese students; consequently, obese children are most likely to experience hyperglycemia. Under hyperglycemic conditions, there is lens thickening, anterior shifting of the anterior pole and thus leading to refractive error in form of myopia, which when not corrected progresses to VI [44–46]. The increased insulin levels promote axial elongation through secretion of Insulin-like growth factor 1(IGF-1) which leads to VI [45, 47].

4.1 Limitations

Our study explored the VA using a standard Snellen chart which could not assess other visual parameters like visual field, colour vision among others, which could have been vital in making inferences on VI. However, persons who were found to have a poor VA, were referred to the Mbarara Referral Eye Centre. Furthermore, due to logistical constraints, we did not perform pinhole tests or clinical eye examinations, which would have helped determine the underlying causes of VI. Future studies should include comprehensive eye examinations, such as pinhole tests and other clinical assessments, to better identify the causes of VI in this population. Finally, VA was assessed without spectacle correction, which may have led to an overestimation of the prevalence of visual impairment. This limitation suggests that our findings could reflect both uncorrected and correctable VI, highlighting the need for further studies that differentiate between the two.

4.2 Strength of study

A key strength of this study is its relatively large sample size, which enhances the reliability of the findings. Furthermore, the study was conducted across multiple schools in different divisions of Mbarara City, a location characterized by a unique combination of urbanization, socioeconomic factors, and lifestyle behaviors that may impact the prevalence of VI. As one of the first studies to assess visual impairment prevalence in the city, it provides valuable insights into the scope of this public health problem.

5 Conclusion

This study revealed a low prevalence of VI among high school students, with older age adolescents, family history of VI, and obesity as associated factors. Implementing targeted screening programs for older students, those with a family history of VI, and obese students could significantly enhance the early detection and management of VI in the region. Further research among visually impaired high school students is needed to characterize the causes of VI, which could inform more effective interventions and support strategies.

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Data availability The datasets generated and analyzed during the study are available from the corresponding author on request.

Declarations

Ethics approval and cosent to participate The Research Ethics Committee of Mbarara University of Science & Technology (MUST-REC) approved this study, approval number; MUST-2023–863. All study procedures were performed in accordance with the relevant guidelines and recommendations and all participants provided written informed consent, while those under 18 provided assent, with additional consent obtained from their teachers. This study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki.

Consent for publication Not applicable.

Competing interests The authors report no competing interests in this work.

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