• Investigation •

Prevalence of visual impairment and estimation of refractive errors among school children in Kakamega, Kenya

Isabel Signes–Soler[1,2,3], *Alfred Ragot*[3], *Sheilah Nangena*[3], *Andrew Wekesa*[3], *Raúl Montalbán Llamusí*[2,4]

[1]Department of Optics and Optometry and Vision Sciences, Universitat de València, Burjassot, Valencia 46010, Spain

[2]NGO Vision Without Borders (Visio Sense Fronteres, VSF), Calpe 03710, Alicante, Spain

[3]Masinde Muliro University of Science and Technology, P.O Box 190 - 50100, Kakamega, Kenya

[4]Clinica Baviera Alicante C/Ausó y Monzó, 16, Alicante 03006, Spain

Correspondence to: Isabel Signes-Soler. Calle Corbeta, 6, Calpe 03710, Alicante, Spain. isabel.signes@uv.es

Received: 2023-07-08   Accepted: 2023-12-20

Abstract

● **AIM:** To investigate the prevalence of visual impairment (VI) and provide an estimation of uncorrected refractive errors in school-aged children, conducted by optometry students as a community service.

● **METHODS:** The study was cross-sectional. Totally 3343 participants were included in the study. The initial examination involved assessing the uncorrected distance visual acuity (UDVA) and visual acuity (VA) while using a +2.00 D lens. The inclusion criteria for a subsequent comprehensive cycloplegic eye examination, performed by an optometrist, were as follows: a UDVA<0.6 decimal (0.20 logMAR) and/or a VA with +2.00 D ≥0.8 decimal (0.96 logMAR).

● **RESULTS:** The sample had a mean age of 10.92±2.13y (range 4 to 17y), and 51.3% of the children were female (*n*=1715). The majority of the children (89.7%) fell within the age range of 8 to 14y. Among the ethnic groups, the highest representation was from the Luhya group (60.6%) followed by Luo (20.4%). Mean logMAR UDVA choosing the best eye for each student was 0.29±0.17 (range 1.70 to 0.22). Out of the total, 246 participants (7.4%) had a full eye examination. The estimated prevalence of myopia (defined as spherical equivalent ≤-0.5 D) was found to be 1.45% of the total sample. While around 0.18% of the total sample had hyperopia value exceeding +1.75 D. Refractive astigmatism (cil<-0.75 D) was found in 0.21% (7/3343) of the children. The VI prevalence was 1.26% of the total sample. Among our cases of VI, 76.2% could be attributed to uncorrected refractive error. Amblyopia was detected in 0.66% (22/3343) of the screened children. There was no statistically significant correlation observed between age or gender and refractive values.

● **CONCLUSION:** The primary cause of VI is determined to be uncorrected refractive errors, with myopia being the most prevalent refractive error observed. These findings underscore the significance of early identification and correction of refractive errors in school-aged children as a means to alleviate the impact of VI.

● **KEYWORDS:** visual impairment; refractive errors; myopia; amblyopia; sustainable development goals

DOI:10.18240/ijo.2024.05.19

Citation: Signes-Soler I, Ragot A, Nangena S, Wekesa A, Montalbán-Llamusí R. Prevalence of visual impairment and estimation of refractive errors among school children in Kakamega, Kenya. *Int J Ophthalmol* 2024;17(5):932-939

INTRODUCTION

Refractive errors are a public health concern and with uncorrected refractive errors being the major cause of visual impairment (VI) in low- and middle-income countries and the second most common cause of preventable blindness in the world[1-2]. Globally, at least 2.2 billion people have a near or distance VI. In at least 1 billion of these cases, VI could have been prevented or has yet to be addressed. These 1 billion people include those with moderate or severe distance VI or blindness due to unaddressed refractive error (88.4 million), cataract (94 million), age-related macular degeneration (8 million), glaucoma (7.7 million), diabetic retinopathy (3.9 million), as well as near VI caused by unaddressed presbyopia (826 million)[3].

Uncorrected refractive errors in children can make it difficult for them to learn at school and generally impair their quality of life. However, the correction of refractive errors with appropriate spectacles is one of the most cost-effective interventions in eye care[4].

In 2004, blindness resulting from uncorrected refractive errors alone was estimated to affect over 8 million people aged 5y and over from different surveys all around the world, with 153 million people estimated to be visually impaired (2008)[4]. A Meta-analysis (1990 to 2016) showed that globally in children (under 20y) the estimated pool prevalence of myopia, hyperopia, and astigmatism was 11.7%, 4.6%, and 14.9%, respectively. In the Africa region, the percentages were as follows 6.2%, 3.0%, and 14.2% respectively[5]. Although projections of myopia and high myopia from 2000 to 2050 indicate significant increases in prevalence globally[6].

VI from uncorrected refractive errors has been attributed to lost educational and employment opportunities, reduced productivity and poor economy for families and societies, and reduced overall quality of life[7]. Many times, children will never know that they are suffering from a refractive error or complain of defective vision. Instead, they choose to develop tactful survival methods like sitting in the front row in class or moving objects closer to them[8].

Despite the availability of corrective measures such as spectacles and contact lenses, the global prevalence of uncorrected refractive errors remains disproportionately high. There exists a correlation between lower socioeconomic status and an elevated burden of uncorrected refractive errors[7]. The cost of eye examinations and spectacles is the biggest barrier to the refractive correction in poor regions. Other barriers identified were lack of perceived need, travel distance and awareness[9]. In an adult population in Nakuru, Kenya, spectacle coverage for distance was found to be only 25.5%[10].

While a lot of studies have focused on the epidemiology of refractive errors in the world, some regions such as the low- and middle-income African countries have multiple cases of refractive errors unaccounted for. Usually, that's attributed to the few studies that have been conducted to estimate the prevalence of refractive errors in these regions.

In Kenya, the main cause of visual acuity (VA) impairment among children aged 5 to 16y was uncorrected refractive error[11]. Specifically, within the regions of Voi and Buguta in South Kenya, the predominant cause of VI was also identified as refractive error, with cataracts following closely as the secondary cause[12]. The region of Kakamega is located in western Kenya, with a population of 1 867 579 people, of which 897 133 are males. The Kakamega primary school is one of the highly populated public schools in Kenya.

The aim of our study is to investigate the prevalence of VI and uncorrected refractive error in school-aged children in the region of Kakamega (Kenya). The assessment of prevalence rates supports government planning by informing resource allocation. This, in turn, enables the early detection of visual errors. Swift intervention is crucial for achieving optimal outcomes, particularly for at-risk school-aged children facing the potential of VI.

SUBJECTS AND METHODS

Ethical Approval Parents were informed in advance about the upcoming eye screening activity before the examination date. Following this notification, they granted consent for their participation in the study, which strictly adhered to the tenets of the Declaration of Helsinki. The Ethic Committee of Masinde Muliro University of Science and Technology (MMUST), represented by the National Commission for science, technology and innovation, has given their approval with number: NACOSTI/P/20/3094.

Sample Selection The study was cross-sectional, and aimed at evaluating the prevalence of VI and estimated the prevalence of refractive errors at Kakamega primary school, Kakamega, Kenya. The school is a public primary school with a total population of 3674 children at the time of data collection. All students attending Kakamega primary school present at the time of examination were included in the study. Students with ocular pathologies or abnormalities unrelated to any form of refractive error were excluded from the study. A total of 3343 students participated in the study.

Examination Protocol The study approval was sought from Kakamega primary school through the outreach coordinator at MMUST. The examination protocol of the study was divided into two parts. Part A included visual screening performed on all children by optometry students of the MMUST. Participants name, school, class, age and sex were recorded. The examination included uncorrected distance visual acuity (UDVA) with an E decimal chart at 5 m, pinhole VA and VA with a +2.00 D lens. The +2.00 D lens was used to detect hyperopic children, as it is suggested that the sensitivity of distance VA screening for moderate hyperopia could be increased by this fogging method[13]. Part B of the examination included a comprehensive examination of participants with an UDVA of 0.6 or worse or VA with +2 D of 0.6 or better. The examination included tests for ocular motility, retinoscopy, cycloplegic and subjective refraction, as well as slit-lamp and fundus examination.

Cycloplegic refraction was performed by instilling 2 drops of 1% cyclopentolate administered 5min apart each one. The refraction was done 30min after to ensure full muscle relaxation. A portable slit lamp was used to assess the integrity of the anterior segment and a direct ophthalmoscope for the posterior pole.

The magnitude of the refractive errors was graded using the spherical equivalent (SE): 1/2 cylinder plus the sphere.

Participant was termed to be myopic if the SE greater than/ equal to -0.50 D, hyperopic if the SE greater than/equal to +2.00 D, and astigmatic if error was greater than 0.75 D (minus cylinder form was used). One was considered myopic if one or both eyes were myopic including anti-ametropic, hyperopic if one or both eyes were hyperopic as long as neither eye was myopic, and emmetropic if neither eye was myopic or hyperopic.

The estimated prevalence of refractive error was determined by assuming that eyes with a VA of 0.6 or higher (decimal) were considered indicative of functional vision. This assumption aligns with the World Health Organization's definitions of VI which state that a UDVA between 0.1 and 0.5 decimal represents VI[14]. Mild VI is characterized by a VA worse than 0.5 decimal, whereas moderate VI is identified by a VA worse than 0.3 decimal. Although using a screening cut-off VA of 0.6 decimal may overlook certain cases of mild myopia, it is worth noting that several authors have adopted this protocol for refractive error assessment[15]. These authors argue that such an approach provides an optimal balance between sensitivity and specificity, particularly when evaluating myopic children.

Refraction Notation The spherocylindrical refractions obtained were converted to vectorial notation using the power vector method. Using this procedure, any spherocylindrical refractive error can be expressed by 3 dioptric powers: M, J0 and J45, being M a spherical lens equal to the SE of the given refractive error, and J0 and J45 two Jackson crossed cylinders equivalent to the conventional cylinder. These numbers are the coordinates of a point in a three-dimensional dioptric space (M, J0, J45). The length of this vector is a measure of the overall blurring strength B of a spherocylindrical refractive error.

According to the power vector method, manifest refractions in conventional script notation [S (sphere), C (cylinder)×φ (axis)] were converted to power vector coordinates and overall blurring strength (B) by the following formulas: $M=S+C/2$; $J0=(-C/2)\cos(2\varphi)$; $J45=(-C/2)\sin(2\varphi)$; and $B=(M^2+J0^2+J45^2)^{1/2}$.

Data Analysis Statistical analyses were performed using SPSS version 26 (SPSS Inc., Chicago, IL, USA). Mean, standard deviation (SD) and range for each of the parameters were calculated. The degree of correlation between clinical variables was assessed using the coefficient of correlation (Pearson or Spearman according to whether or not they comply the condition of normality). Normality was confirmed by Kolmogorov-Smirnov test. Correlation was considered statistically significant when P-value was <0.05.

RESULTS

A total of 3343 children from the primary school of Kakamega (Kenya) were examined in November 2021. The mean age of the sample was 10.92±2.13 (range 4-17y) and 51.3% were female (n=1715). The majority of the children (89.7%) were age 8 to 14y.

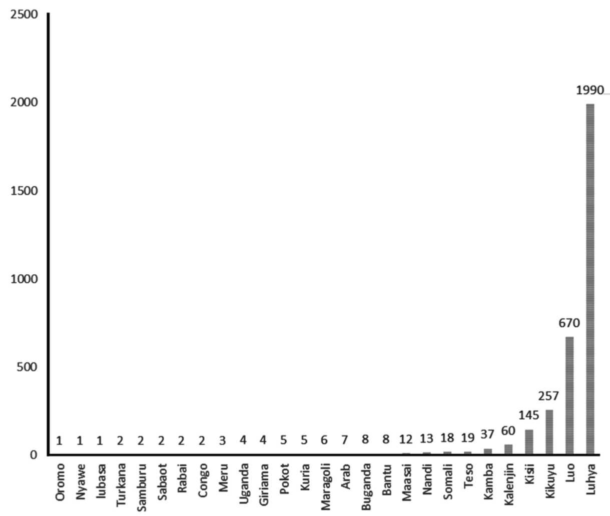

Figure 1 Number of children in each ethnic group in the total sample.

A total of 27 different ethnic groups were registered among the participants. Most of the children were from the Luhya ethnic group (n=1990, 60.6%) followed by Luo (n=670, 20.4%) and Kikuyu (n=257, 7.8%). Figure 1 shows the distribution according to the participants' ethnic group.

Of these, a total of 246 (7.4%) who had a UDVA<0.6 decimal (0.20 logMAR) and/or a VA with +2.00 D ≥0.8 decimal (0.96 logMAR) underwent a second comprehensive eye examination by an optometrist.

Visual Impairment To provide a more realistic assessment of the functional vision among the sampled children, the VA of the best eye was selected as a study variable. The mean value of UDVA for the best eye in logMAR was 0.29±0.17 (ranging from 1.70 to 0.22).

According to the VI classification, no VI was detected in 98.74% (3301/3343) of the students as they had a best eye UDVA of 0.5 logMAR (0.3 decimal). Mild grade VI was observed in 0.54% (18/3343) and moderate in 0.72% (24/3343).

Following the correction of refractive errors, only 0.15% of the total student population (5 out of 3343) displayed mild VI. This was indicated by their best eye corrected distance visual acuity (CDVA) falling below 0.3 logMAR (0.5 decimal). Similarly, an equivalent percentage of 0.15% (5 out of 3343) was observed for moderate VI, with best eye CDVA below 0.5 logMAR (0.3 decimal). A vast majority, 99.77% (3333 out of 3343), in the study had good vision in their best eye, with a CDVA equal to or better than 0.3 logMAR (0.5 decimal). This ensures their ability to easily carry out daily tasks. Uncorrected refractive error accounts for 76.2% (32/42) of our visual impaired cases.

Table 1 Summary of uncorrected distance visual acuity (logMAR) by type of ametropia mean±SD (range)

Patients (*n*=236)	VA right eyes	VA left eyes
Emmetropia (SE -0.25 D to +1.75 D)	0.24±0.05 (0.22 to 0.40)	0.24±0.05 (0.22 to 0.52)
Myopia (SE≤-0.50 D)	0.48±0.30 (0.22 to 1.70)	0.50±0.31 (0.22 to 1.70)
Hyperopia (SE≥+2.00 D)	0.41±0.18 (0.22 to 0.700)	0.61±0.35 (0.22 to 1.00)

VA: Visual acuity; SE: Spherical equivalent; SD: Standard deviation.

Visual Outcomes for Children who Underwent a Full Eye Examination Mean logMAR UDVA was 0.31±0.19 (range 1.70 to 0.22 logMAR) for the right eyes and 0.33±0.29 (range 3.00 to 0.22 logMAR) for the left eyes. Achieving an UDVA of 0.1 logMAR (0.8 decimal) or better was observed in 24.4% of children in the better eye, while 2.4% of eyes had a UDVA of 1 logMAR (0.1 decimal) or worse. Table 1 displays the UDVA for emmetropic, myopic, and hyperopic eyes. The sample size in Table 1 is 236 patients, as opposed to 246, due to the exclusion of outliers. Specifically, some children were categorized as emmetropic because they were unable to improve their VA through refractive correction but exhibited unusually low VA that distorted the overall range of measurements.

Refractive Outcomes Mean magnitude of sphere and refractive cylinder was -0.05±1.14 D and -0.07±0.33 D in right eyes and -0.04±1.21 D and -0.07±0.29 D in left eyes. Table 2 summarizes the refractive data in both conventional and vector format. The CDVA for the best eye was 0.04±0.11 (ranging from 1.00 to 0.00) in logMAR. Figure 2 shows in a box plot the spherical equivalent for the right and left eyes of the refracted students.

When comparing whether there are differences in the refraction obtained (SE) between right and left eye, no statistically significant differences were found (P=0.902, Wilcoxon signed ranks test) as expected. Refractive error was found in 21.95% of the right eye and in 22.36% of the left eye. Figure 3 shows the distribution of cases according to the ametropic defect. The highest percentage of students were emmetropic reaching a proportion close to 77% (98% of the total sample). The proportion of students with myopia (defined as SE ≤-0.5 D) was close to 20% (1.45% of the total sample), leaving a percentage of around 2.5% (0.18% of the total sample) of patients with a hyperopia value higher than +1.75 D.

Refractive astigmatism (cylinder <-0.75 D) was present in 2.85% (7/246) of the cases for the right eyes, with an average cylinder of 1.71±0.76 D. Likewise, it was present in 2.03% (5/246) of cases for the left ones with an average of -1.85±0.49 D. This represents 0.21% and 0.15% of the total sample for right and left eye respectively. Thus, we can state that 0.21% of the children had a refractive astigmatism higher than 0.75 D.

Spearman's correlation ratio between myopia and age was found to be for right eyes r=0.121 (P=0.411) and for left eyes r=-0.067 (P=0.648). Therefore, no statistically significant correlation was found between the age and the refractive value (SE) of the children.

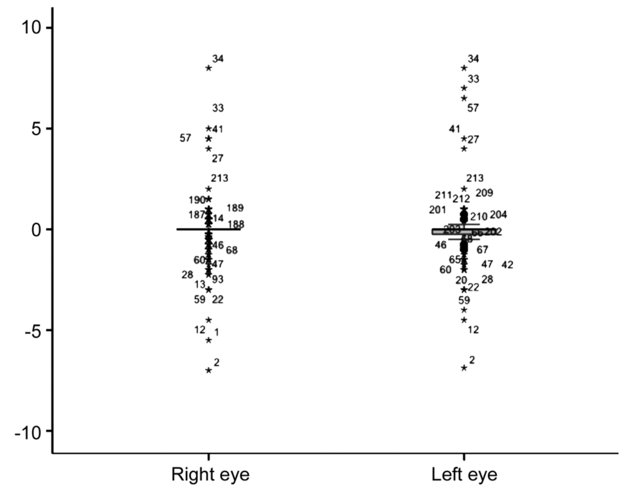

Figure 2 Box plot of the spherical equivalent for the right and left eyes of the refracted sample.

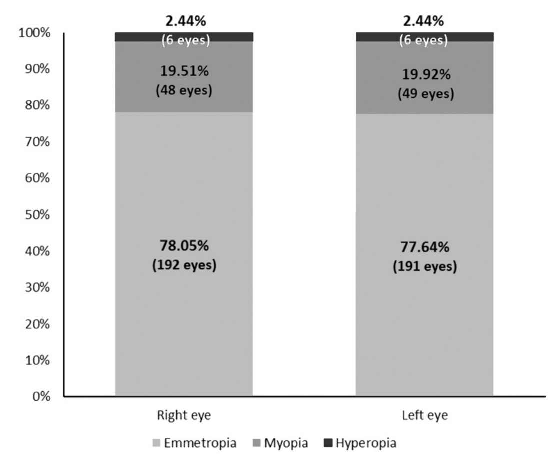

Figure 3 Percentages of cases according to the distribution used in the present study for each ametropia for children that underwent a complete eye examination (*n*=246).

Table 2 Refractive outcomes in conventional and vector notation mean±SD (range; D)

Patients (*n*=246)	Right eyes	Left eyes
Sphere	-0.05±1.14 (-6.00 to +8.00)	-0.04±1.21 (-6.25 to +8.0)
Cylinder	-0.07±0.33 (-3.00 to 0.00)	-0.07±0.29 (-2.50 to 0.00)
SE	-0.09±1.19 (-7.00 to +8.00)	-0.07±1.23 (-6.88 to +8.00)
J0	0.02±0.15 (-0.50 to 1.50)	0.01±0.12 (-0.38 to 1.00)
J45	0.01±0.07 (-0.35 to 0.87)	-0.01±0.09 (-1.25 to 0.19)
B	0.53±1.09 (0.00 to 8.00)	0.52±1.13 (0.00 to 8.00)

D: Diopter; SE: Spherical equivalent; SD: Standard deviation.

When comparing the retinoscopy value (SE Rtx) with the obtained refraction (SE), a high degree of correlation was found between both values, with a statistically significant Spearman's ratio for the right eyes of 0.732 ($P<0.005$) and for the left ones of 0.767 ($P<0.005$). This finding shows that retinoscopy in this type of school screenings, provides an objective refraction value to be considered.

No statistically significant correlation was found between the sex and the refractive value (SE) of the children (Mann-Whitney *U* test).

Amblyopia A difference VA between the two eyes greater than or equal to two lines was considered as amblyopia. For the presence of bilateral amblyopia, the assessment criterion was established as those students whose VA with correction was less than or equal to 0.22 logMAR (0.6 decimal). A total of 22 students were detected with amblyopia with 15 of them being girls. This accounts for 8.9% (22/246) of children who underwent refractive examination. No significant differences in VA were observed based on gender (Mann-Whitney *U* test). When considering the total number of children screened, represent 0.66% of the total children (22/3343). Out of all the cases of amblyopia, 12 students had bilateral amblyopia. This accounts for 4.9% (12/246) of the refracted children or 0.36% of the total sample. In assessing the causes of amblyopia, 7 cases were found to be related to refractive problems. This accounts for 2.8% (7/246) of the refracted children or 0.21% of the total children. Among the cases of amblyopia, 5 cases were related to ocular pathology or visual deprivation. This represents 2% (5/246) of the refracted population or 0.15% of the total children. There were 10 cases where amblyopia was classified as idiopathic, meaning the cause was unknown. This corresponds to 4.1% (10/246) of the screened population or 0.30% of the total children. Out of the 246 children examined, only one case had esotropia, which was attributed to severe intraocular ocular pathology, resulting in light perception vision.

Visual Health Assessment In the slit-lamp examination, signs of inflammation of the conjunctiva were found in 7 of the 246 students examined (0.21% of the total), of whom 4 were boys and 3 were girls. The rest of the more severe pathology detailed below was found only in girls. Two 13-year-old girls underwent surgery for congenital cataract (0.06% of the total). One of them achieved after surgery a VA with correction of 0.4 logMAR (0.4 decimal) but the other one however had a very pale red reflex in the pupillary area with light perception vision together with esotropia in the Bruckner test. A 12-year-old girl who had suffered severe trauma on the left eye with severe corneal involvement (0.03% of the total) had light perception vision. A 7-year-old girl had a congenital posterior subcapsular cataract (0.03% of the total) in her right eye and achieved a CDVA of 0.22 logMAR (0.6 decimal). Finally, a 13-year-old girl presented a very pale reflex to the Bruckner test in both eyes related to posterior chamber pathology reaching a CDVA of 1.0 logMAR (0.1 decimal).

DISCUSSION

Integrating eye exams into school interventions provides a crucial community service. It enhances access to eye care, enables early detection and treatment of vision issues, supports academic success, and raises awareness about the significance of eye health. The United Nations General Assembly adopted its first resolution on vision: "Vision for All: Accelerating action to achieve the Sustainable Development Goals (SDGs)". This resolution establishes targets and urges the global community to enhance the vision of the 1.1 billion individuals with preventable VI by 2030[16]. Visual deficits not only diminish mobility and mental well-being but also elevate the likelihood and demand for social care.

Eye health services aimed at maximising vision, eye health and functional ability have broad benefits and can promote the advancement of multiple SDGs, in particular, reducing economic poverty and improving educational outcomes[17]. In order to improve educational outcomes and knowing the impact that vision has on the whole learning process of children, this first intervention of the Kakamega School of Optometry was organised together with a representative of the University of Valencia (Spain), lecturers of MMUST (Kenya) and the head of the Kakamega primary school. The intervention linked the optometry practice of the fourth- and fifth-year university students with community service.

For many of the children, this was their first eye examination, and some of them discovered that their vision was not as perfect as that of their peers. A local private optical company donated the prescription glasses for those who could not afford them. Access to proper eyeglasses is essential for children to thrive in their academic and daily activities.

To our knowledge, this is the first study to report the visual outcome of a massive screening program in this remote area.

Prevalence of Visual Impairment and Estimation of Refractive Error A total of 7.4% of the children did not pass the first screening and presented a spontaneous VA of 0.5 or less. Some children, when examined by the optometrists, showed better vision than initially recorded. Several reasons may explain why some students did not perform well on the VA measurement including lack of attention, difficulty understanding the test, or temporary fluctuations in vision due to factors such as eye fatigue, dryness, or other environmental conditions, all of which can contribute to the results. A study conducted in Ethiopia reported a prevalence of refractive errors at 12.9%[18], which was significantly higher than the findings in our study. In Ethiopia the authors identified various factors associated with refractive errors, including family history, lack of paternal formal education, and attendance at public schools. However, the specific reasons behind these associations were not the focus of our investigation.

Uncorrected refractive error has been identified as the leading cause of VI, making it difficult to engage in various activities[19]. In a study conducted in Zimbabwe, the prevalence of VI was reported to be 56.8%. The study included participants ranging in age from 5 to 100 years old. The results revealed that the most common cause of VI was uncorrected refractive errors, accounting for 54.2% of the cases[20]. In our students uncorrected refractive error was found to be responsible for 73% of all the cases of VI.

A systematic review done in Ethiopia, showed slightly low prevalence of VI and refractive error when compared to the current study[21]. The variation can be attributed to universal health coverage in Ethiopia, which is slightly higher compared to Kenya.

A Meta-analysis to investigate the prevalence of refractive error in Chinese children under 18y showed a pooled prevalence of myopia, high myopia, hyperopia and astigmatism was 38.0% 2.8%, 5.2% and 16.5%, respectively[22].

In general, Africa has shown a relatively low prevalence of refractive errors, particularly myopia. The prevalence rates vary across different countries in the region. For example, a study conducted in Nigeria reported a low prevalence of 1.2% for myopia[23], while another study in Somalia reported a higher prevalence of 9.1%[24]. Based on a comprehensive systematic review, global estimates indicate the following prevalence rates for refractive errors: myopia (defined as SE≤-0.5 D) at 11.7% (95%CI: 10.5%-13.0%), hyperopia (defined as SE≥+2 D) at 4.6% (95%CI: 3.9%-5.2%), and astigmatism at 14.9% (95%CI: 12.7%-17.1%)[5]. Within the context of this review, examining the data specific to Africa reveals interesting findings. Among children under the age of 15, Ghana had the lowest reported prevalence of myopia (defined as SE≤-0.5 D) at 3.2%[25] whereas Uganda had the highest prevalence at 11% among children aged 6 to 9[26]. These statistics highlight the variability in myopia prevalence across different African countries and age groups, underscoring the importance of regional factors in understanding and addressing refractive errors in the African context. In our study, we observed a prevalence of myopia (defined as SE≤-0.50 D) of 1.45%, slightly higher than the Nigeria myopia study (1.2%)[23], but much lower than that reported in the Somalia study (9.1%)[24]. This disparity could be partly explained by the fact that the referenced articles are from 2013[25] and 2002[26] indicating a potential temporal shift in the prevalence of refractive errors. The variation in prevalence rates between studies can be attributed to several factors, including differences in the studied populations and variations in data collection methods. However, it is important to consider the influence of technology as a current factor, which has been implicated in the rising prevalence of myopia, particularly in Asian populations, reaching levels as high as 84%[27-29].

The study conducted in Ghana reported the lowest prevalence of hyperopia (defined as SE≥+2.00 D) at 0.3%[25], while the study conducted in Uganda reported the highest prevalence at 37% (defined as SE≥+0.5 D)[26]. Our study indicates a hyperopia prevalence of 0.18 within the total sample, defined as SE of ≥+1.75 D. This figure is notably lower than the estimated pool prevalence observed in South-East Asia (2.2%) and Africa (3%) for children[5]. This suggests that the findings of the current study diverge from the global patterns of hyperopia prevalence observed in different populations[24]. The specific criteria used to categorize individuals as having a particular ametropia can differ among studies, leading to variations in prevalence rates.

Refractive Astigmatism Refractive astigmatism greater than 0.75 D was not very prevalent in our population with only 0.21% of the total sample. The results obtained in our study regarding the prevalence of astigmatism are slightly lower than those published in a population of children and young adults in Ethiopia, where a prevalence of 1.3% was reported[30]. However, the results differ significantly from the study conducted in Uganda, where a prevalence of 52% was reported[26]. Furthermore, a recent study conducted in Somalia among students of comparable ages to our study reported a prevalence of 3.9%[24] for astigmatism. According to the results of a Meta-analysis, approximately 15% of children and 40% of adults were found to have astigmatism[5]. However, when specifically considering studies conducted in African countries, the prevalence of astigmatism shows notable variation among different research findings. Reported rates range from as low as 1.3% in Ethiopia[30] to as high as 91.9% in Benin[31]. It is important to recognize that the selection of cylinder power as the cut-off point can impact the reported range of astigmatism prevalence.

The observed variations in prevalence of astigmatism, myopia, and hyperopia within African countries indicate the influence of regional and population-specific factors. Factors like genetic predisposition, environmental influences (such as lifestyle, outdoor activities, and near-work), and healthcare access can contribute to these differences. By conducting comprehensive studies and understanding the underlying factors associated with refractive errors in diverse populations, we can inform public health initiatives, develop targeted interventions, and improve access to eye care services to reduce the burden of these VI.

Amblyopia and Other Ocular Conditions The global estimate of prevalence of amblyopia stands at 1.36% (95%CI:

1.27%–1.46%), however, the estimates varies depending to different regions[32]. The prevalence in Africa is believed to be low with 0.38% while Europe showing the highest of about 2.66%[32]. The above prevalence rates, based on a limited number of articles included in a Meta-analysis, may not be representative of the actual prevalence. With only three articles from Africa, the rate reported for that region may be inaccurate. In the present study the prevalence of amblyopia was found to be 0.66% of the children screened. In Kenya, this high prevalence in comparison to other African countries[32], can be partly explained by the uneven distribution of human resources in the county and by the fact that Kakamega is a rural area far from the capital.

Amblyopia is a significant vision problem worldwide and is expected to affect more than 220 million people by 2040[33]. In this systematic review[33], they found that the most common contributing factor to amblyopia was refractive error, whereas in our study, only 31% of amblyopia cases were attributed to refractive errors, while in most cases (45%) the cause could not be determined or was unknown. Successful treatment of amblyopia is achieved by early diagnosis and adherence to the administered therapy[34]. However, in the current study, the findings on the administered treatment were poor, as those affected were not attended. By emphasizing the importance of increased awareness, continued screening programs, and improved treatment strategies, it is possible to enhance the outcomes for individuals with amblyopia. Collaborative efforts among healthcare professionals, policymakers, and communities can contribute to better management and outcomes for those affected by the condition.

Visual Health The study also revealed the prevalence of other ocular pathologies, with conjunctival inflammation accounting for 0.21% of the cases. However, it is important to note that this prevalence was comparatively lower than a similar study conducted in Ethiopia, which reported a prevalence of approximately 5.8% for keratoconjunctivitis among children under 18 years old[30]. Misalignment of the eyes causing visual cortex suppression was only found in one girl, visual axis deprivation due to congenital cataracts was found in two girls. Although the sample was very equal between boys and girls, the most severe pathology was found in girls.

In conclusion, refractive error was the main cause of VI in our sample. The estimated prevalence of myopia in our study was high compared to other previous studies in the region. Despite the development of various management strategies, myopia has been on a steady rise even in rural Africa. Conversely, hyperopia has become a neglected condition, and its effects should not be overlooked. Amblyopia should be a priority in terms of screening and diagnosis within the country. The study revealed shortcomings in how the condition is currently handled, emphasizing the need for improvement in its management.

ACKNOWLEDGEMENTS

We extend our thanks to the staff of Kakamega Primary School for their cooperation and support in facilitating the screening program. We would like to express our appreciation to Visio Sense Fronteres (Vision Without Borders) for generously providing the necessary technical instruments for the screenings. We would like to extend our heartfelt thanks to the four- and five-year-old students, as well as the faculty and staff of the Department of Optometry and Vision Science at Masinde Muliro University of Science and Technology. Their dedication and assistance were instrumental in successfully screening the children and ensuring the smooth execution of the program.

Conflicts of Interest: Signes-Soler I, None; **Ragot A,** None; **Nangena S,** None; **Wekesa A,** None; **Montalbán-Llamusí R,** None.

REFERENCES

1 Flaxman SR, Bourne RRA, Resnikoff S, Ackland P, Braithwaite T, Cicinelli MV, Das A, Jonas JB, Keeffe J, Kempen JH, Leasher J, Limburg H, Naidoo K, Pesudovs K, Silvester A, Stevens GA, Tahhan N, Wong TY, Taylor HR, Vision Loss Expert Group of the Global Burden of Disease Study. Global causes of blindness and distance vision impairment 1990-2020:a systematic review and meta-analysis. *Lancet Glob Health* 2017;5(12):e1221-e1234.

2 Causes of blindness and vision impairment in 2020 and trends over 30y, and prevalence of avoidable blindness in relation to VISION 2020: the Right to Sight: an analysis for the Global Burden of Disease Study. *Lancet Glob Health* 2021;9(2):e144-e160.

3 Fricke TR, Tahhan N, Resnikoff S, Papas E, Burnett A, Ho SM, Naduvilath T, Naidoo KS. Global prevalence of presbyopia and vision impairment from uncorrected presbyopia: systematic review, meta-analysis, and modelling. *Ophthalmology* 2018;125(10):1492-1499.

4 Resnikoff S, Pascolini D, Mariotti SP, Pokharel GP. Global magnitude of visual impairment caused by uncorrected refractive errors in 2004. *Bull World Health Organ* 2008;86(1):63-70.

5 Hashemi H, Fotouhi A, Yekta A, Pakzad R, Ostadimoghaddam H, Khabazkhoob M. Global and regional estimates of prevalence of refractive errors: Systematic review and meta-analysis. *J Curr Ophthalmol* 2018;30(1):3-22.

6 Holden BA, Fricke TR, Wilson DA, Jong M, Naidoo KS, Sankaridurg P, Wong TY, Naduvilath TJ, Resnikoff S. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. *Ophthalmology* 2016;123(5):1036-1042.

7 Lou LX, Yao CL, Jin YH, Perez V, Ye J. Global patterns in health burden of uncorrected refractive error. *Invest Ophthalmol Vis Sci* 2016;57(14):6271-6277.

8 Sheeladevi S, Seelam B, Nukella PB, Borah RR, Ali R, Keay L. Prevalence of refractive errors, uncorrected refractive error, and

presbyopia in adults in India: a systematic review. *Indian J Ophthalmol* 2019;67(5):583-592.

9 Thompson S, Naidoo K, Gonzalez-Alvarez C, Harris G, Chinanayi F, Loughman J. Barriers to use of refractive services in Mozambique. *Optom Vis Sci* 2015;92(1):59-69.

10 Bastawrous A, Mathenge W, Foster A, Kuper H. Prevalence and predictors of refractive error and spectacle coverage in Nakuru, Kenya: a cross-sectional, population-based study. *Int Ophthalmol* 2013;33(5):541-548.

11 Muma S, Obonyo S. The prevalence and causes of visual impairment among children in Kenya - the Kenya eye study. *BMC Ophthalmol* 2020;20(1):399.

12 Signes-Soler I, Piñero DP, Javaloy J. Prevalence of visual problems in a rural population of Kenya. *Acta Ophthalmol* 2013;91(2): e165-e166.

13 Williams WR, Latif AH, Hannington L, Watkins DR. Hyperopia and educational attainment in a primary school cohort. *Arch Dis Child* 2005;90(2):150-153.

14 Brämer GR. International statistical classification of diseases and related health problems. Tenth revision. *World Health Stat Q* 1988;41(1):32-36.

15 Santiago HC, Rullán M, Ortiz K, Rivera A, Nieves M, Piña J, Torres Z, Mercado Y. Prevalence of refractive errors in children of Puerto Rico. *Int J Ophthalmol* 2023;16(3):434-441.

16 Lazuka-Nicoulaud E, Naidoo K, Gross K, Marcano Williams J, Kirsten-Coleman A. The power of advocacy: advancing vision for everyone to meet the sustainable development goals. *Int J Public Health* 2022;67:1604595.

17 Zhang JH, Ramke J, Jan C, Bascaran C, Mwangi N, Furtado JM, Yasmin S, Ogundo C, Yoshizaki M, Marques AP, Buchan J, Holland P, Ah Tong BAM, Evans JR, Congdon N, Webson A, Burton MJ. Advancing the Sustainable Development Goals through improving eye health: a scoping review. *Lancet Planet Health* 2022;6(3):e270-e280.

18 Alem KD, Gebru EA. A cross-sectional analysis of refractive error prevalence and associated factors among elementary school children in Hawassa, Ethiopia. *J Int Med Res* 2021;49(3):300060521998894.

19 Sheeladevi S, Seelam B, Nukella PB, Modi A, Ali R, Keay L. Prevalence of refractive errors in children in India: a systematic review. *Clin Exp Optom* 2018;101(4):495-503.

20 Tagoh S, Kyei S, Kwarteng MA, Aboagye E. Prevalence of refractive error and visual impairment among rural dwellers in mashonaland central province, Zimbabwe. *J Curr Ophthalmol* 2020;32(4):402-407.

21 Atlaw D, Shiferaw Z, Sahiledengele B, Degno S, Mamo A, Zenbaba D, Gezahegn H, Desta F, Negash W, Assefa T, Abdela M, Hasano A, Walle G, Kene, Gomora D, Chattu VK. Prevalence of visual impairment due to refractive error among children and adolescents in Ethiopia: a systematic review and meta-analysis. *PLoS One* 2022;17(8):e0271313.

22 Tang Y, Chen AM, Zou MJ, Liu ZZ, Young CA, Zheng DY, Jin GM. Prevalence and time trends of refractive error in Chinese children: a systematic review and meta-analysis. *J Glob Health* 2021;11:08006.

23 Akinremi SO, Ademola-Popoola DS, Olatunji FO, Ogunmuyiwa SO. Prevalence of refractive errors and the impact of its correction on academic performance of primary school children in Nigeria. *Niger J Ophthalmol* 2021;29(2):94.

24 Abdi Ahmed Z, Alrasheed SH, Alghamdi W. Prevalence of refractive error and visual impairment among school-age children of Hargesia, Somaliland, Somalia. *East Mediterr Health J* 2020;26(11):1362-1370.

25 Kumah BD, Ebri A, Abdul-Kabir M, Ahmed AS, Koomson NY, Aikins S, Aikins A, Amedo A, Lartey S, Naidoo K. Refractive error and visual impairment in private school children in Ghana. *Optom Vis Sci* 2013;90(12):1456-1461.

26 Kawuma M, Mayeku R. A survey of the prevalence of refractive errors among children in lower primary schools in Kampala district. *Afr Health Sci* 2002;2(2):69-72.

27 Saxena R, Gupta V, Prasad P, Bhardwaj A, Vashist P. Prevalence of myopia and its risk factors in rural school children in North India: the North India myopia rural study (NIM-R Study). *Eye (Lond)* 2022;36(10):2000-2005.

28 Ye L, Yang YQ, Zhang GY, Wang WJ, Ren MX, Ge P, Zhang J, Zhang N, Liu XZ, Zhang ML, Tong YJ, Lu LC, Lv MQ, Zhou DX, Pei C. Increasing prevalence of myopia and the impact of education in primary-school students in Xi'an, north-western of China. *Front Public Health* 2022;10:1070984.

29 Zhang XJ, Zhang YZ, Kam KW, Tang FY, Li Y, Ng MPH, Young AL, Ip P, Tham CC, Chen LJ, Pang CP, Yam JC. Prevalence of myopia in children before, during, and after COVID-19 restrictions in Hong Kong. *JAMA Netw Open* 2023;6(3):e234080.

30 Yared AW, Belaynew WT, Destaye S, Ayanaw T, Zelalem E. Prevalence of refractive errors among school children in Gondar town, northwest Ethiopia. *Middle East Afr J Ophthalmol* 2012;19(4):372-376.

31 Sounouvou I, Tchabi S, Doutetien C, Sonon F, Yehouessi L, Bassabi SK. A study of refractive errors in a primary school in Cotonou, Benin. *J Fr Ophtalmol* 2008;31(8):771-775.

32 Hu BD, Liu ZS, Zhao J, Zeng L, Hao GS, Shui D, Mao K. The global prevalence of amblyopia in children: a systematic review and meta-analysis. *Front Pediatr* 2022;10:819998.

33 Fu ZJ, Hong H, Su ZC, Lou B, Pan CW, Liu H. Global prevalence of amblyopia and disease burden projections through 2040:a systematic review and meta-analysis. *Br J Ophthalmol* 2020;104(8):1164-1170.

34 Lingham G, McGuinness MB, Safi S, Gordon I, Evans JR, Keel S. Clinical practice guidelines for the detection and treatment of amblyopia: a systematic literature review. *J Binocul Vis Ocul Motil* 2022;72(2):77-85.