• Investigation •

Epidemiological investigative report on ocular morbidity in children in rural Kenya

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Abstract

• **AIM:** To ascertain the pattern of ocular morbidity in a population of primary school children in rural Kenya as it is a prerequisite for planning effective preventive and therapeutic strategies.

• **METHODS:** A cross-sectional survey of ocular symptoms and clinical eye examinations were performed in a sample of 35 rural primary schools in the semi-arid region of Kajiado West sub-county in S.W. Kenya, amongst a semi-nomadic tribe (Maasai). Students in Grades 1-8 were included. Visual acuity was measured using the Snellen "tumbling E" chart at 6 m. Children with symptoms of refractive error underwent non-cycloplegic refraction.

• **RESULTS:** A total of 2036 children (1084 males) between the ages of 4-20y were examined. Conjunctival actinic changes were present in 22% (442/2036). Nine cases were seen with a potential squamous carcinoma. No overt classical ocular signs of vitamin A deficiency were noted, although 181 (8.9%) children complained of nyctalopia. Three hundred thirty-six (16.5%) children had a visual acuity worse than 6/12 in either eye, were unable to read N10 near text at 40 cm or had symptoms suggestive of refractive error. Refractive data led to an estimate of hyperopia of +1.00 D or more in 3.9% and of myopia of -0.50 D or more in either eye in 3.0% of the study population.

• **CONCLUSION:** Solar exposure- and dust-related conjunctival pathology is common. As this may develop into potentially sight- or even life-threatening conditions, it warrants further study, and preventive strategies may be needed. Complaints of nyctalopia were common and could suggest vitamin A deficiency. The prevalence of refractive errors is low in this rural African population.

• **KEYWORDS:** ocular morbidity; epidemiological investigation; actinic conjunctival changes; refractive error; rural Kenyan children

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INTRODUCTION

It has been estimated that 75% of the world's blind or visually-impaired children live in middle- or low-income countries[1] and that uncorrected refractive error is the most common cause (77%)[2]. Eye health impacts school attendance, learning, and eventual academic achievement and quality of life. Understanding the pattern of local morbidity is a prerequisite for planning potential preventive and therapeutic strategies. While there has been great interest in the "epidemic" of childhood myopia in relatively developed settings[3], childhood ocular health has been less well studied in less-developed settings.

Ocular morbidities and refractive error in urban and rural school children have been studied in several sub-Saharan countries, such as Ethiopia[4-5] and Rwanda[6]. A Meta-analysis of 7647 children reported in nine studies in Ethiopia found visual impairment (visual acuity less than 6/18 in the better eye) in 7% of the children, with a higher prevalence in females[4]. A Meta-analysis of 20 088 children from 22 studies in Ethiopia reported visual impairment due to refractive error (visual acuity 6/12 or worse in either eye) in 6% of the

children[5]. A 2023 study of 27 075 primary and secondary school children in Rwanda found that the main ocular morbidity was allergic conjunctivitis (3.1%) followed by strabismus (0.26%), and refractive error (0.18%)[6].

In Kenya, a sub-Saharan country, there have been few studies of ocular morbidity in the school population. The paucity of data is greatest amongst rural primary school children. In 2020, Muma and Obonyo[7] performed a hospital-based study across Kenya involving 3400 children, with a mean age of 12y. The presenting visual acuity was 6/18 or worse in 2.4% of children, attributed to uncorrected refractive error in 1.5%, amblyopia in 0.6% and nystagmus in 0.3%[7]. Nyamai and Kanyata[8] in 2019 studied refractive error in eleven Nairobi secondary schools and found a prevalence of myopia of -0.50 D or more of 15.5%. A prevalence study of trachoma in the Kajiado district in 2006 found a prevalence of 28% among children aged 1-9y[9]. However, the prevalence of other ocular morbidities such as vitamin A deficiency, infectious or traumatic causes of visual impairment, congenital conditions, actinic changes (which may be prone to malignant development) has not been systematically studied in rural Kenyan children.

We have conducted a comprehensive cross-sectional epidemiologic survey in primary school (Grades 1-8) children to ascertain the nature and extent of ocular morbidity in poor, semi-nomadic Maasai primary school children of the remote Kajiado West sub-County in S.W. Kenya.

PARTICIPANTS AND METHODS

Ethical Approval The study followed the tenets of the Declaration of Helsinki. Ethics approval was given by the University of Edinburgh Medical School Ethics Committee, EMREC Number AC22125. Authorization to conduct the study, visit the schools and examine the students was given by the Chief Educational Officer of Kajiado West sub-county. The head teacher of each school informed parents of the study team's visit to obtain parental informed consent for the children to be examined.

Participants The primary aim of the study was to determine the cross-sectional prevalence of eye diseases in school children, in order to acquire an overview of the total burden of eye diseases in this population. The secondary aim was to determine the cross-sectional prevalence of refractive errors in primary school children. Moreover, this study has a stratified design by gender to obtain reliable outcomes in both boys and girls.

A sample size calculation was performed to ensure sufficient numbers for the primary aim of the study with the following formula:

$$\text{Sample size}=N\times\frac{\frac{Z^2\times p\times(1-p)}{e^2}}{N-1+\frac{Z^2\times p\times(1-p)}{e^2}}$$

Wherein N is the size of the total population eligible for inclusion in the study (estimated at 30 000 children); Z is z-value of the normal distribution of the desired confidence interval (chosen at 1.96); p is the estimated proportion of children affected by eye diseases (unknown, set conservatively at 0.5 to ensure sufficient power), and e is the desired margin of error for the estimated proportion (chosen at 0.025, hence 0.05 for the analysis by gender). The sample size was calculated to be 1462. To obtain a representative sample, 35 of the 120 primary schools were sampled by convenience across all four Education Zones: Kisamis, Magadi, Elongata-Waus and Ewuaso of the Kajiado West sub-county, an area of 7800 km^2. Most children belonged to the Maasai. When visiting a school, all children were offered an eye examination, which led to a higher number of children than needed according to the power calculations. Similarly, stratification by gender was not performed, but in fact the number of boys and girls was very similar across all schools.

Before conducting study procedures, the Community Eye Health Worker gave a short presentation, using a model of an eye, to the students in their local language. The procedures of the eye examination were explained and demonstrated, particularly the process of measuring visual acuity. The visiting eye team consisted of the principal investigator (Long ME), the research assistant, an optometrist (when available), a community eye health worker, and a community nurse.

Clinical History The demographic and ocular history were obtained from each child, including the chief presenting symptom, any family history of ocular disease or blindness, and any contact with eye health services. The interviews were conducted by the community nurse or the trained research assistant in the local Maa or Kiswahili language.

Ocular Examination Visual acuity with and without correction using the Snellen "tumbling E" chart was obtained, and each child then underwent an examination by either the principal investigator or optometrist, which included lids and adnexa, anterior segment by torch/direct ophthalmoscope, extraocular motility, evaluation for nystagmus and strabismus, and undilated direct ophthalmoscopy in a dim room. The lid and adnexa examination observed apposition of the lid to the globe, proptosis, ptosis, and trichiasis. The eyelids were everted to inspect for features of trachoma such as follicles and scarring. The conjunctiva was examined for surface texture and actinic changes, proliferative/degenerative lesions (such as pinguecula and pterygium), melanosis, inflammation, and pre-malignant/neoplastic changes. The position of lesions was registered (limbus, bulbar conjunctiva, tarsal conjunctiva). The corneal examination analyzed clarity and curvature. Pupillary reflexes were tested, and a direct ophthalmoscope was used to assess the clarity of the media and examine the fundi.

Refraction Students found to have visual acuity of 6/12 or worse in either eye, who were unable to read N10 near text at 40 cm using either eye, or who had symptoms suggestive of refractive error (difficulty reading, difficulty in seeing the blackboard, tearing, blurred vision, diplopia, or asthenopia) were scheduled to undergo refraction. Children underwent non-cycloplegic refraction by an optometrist, when available, using an Auto-refractor (Model RM 9000), or trial lenses. When available, glasses were prescribed. Others were referred to an urban Eye Hospital.

Definitions The International Classification of Diseases[10] and the World Health Organization classification of visual impairment were used[10]. Presenting distance visual impairment in either eye was classified into the following groups: normal (visual acuity up to 6/12); mild (<6/12 to 6/18); moderate (<6/18 to 6/60); severe (<6/60 to 3/60); blind (<3/60). Near vision impairment was defined as a vision worse than N10 at 40 cm.

Myopia was defined as a refractive error of -0.50 D or more (the International Myopia Institute definition) in either eye[11]. In line with recent international studies, hyperopia was defined as +1.00 D or more in either eye[12]. However, to facilitate comparisons with studies using the Refractive Error Study in Children protocol[13], we also report hyperopia of +2.00 D or more in either eye. Furthermore, we report astigmatism of 1.00 D or more in either eye in the absence of hyperopia or myopia in either eye.

Referrals Children found to have ocular conditions such as suspected malignancies [*e.g.,* ocular surface squamous neoplasia (OSSN), melanoma], intra-orbital tumors, strabismus, or nystagmus were directed towards specialist assessment and treatment. Teachers were given information to communicate with the child's parents in their local language, verbally and in writing.

Statistical Analysis A descriptive analysis of the data was carried out to describe the study population and the pattern of ocular morbidities among the children. Univariate analysis using logistic regression was conducted with types of ocular morbidity as the main outcome against sex, the predictor of interest. Other possible associations were not tested, due to the limited size and scope of the study. The statistical analysis was performed using the *R* program.

RESULTS

Demographics and Description of the Study Population Approximately 30 000 children were enrolled in rural primary schools in the sub-county at the time of the study (personal communication, Ministry of Education). A total of 2036 students between the ages of 4-20y were examined, between November 2022 and March 2023. One child was 18 and one 20 years old, all others were <18 years of age. The mean age was 10.7 (SD 2.56) and the median age was 11y, and 952 (47%) children were females and 1084 (53%) males. The homogeneous student population belonged to the semi-nomadic Maasai tribe of Southwest Kenya in the southern semi-arid Rift Valley. According to the teachers, most of the parents are herders and non-alphabetized, and the children walk an average of 20-24 km per day to and from school, averaging approximately 7-9h of sunlight exposure per day. These large distances to school in addition to their nomadic lifestyle are major contributors to the late entry and presence in the school. They have no night homework and have no digital devices. The schools offer free meals, clean running water, and a clean environment. Of the 2036 students enrolled in this study, ocular examination data was not obtained in 60 students, who after submitting demographic data and having their visual acuity tested, went to their classes for school tests. We only included their demographic and visual acuity data, but not any clinical eye examination data. At the time the study was conducted, the most pressing health challenge in the area was under-nutrition/near starvation, due to a severe drought, especially in the Kajiado counties.

Health Seeking Behavior and Family History Sixty-one (61/2036, 3%) children reported a history of seeking eye care, 43 (2%) in an eye hospital, and 277 (14%) had a family history of "eye problems" which largely consisted of similar complaints to those of the students, *e.g.*, itching and tearing due to dust and wind, and photosensitivity.

Symptoms One hundred thirty-four (134/2036, 6.6%) children mentioned ocular pain as their chief complaint (Table 1), 98 (4.8%) itching, 73 (3.6%) poor vision, 71 (4.5%) photosensitivity, and 50 (2.5%) tearing; 401 (20%) had "other" symptoms, which included 181 (8.9%) children who were "not able to see well at night" (nyctalopia) and 21 (1%) with "reaction to dust/sand".

Vision, Visual Impairment and Suspected Refractive Error Visual acuity was determined in all children. The prevalence of any visual impairment (vision in at least one eye <6/12) was 58/2036 (2.9%; Table 1). Twenty-six children (1.3%) presented with mild visual impairment (visual acuity <6/12–6/18) and thirty-two (1.6%) with moderate visual impairment or worse (visual acuity <6/18). Four children had severe visual impairment, and one was blind; the causes were not determined, and they were referred to a tertiary center. Normal visual acuity (6/6 to 6/12) was present in 1978 (97%) children (Table 1).

In addition to the children with had a visual acuity worse than 6/12 in either eye, the children who were unable to read N10 near text at 40 cm or had symptoms suggestive of refractive error underwent further examination. Of these three hundred thirty-six (336/2036, 17%) students (170 females and 166

Table 1 Visual acuity symptoms and signs of morbidity

Parameters	Males (*n*=1084)	Females (*n*=952)	Total (*n*=2036)
Visual impairment[a]			
Visual acuity 6/12 or better	1049 (97%)	929 (98%)	1978 (97%)
Mild impairment (<6/12–6/18)	13 (1.2%)	3 (1.4%)	26 (1.3%)
Moderate impairment (<6/18–6/60)	18 (1.7%)	9 (0.9%)	27 (1.3%)
Severe impairment (<6/60–3/60)	4 (0.4%)	0	4 (0.2%)
Blind (<3/60)	0	1 (0.1%)	1 (0.1%)
Symptoms[b]			
Pain	73 (6.7%)	61 (6.4%)	134 (6.6%)
Itching	55 (5.1%)	43 (4.5%)	98 (4.8%)
Poor vision	39 (3.6%)	34 (3.6%)	73 (3.6%)
Photosensitivity	28 (2.6%)	43 (4.5%)	71 (3.5%)
Tearing	31 (2.9%)	19 (2.0%)	50 (2.5%)
Other	179 (17%)	222 (23%)	401 (20%)
None	679 (63%)	530 (56%)	1209 (59%)
Signs			
Any[c]	460	403	863
Conjunctiva			
Any	371 (30%)	302 (38%)	673 (33%)
Actinic keratosis			442 (22%)
Pterygium			25 (1.2%)
Pre-pterygium			185 (9.1%)
Melanosis			216 (11%)
Conjunctivitis			47 (2.3%)
Other	126 (12%)	120 (13%)	253 (12%)
Eyelid			
Chalazion	1 (0.1%)	2 (0.2%)	3 (0.1%)
Ptosis	1 (0.1%)	0	1 (0.1%)
Trachoma	5 (0.5%)	3 (0.3%)	8 (0.4%)
Other			3 (0.1%)
Total	7 (0.7%)	4 (0.4%)	15 (0.7%)
Cornea	13 (0.1%)	12 (1.3%)	25 (1.2%)
Trauma	22 (2.0%)	17 (1.8%)	39 (1.9%)
Suspected refractive error	166 (15%)	170 (18%)	336 (17%)
Strabismus	50 (4.6%)	46 (4.8%)	96 (4.7%)
Nystagmus	6 (0.6%)	4 (0.4%)	10 (0.5%)

[a]WHO classification; [b]Symptoms are the "chief symptom" for each child–one symptom per child; [c]Any abnormal sign. Each child could have more than one morbidity sign.

males), we were able to do a refraction (without cycloplegia) in 267 (261 children by auto refraction and 6 by trial lenses).

A total of 267 children from the 336 with symptoms of refractive error were refracted by autorefractor or hand, while refraction was not possible for 69 children who had to return early to classes. Hyperopia of +1.00 D or more in either eye was present in 63/267 children (24%), myopia of -0.50 D or more in either eye in 49/267 (18%), and astigmatism in the absence of hyperopia or myopia in 15/267 children (5.6%). To avoid underestimating prevalence, we assumed that the children who had been selected for refraction but were not available, had similar findings to those who were refracted. We adjusted our calculations accordingly. With percentages for hyperopia of 24%, myopia of 18% and astigmatism of 5.6%, this led to total numbers of children with hyperopia of 80, myopia of 62, and astigmatism of 19 in the selected group of 336 children. The assumed presence of 80 children with hyperopia gave an estimated prevalence of 80/2036×100% or 3894 /100 000 (3.9%) and thus 1170 children in the Kajiado West subcounty (applying this prevalence to the estimated total of 30 000 children in rural primary schools in Kajiado West subcounty at the time of the study). Similarly, the prevalence

of myopia was estimated at 62/2036×100% or 3028/100 000 (3.0%), corresponding to 908 children in the Kajiado West subcounty. In addition, 19 cases of astigmatism of 1.00 D or more in the absence of hyperopia or myopia leads to an estimated prevalence of 19/2036×100% (0.9%) or 927/100 000 in the study population, and of 278 children in the Kajiado West subcounty. The overall estimated rate of symptomatic refractive error (hyperopia, myopia and astigmatism as defined above) was 7849/100 000 (7.8%), 2355 children in the Kajiado West subcounty.

Within the groups reported as hyperopic or myopic, 5/267 had hyperopia of +2.00 D or more in either eye [estimate of 309/100 000 (0.3%) of the study population], and 27/267 had myopia of -1.00 D or more in either eye [estimate of 1669/100 000 (1.7%) of the study population].

Prevalence of Ocular Morbidity Signs Any ocular morbidity signs were recorded in 863 of 2036 [42%, 95% confidence interval (CI) 42.3%-42.4%] children (460 males and 403 females; Table 1). Each child could have more than one ocular morbidity.

Conjunctival conditions The most striking clinical finding was a conjunctival abnormality in 673 of 2036 (33%) children. Each child could have more than one conjunctival abnormality. The commonest was conjunctival actinic changes in 442 (22%) children (Table 1, Figure 1). The appearances were akin to those found in adults of the coastal and semi-arid regions in the north (Turkana) of the country (personal observation Long ME).

Diagnoses were made visually without the possibility of histopathological analysis. Pterygia were relatively uncommon, with 25 cases (1.2%). There was one case of sub-acute inflammation of a pterygium, while 185 (9.1%) children exhibited pre-pterygium lesions. Nine (0.4%) children had lesions that were highly suspect for OSSN. Congenital, "complexion-associated" melanosis was a common finding (as expected in an African population), with 216 (11%) cases; however, the lesions were often multiple and, in some cases, larger, more irregular in configuration with irregular borders and slightly raised and with more irregular surfaces than those found in adult coastal/semi-arid area populations in Kenya (personal observation Long ME). Pigmentation was circo-limbal in 31 (1.5%) cases (Figure 1). Forty-five (2.2%) children had conjunctival naevi (Figure 2) and there were two (0.1%) cases of suspected conjunctival malignant melanoma. There were two (0.1%) cases of oculodermal melanocytosis, Naevus of Ota, one male and one female.

Other ocular morbidities Ninety-six (4.7%) children had strabismus (Table 1), ten (0.5%) had nystagmus, and 39 (1.9%) had a history of past trauma, with signs of old healed scars, corneal opacities, or traumatic cataract. Trauma was most often induced with a stick, some were sports related, and one child's injury was the result of an encounter with an elephant. None were due to an infectious process. Fifteen (0.7%) children had lid lesions, which included eight (0.4%) cases of active trachoma (follicular stage), three chalazia, one case of mild congenital unilateral blepharoptosis, and three "others". Twenty-five (1.2%) children had corneal conditions including one case of keratoconus, and five superficial and five deeper traumatic corneal scars. No overt classical ocular signs of vitamin A deficiency (xerosis, Bitot's spot) were noted; however, 181 (8.9%) children complained of nyctalopia.

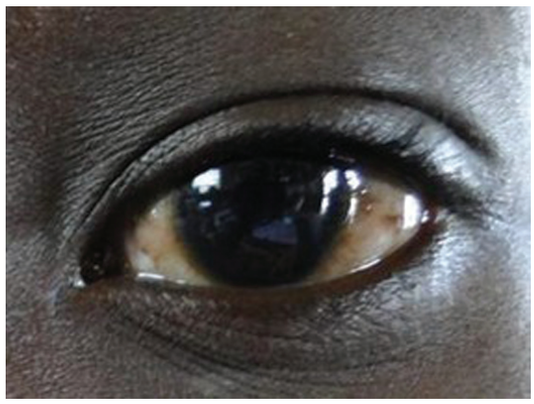

Figure 1 Abnormal conjunctival appearance: circo-limbal melanosis with actinic changes.

Figure 2 Ill-defined naevus with cystic change.

Management of Conditions Found in the Study A total of 326/2036 (16%) children was referred for specialist care, including two cases with an orbital tumor; 11 cases of suspected conjunctival malignancy (nine OSSN, two melanoma); 96 cases of strabismus, ten with nystagmus, and one keratoconus. Sixty-nine of the 336 children with suspected refractive error were referred for refraction when an optometrist was not available during the school visit.

Association of Ocular Morbidity and Sex There was no association between ocular morbidity and sex, odds ratio (OR) 0.99 (95%CI 0.83-1.18), P=0.96, and no individual form of morbidity was associated with sex (Table 2).

DISCUSSION

In this cross-sectional epidemiological study, we determined

Table 2 Ocular conditions of females compared to males

Predictor	Males (*n*=1084)	Females (*n*=952)	Unadjusted OR (95%CI)	*P*
Ocular morbidity	460 (42%)	403 (42%)	0.99 (0.83-1.18)	0.96
Suspected refractive error	166 (15%)	170 (18%)	0.89 (0.69-1.14)	0.35
Conjunctival conditions	371 (30%)	302 (38%)	0.97 (0.81-1.18)	0.81
Trauma	22 (2.0%)	17 (1.8%)	0.88 (0.46-1.66)	0.69
Cornea	13 (1.2%)	12 (1.3%)	1.05 (0.48-2.32)	0.90
Strabismus	50 (4.6%)	46 (4.8%)	1.05 (0.70-1.58)	0.82
Nystagmus	6 (0.6%)	4 (0.4%)	0.76 (0.21-2.67)	0.67
Any treatment	31 (2.9%)	30 (3.2%)	1.11 (0.66-1.84)	0.70

OR: Odds ratio; CI: Confidence interval.

the ocular morbidity in primary school children in a remote, rural district in Kenya. The commonest finding was conjunctival actinic changes in 442 (22%) children. In addition, the symptomatic refractive error rate was 7.8%. Hyperopia of +1.00 D or more in either eye was present in 3.9%, and myopia of -0.50 D or worse in 3% of the children. Field studies in remote, rural areas of Africa are infrequent due to the many logistic difficulties, and the findings of a high prevalence of actinic injury and a low prevalence of myopia are of interest.

Kenya straddles the Equator and has sunlight all year round. Kajiado county is a semi-arid area known for cattle keeping and the study children spend most of their time outdoors. It is therefore not surprising that the most striking findings in this study were the high prevalence of actinic conjunctival changes and the relatively low prevalence of myopia. Our study population spent several hours walking to and from school each day in a dry and dusty environment and had no electricity supply or digital devices at home. While several children were referred to eye clinics, clinical follow up of these referred cases was not available and histopathological diagnoses were not provided. We therefore only report clinical diagnoses. Low rates of myopia have been reported in similar less developed rural populations[14-16], in contrast to more developed global regions[17] and may be related to lifestyle.

Actinic Conjunctival Changes, Pinguecula, Pterygium, Ocular Surface Squamous Neoplasia Ultraviolet radiation exposure is associated with the development of pterygia[18] and OSSN. Though benign and slow growing, pterygia may eventually become sight-threatening by growing over the visual axis, necessitating surgical removal. They can also disturb tear-film function leading to dry eyes. While it is generally thought that malignant transformation does not occur, histological studies of pterygia have found dysplastic and pre-malignant changes[19]. The spectrum of histopathology of OSSN can range from epithelial dysplasia to carcinoma *in-situ*, to invasive squamous cell carcinoma[20] and lesions have a strong association with histologic conjunctival solar elastosis[21].

The median age of patients with OSSN in the northern hemisphere is 60y, and 35y in the southern hemisphere[20]. The average ages of occurrence reported for East Africa (Uganda, Tanzania and Kenya) were between 33 and 38y[22]. In the current study, we only looked at primary school children. However, in this study we only have clinical suspicion of OSSN as it was not feasible to perform histopathology, and this may have led to an overestimation of the prevalence. The relatively high prevalence of potential OSSN is probably not caused by human immunodeficiency virus (HIV) infections among the children[20], because of the age group, and HIV infections are not thought to occur frequently in the isolated population we studied.

Melanoma Ultraviolet light has not only been implicated in the etiology of pterygia and OSSN but also in that of conjunctival melanoma[23]. Conjunctival naevi, which were found in 45/2036 (2.2%) of the study population, were judged to be benign, except for two cases of suspected melanoma. While conjunctival naevi rarely undergo malignant transformation, especially in young people[24-25], it has been reported that 14%-20% of conjunctival melanomas arise from pigmented naevi[26]. Strempel and Kroll[26] reported 3 cases of childhood conjunctival melanoma. The two cases of oculodermal melanocytosis had scleral involvement and are therefore at risk of choroidal melanoma[27], although the risk is not well studied in people of African descent.

Refractive Errors Based on the sample of 267 symptomatic students refracted during the visits of volunteer Optometrists, an estimated 3.9% of the student population were hyperopic, and 3.0% were myopic in either eye. A Meta-analysis of 42 refractive error studies in Africa showed a prevalence of myopia (-0.5 D or more) of 4.7%[28]. Rates were higher in urban settings (6%) than in rural settings (4.9%), were higher during 2016–2021 (6.3%) than 2000–2005 (4.3%) and were higher in Northern (6.8%) and Southern (6.3%) than in Western (3.5%) and Eastern (4.7%) regions of Africa[28].

Refraction status is related to age, and to genetic and environmental factors. Worldwide studies over the past decade

have revealed an epidemic of myopia[3]. So-called "school myopia" occurs during school years due to prolonged close work and reduced exposure to outdoor activities[29]. A study in Chinese children showed that children who spent more time outdoors had a reduced rate of myopia[30].

A study of rural school children in India with lifestyles similar to our population found a very low prevalence of myopia (0.2%)[15], as did a study in rural Iran (2.6%)[16]. These findings are in keeping with previous studies in Kenya (1.7%)[14]. Our findings are consistent with the concept that increasing rates of myopia globally are associated with economic development, specifically time spent indoors performing near work[31]. Recent large international studies of the interaction of genetic and environmental factors point to predominantly environmental causes of myopia, interacting with certain gene loci[32].

Of the 336 pupils that were suspected to have refractive error based on symptoms and measurement of visual acuity, 267 (79%) were refracted by volunteer (*pro bono*) optometrists. However, children without visual complaints and with good visual acuity were not refracted. We did not ascertain asymptomatic hyperopia. Non-cycloplegic refraction may have over-estimated myopia and under-estimated hyperopia. We did not have ethical permission to perform cycloplegic refraction in the current survey.

Trachoma and Vitamin A Deficiency Only eight (0.4%) students had active or early-stage trachoma in our study. This contrasts with a study done by Nyamwaro[33] in Kajiado West who surveyed village children aged 1-9y and found a prevalence of 18.6 % in 2016. This study was of non-schooled village children, with poor environmental hygiene associated with close contact with their herds and mud and stick dwellings. Our study was of school-going children, who at school had access to clean water, were taught and practiced good personal hygiene habits, and were in a clean environment and not exposed to animals or waste when at school.

Though being undernourished and lacking in any yellow or green vegetables, no overt classical ocular signs of vitamin A deficiency (xerosis, Bitot's spots) were noted. However, 181 (8.9%) children did complain of nyctalopia, a very inconvenient symptom in villages with no electrical supply, and suggestive of early disease. Such findings warrant closer investigation and consideration of a vitamin A supplement program in the area since vitamin A deficiency is a leading cause of preventable blindness in children worldwide[34].

In conclusion, the high prevalence of actinic conjunctival conditions amongst the primary school age group is a cause for concern, as is the high prevalence of complaints of nyctalopia. The prevalence of refractive errors (myopia -0.50 D or more 3.0%, hyperopia +1.00 D or more 3.9%) was consistent with other studies performed in other less developed, rural populations.

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