PREVALENCE OF REFRACTIVE ERRORS AMONG PRIMARY SCHOOL CHILDREN IN MAKUENI DISTRICT, KENYA

A dissertation submitted as part fulfillment

for the degree of Masters of Medicine (Ophthalmology),

University of Nairobi

By

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DECLARATION

This dissertation is my original work and has not been presented for a degree at any other University.

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APPROVAL

This dissertation has been submitted for examination with our approval as University supervisors.

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DEDICATION

To my wife Kachikonyo and our daughter Insansa for their patience and understanding, the loss of some special moments to this task.

To the Kenyan people who are such a great people. May God bless them all abundantly.

Most importantly to the Lord Jesus Christ our strength and our hope.

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LIST OF ABBREVIATIONS

1. **CI**: Confidence interval
2. **D**: Diopters
3. **DC**: Diopter cylinders
4. **DEO**: District Education Officer
5. **DS**: Diopter spheres
6. **HEMA**: Hydroxylethyl Methacrylate Molecule
7. **KNH**: Kenyatta National Hospital
8. **MoE**: Ministry of Education
9. **MoH**: Ministry of Health
10. **NGOs**: Non-Governmental Organisations
11. **NHANES**: National Health and Nutrition Examination Survey
12. **OR**: Odds ratio
13. **PMMA**: Polymethyl Methacrylate
14. **PRK**: Photorefractive Keratectomy
15. **RD**: Retinal detachment
16. **SPSS**: Statistical Package For Social Scientists
17. **SR**: Subjective Refraction
18. **TV**: Television
19. **UK**: United Kingdom
20. **USA**: United States of America
21. **VA**: Visual Acuity
22. **WHO**: World Health Organisation

STUDY DEFINITIONS

The following definitions were considered for the study.

Amblyopia: Unilateral or bilateral decreased best corrected visual acuity caused by form of visual deprivation and/or abnormal binocular interaction for which there is no pathology of the eye or visual pathway.

Aphakia: absence of the crystalline lens from the papillary area.

Blindness: vision of less than 3/60 in the best-corrected eye.

Child: someone below the age of 15 years of age according to WHO.

Low vision: Vision of worse than 6/18 and up to 3/60 according to WHO.

Nystagmus: Is a repetitive, involuntary to and fro oscillation of the eyes which may be physiological or pathological.

Significant astigmatism: of more than +/- 0.5 dioptre

Significant hyperopia: of more than + 0.5 dioptre

Significant myopia: of more than - 0.5 dioptre

Strabismus: Any deviation of the eye

Vision 2020: Global initiative by NGOs and governments to reduce the burden of preventable and avoidable blindness by the year 2020. One of the components targeted is to identify and treat the refractive errors in children.

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ABSTRACT

Title: Prevalence of refractive errors among the primary school children of Makueni District, Kenya.

Objective: To determine the magnitude and pattern of significant refractive errors in primary school children in Kilungu division of Makueni District.

Methodology: A cross – sectional primary school based study of significant refractive errors was conducted in Kilungu division of Makueni District on pupils aged between 12 and 15 years old. All the pupils present during the time of the study in the selected schools were included in the study. Demographic data, history of ocular complaints and use of spectacles in the family was obtained. Visual acuity was assessed from each pupil using a Snellen's E chart. Ocular examination was carried out using a torch and magnifying 20 Dioptre loupe. Significant refractive error was defined VA of worse than 6/18 and therefore objective refraction under cycloplegia was carried out in all those pupils with visual acuity of worse than 6/18 followed by subjective refraction. The type of refractive error after refraction was grouped into hypermetropia, myopia or astigmatism.

Results: 1522 primary school pupils were eligible to participate in the study, but 1439 pupils (94.5%) were screened for refractive errors and 83 pupils (5.5%) were absent. The response rate was high at 94.5%.

The females contributed 59.2% and the males 40.8%. There was no statistical difference between the sexes, p = 0.453. The mean age of those was 13.28 years with standard deviation of 1.10 years and the median was 13.0 years. The prevalence of significant refractive error was 5.2% (75/1439), being responsible for 92.6 % of all causes of poor eyesight. Hypermetropia accounted for 3.2%, myopia 1.7% and astigmatism 0.3% of refractive errors. Myopia was more likely to be present in the pupils aged 14 to 15 years than those aged 12 to 13 years with OR 0.3 which was statistically significant (p = 0.022).

Conclusion: The overall prevalence of significant refractive errors (VA worse than 6/18) in pupils aged 12 to 15 years in Makueni's Kilungu division was 5.2%. A regular school screening programme would be beneficial to the primary schools in this area. Hypermetropia was the most prevalent refractive error at 3.2% followed by myopia at 1.7% and astigmatism at 0.3%.

1.0.0 Introduction

Refractive errors are the fourth commonest cause of blindness in the developing world.[1] In the developed countries, screening for eye diseases including refractive errors in school going children is done routinely.[2] In the UK for instance, almost all children with important visual problems including refractive errors have been detected before entry into school, and by the age of 8 years only 1.7% have not been screened for eye diseases.[2] This is so because eye services are easily accessible in the developed countries and majority of children with eye problems access them without requiring referral by other health professionals from the primary level of health care.[2, 3]

However, in many developing countries there are no national preschool or school eye screening programmes and in most cases screening is done for the purposes of research.[1] Therefore, little is known about the prevalence and public health importance of eye diseases in school age children. [4]

Effective management of blindness due to refractive errors is readily available in developed countries as compared to developing countries where it is scarce.[1] This management includes prompt refraction, easy accessibility to primary eye and affordable quality spectacles.[1] In Africa, centres which offer these services are few, inadequate and limited compared with the magnitude of the problem. These very few centres are also not easily accessible and the spectacles are not affordable to most people. [5] There is, therefore, need to develop service structures to match the magnitude of the problem.[5, 6]

2.0.0 Literature Review

2.1.0 Types of refractive errors

Refractive errors are not diseases of the eye, but ocular disorders[6]. Normally, light is refracted by the cornea and lens so that a clear image can be focused on the retina and be seen. For those with refractive errors, the image is focused either in front or behind the retina resulting in blurred images. There are three types of refractive errors; hyperopia, myopia and astigmatism.[7]

2.1.1 Hyperopia

This is also known as hypermetropia or far-sightedness.[7] In this type of refractive error an image of a distant object becomes focused behind the retina, either because the eyeball axis is too short, or because the refractive power of the cornea and the lens are insufficient.[7] Hyperopia is usually present at birth, except in premature infants. At birth more than 70% of the eyes are hyperopic to the extent of +2.50DS to +3.00 DS. In as many as 50% of these, emmetropia is not achieved and therefore an element of hyperopia persists until about the age of 12 to 14 years when hyperopia resolves completely. [7] Williams et al reported that by age of 7 years 10.8% of the children are still hyperopic and only 2% by the age of 15 years.[7]

The hyperopic condition makes near objects appear out of focus and may cause headaches, eyestrain, or fatigue. Straining, eye rubbing, lack of interest in school, and difficulty in reading are often seen in children with hyperopia.[7]

Hyperopia is often categorized by the amount of refractive error[7]:

- Low hyperopia is a refractive error of +2.00 D or less.
- Moderate hyperopia is a refractive error from +2.25 to +5.00 D.
- High hyperopia is a refractive error of +5.25 D or more.

2.1.2 Myopia

This is also known as near-sightedness. In this condition, unlike hyperopia, an image of a distant object becomes focused in front of the retina because either the eyeball axis is too long or because the refractive power of the cornea and the lens is too high[8]. To date, the real aetiology of myopia is still not well elucidated. Myopia is the most common refractive error seen in children.[1] It rarely occurs below the age of five years and new cases appear throughout childhood and adolescence particularly between the ages of 6 to 15 years. [8] It mostly occurs at the age of 8 to 10 years in girls and 11 to 14 years in boys.[9,10] Thereafter, the prevalence of myopia appears to stabilize, especially by the age of 15 to 17 years. [8] Children with this condition may be noticed to sit close to the television and often strain to better see distant objects.

Myopia is often categorized by the amount of refractive error [8]:

- Low myopia is a refractive error of less than 5.75D.
- High myopia is a refractive error of more than 6.00D.

2.1.3 Astigmatism

Astigmatism is a condition where the cornea or the lens has different refractive powers at different meridians.[11] Lens astigmatism is common in the elderly, where the lens may become somewhat irregular in shape because of cataractous changes. Astigmatism may be simple when not combined with hyperopia or myopia, or compound when an eye has both myopia and astigmatism or hyperopia and astigmatism. [11] Astigmatism may also be mixed when myopia is combined with hyperopic astigmatism, or when hyperopia is combined with myopic astigmatism. [11] Astigmatism can start in childhood or in adulthood. Symptoms include headache, eye strain, or fatigue. Eye rubbing and head tilt or turn is sometimes noted. Where correction is needed, vision tends to be sharper and more consistent with spectacles than contact lenses.

2.2.0 Prevalence of refractive errors

Severe refractive errors have been estimated to account for about 5 million blind people worldwide. [1] The prevalence of refractive errors differs by ethnic group and geographical region. [5] Estimates of the number of people worldwide with refractive error range from about 800 million to 2.3 billion. No prevalence data are available from the WHO or from any other source relating to very large populations such as groups of nations, or whole countries. [2] There are no prevalence figures for the population of even the USA where refractive errors are estimated to affect 25% of the population by the age of 15 years. [1]

Etyale et al of the WHO reported at a special session on refractive error at an International Agency for Prevention of Blindness meeting in 2001, that 5 - 15% of children are considered to have refractive errors, the majority of whom are uncorrected, and that there is currently a need for population based studies to ascertain these figures. [12]

Although Vision 2020 imposes a mandate to correct refractive errors, little infrastructure and few resources are available to accomplish the task. [12] Etyale et al noted that while access to general medical services is possible for about 25% of populations in developing countries, access to medical eye care, including refraction, can be obtained by only about 10%. [12]

A study carried out in Nairobi, Kenya by Nzuki et al found that the prevalence of significant refractive errors was 10.2% in school children. Of these 92.2% had myopia, 0.3% had hyperopia and 0.5% had astigmatism. [13]

Similarly, Kawuma et al found a prevalence of significant refractive errors of 11.6% among primary school children aged 12 – 13 years in Uganda, 52% of which had astigmatism with few cases having hyperopia or myopia. [14]

In Tanzania Mwanza city, Wedner et al found the overall prevalence of significant refractive errors in school pupils age 11 – 17 years to be 6.1%. [15] This was slightly lower than what Nzuki et al found in Nairobi, Kenya. Of the 6.1%, myopia accounted for 5.6%, hyperopia 0.4%, astigmatism 0.1%, strabismus 0.2%, amblyopia 0.4% and other non-refractive causes of poor eyesight were 0.8%. [15]

In Singapore the prevalence of the refractive errors among the school children aged 12 – 17 years was found to be 22.3% by Ho et al. [16]

Ming-Zhi Zhang et al conducted a study on children, aged 6 to 7 years in Singapore and Xiamen. A wide variation in prevalence rates was found, for Xiamen city (6.8%), Xiamen countryside (8.7%), and in Singapore (17.1%). [17]

In India a study conducted by Malta et al, showed 12.5% children to have refractive errors. [11] 55.6% had myopia, hypermetropia 16.9% cases and astigmatism 27.4 %. [11]

2.3.0 Variation among ethnic groupings

Numerous studies undertaken on different groups of people of varying ethnicity have provided clues about refractive error distribution.

Crawford et al examined school children from ten ethnic groups in Hawaii and found significant differences in refractive errors among the different ethnic groups. Chinese school children exhibited the greatest amount of myopia (17%), followed by Koreans (13%), and Japanese (12%). [18] Myopia occurred within other groups in the following descending order; Caucasians, Spanish, Portuguese, Filipinos, Puerto Ricans, Partial Hawaiians and Hawaiians. Hyperopia was found in 3% to 5% for all the groups. [18]

Wedner et al found that the prevalence of refractive errors was different depending on the ethnic group of the students. [15] It was found that the Tanzanians of Asian origin were 3.6 times more likely to be myopic compared to the black Tanzanians. [15] Similarly Mclaren found that the Tanzanians of Asian origin aged 7-14 years were more likely to be myopic than their counterpart black Tanzanians with similar age range. [19]

Similarly Ho et al reported prevalence of refractive errors among children of different ethnic groupings as Chinese 21.4 %, Malay 22.4%, Indian 21.0% and other races (races not stated in the report) 21.0%. [16]

In many studies carried out in different parts of the world, myopia has been found to be the most prevalent refractive error. A study carried out by Naidoo et al in South Africa showed a prevalence of myopia of 9.6% compared with 1.8% of hyperopia. [20]

Fan et al also found a high prevalence of myopia of 36.71 % in the school children of Hong Kong compared to hyperopia and astigmatism.[21]

2.4.0 Variation with age and sex

In Jordan, Baldwin et al, it showed that myopia tended to increase age in children, with the young children being hyperopic and the older children being more myopic. [22] Myopia was reported to be about 25% in the children aged between 10 – 15 years.

Au Eong et al reported that myopia not only increased with the age, but also increased with advancement in education as well. [23] Malta et al also found that all the refractive errors increased with increasing age and this phenomenon was observed in the age group of 10-14 years. [11]

From the NHANES, Macias et al showed that astigmatism increased with age, and it was 21.2% in males and 57.3% in females. [24] Wedner et al found that females aged 11-13 years were more myopic compared to the boys of the same age. [15] Nzuki et al found that the female pupils were more myopic at 54% compared to male pupils at 46%. [13]

In a study involving subjects of all ages by Dandona et al on refractive errors in Hyderabad, India, it showed that in subjects 15 years old or less, myopia was 4.4%, hyperopia 59.4% and astigmatism 6.9%, while in those older than 15 years, myopia rose to 19.3%, hyperopia fell to 9.8%, and astigmatism was detected in 12.9%. [25] The Dandona study showed that variations were present in different age groups although there was no comment as to whether there were variations between sexes. [25]

2.5.0 Variation with socioeconomic status

Some studies have found that the refractive errors found in different areas are also influenced to a great extent by the socioeconomic status of the children, that is, the high education status of the parents and the types of entertainment they are exposed to such as videos games and TV. [15] In Tanzania, Wedner et al found that the urban children were 5.6 times more myopic than the children in the rural area, regardless of ethnic grouping.[15]

In Nepal, Garner et al reported that children with similar genetic backgrounds who led a rural lifestyle had a prevalence of myopia of only 2.9% compared with 21.7% for children who led an urban lifestyle, with more rigorous schooling. [26]

2.6.0 Importance of Refractive Error correction

Children with uncorrected refractive errors may complain of blurred vision, asthenopia, accommodative dysfunction, binocular dysfunction, nystagmus, amblyopia, and strabismus. Wedner et al reported a prevalence of nystagmus of 0.5% and amblyopia 0.2%. [15] Williams et al found prevalence of strabismus and amblyopia of 4.1% in each. [7]

Without eyeglasses, children with refractive errors struggle in school, straining to make out blurry images on the black board, straining to see classroom demonstrations, and falling behind on everyday tasks like homework. [4] Even leisure activities such as playing ball or watching movies present difficulties that teachers, family, and friends do not always understand. [5] Frustrated by the inability to see clearly, a child may act out and be labelled as having a learning or behaviour problem. [22]

Poor vision may even lead a child to drop out of school as a result of chronically poor academic performance. For a child with visual impairment, corrective eyeglasses are as academically essential as books, papers, and pencils. [12]

In order to improve access to primary eye care services, epidemiologic research on the types and distributions of refractive errors are important to conduct in order to enable more efficient planning for both improved access to eye care, and provision of corrective eyewear. [1, 5]

2.7.0 Correction of refractive errors

This can be done with spectacles, contact lenses or surgery.

2.7.1 Spectacle correction

2.7.1.1 Hypermetropia

Refraction is conducted under cycloplegia and spectacles are given for the error of +2.00DS or more.

2.7.1.2 Myopia

Low degree of myopia is considered to be up to -6.00DS and this should be given optical correction. High myopia should be given lenses with the best visual acuity without any distress. One must not be overcorrected in order to allow them to be able to accommodate. Myopic patients with severe pathological changes and complications such as RD in the fundus can be helped with low visual aids.

2.7.1.3 Astigmatism

Cylindrical lenses are used to correct astigmatism. Smaller astigmatism without asthenopia and eyestrain may be left without correction.

2.7.2 Contact lenses

These can be hard or soft contact lenses. They can be used to correct all forms of refractive errors. The hard ones made of PMMA are mostly not water absorbing and can be used to correct astigmatism of several diopters. The soft ones made of HEMA are hydrophilic and can be used effectively for myopia and hyperopia. These are not good for astigmatism as they can easily take the shape of the cornea.

2.7.3 Surgery

2.7.3.1 Intraocular lens

This is an alternative in the management of Aphakia.

2.7.3.2 Refractive surgery

2.7.3.2.1 Radial keratotomy

This form of correction decreases myopia by flattening the cornea through a series of deep radial incisions.

2.7.3.2.2 Laser in situ keratomilleusis (Lasik)

This can correct myopia upto -16.00DS

2.7.3.2.3 Excimer laser photorefractive keratectomy

Photorefractive keratectomy (PRK) with excimer laser involves the reshaping of the anterior cornea for correction of refractive errors. It is useful for myopia upto -6.00DS, hyperopia +2.50DS and astigmatism of 3.00DC.

3.0.0 Rationale

Childhood blindness from refractive errors presents an enormous problem in terms of morbidity, economic loss and social burden. It is thus important to know the types of refractive errors presenting in different social settings so that proper intervention measures can be carried out in order to combat the problem of preventable childhood blindness due to refractive error.

Data is lacking on the prevalence of significant refractive errors in primary school children not only in rural Kenya but in most of rural Africa as well. It is important to have some baseline data on the magnitude of refractive errors in school going children. This study aimed to provide this data and therefore help in assessing how much need there is for interventional measures in correcting refractive errors.

4.0.0 Objectives

4.1.0 Main objective

To determine the magnitude and pattern of significant refractive errors in primary school children in Kilungu division of Makueni District.

4.2.0 Specific Objectives

1. To determine the prevalence of significant refractive errors in primary school children aged 12 – 15 years in Kilungu division of Makueni District.
2. To determine the pattern of significant refractive errors in primary school children in Kilungu division of Makueni District.
3. To determine the proportions of uncorrected significant refractive errors in primary school children in Kilungu division of Makueni District.

5.0.0 Methodology

5.1.0 Study design

Cross – sectional school based study.

5.2.0 Study population

Primary school pupils in Kilungu division in Makueni district – rural Kenya

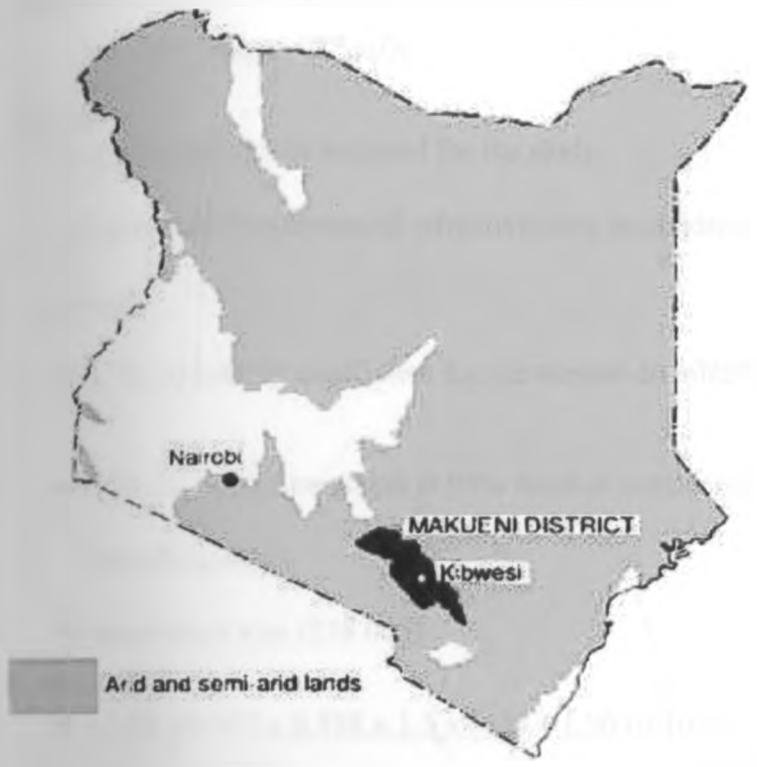
5.3.0 Study area and study period

Makueni District is one of the 12 Districts in the Eastern province of Kenya. It is situated about 145 kilometres south east of Nairobi, the capital city of Kenya. The District has a population of 771 545 who are distributed in the 5 divisions it has. Makueni District lies in the Arid and Semiarid (ASAL) zone. The district is part of rural Kenya. This study took place in Kilungu division of the same district. Kilungu division has 56 primary schools in total. The number of pupils in the primary schools ranges from 450 to 850 pupils per school.

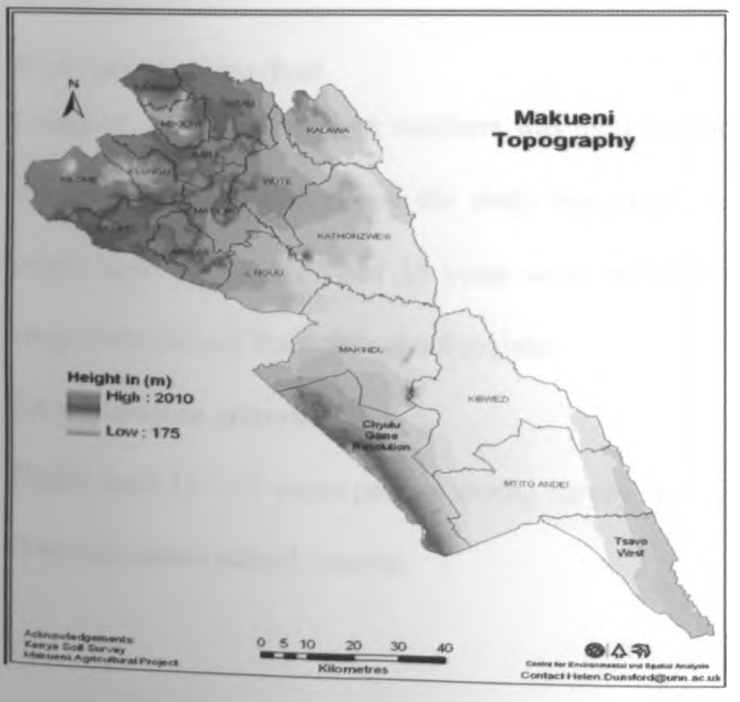
Study period was February 2007.

Below are two maps showing location of Makueni district and its topography.

Location of Makueni district on the map of Kenya.



Map showing topography of Makueni district and location of Kilungu division (located on the north - west).



5.4.0 Sample size

Determination of the required minimal sample size of the total number of children that were interviewed was based on the following formula:

$$n = T^2pq/e + T^2pq/N$$

Where:

n=minimum sample required for the study

p=Estimated Prevalence of refractive error in children = 10.2%

q=1-p

T=1.96, reliability coefficient for the normal distribution to the significant level 0.05

e=0.05 degrees of precision at 95% level of confidence (maximum tolerable random sampling error)

N=population size (238 000)

$$n = \frac{1.96^2 (0.102 \times 0.898 \times 1.5 \times 5x5)}{0.05^2} + \frac{1.96^2 (0.102 \times 0.898 \times 0.50 \times 1.5 \times 5x5)}{238\,000} = \mathbf{448}$$

n = 448 pupils

5.5.0 Sampling method

Computer generated random numbers was used to randomly select Kilungu divison and the primary schools in which the study was conducted. From the selected schools all pupils aged between 12 and 15 years were included into the study. Pupils in this age range were picked from the school register.

5.6.0 Inclusion criteria

Pupils aged 12 – 15 years present during survey. The ages of the pupils were determined from admission school records.

5.7.0 Exclusion criteria

Pupils aged 12 – 15 years absent during the survey.

5.8.0 Data collection and processing

Questionnaires were used to collect data. All data was analyzed using the SPSS version 12 statistical software. Results were presented using ratio proportion, rates, tables and diagrams wherever appropriate. Statistical significance testing was carried out whenever appropriate and level of significance was taken at 5%.

5.9.0 Case definition

For pupils with visual acuity worse than 6/18 and clear ocular media, objective and subjective refraction was carried out. Significant refractive error was defined as 0.5D and more.

5.10.0 Materials

1. Questionnaire
2. Pens, pencils and rubbers
3. Torch with batteries and spare bulbs
4. Snellens charts
5. Retinoscope
6. Cyclopentolate 1%
7. Ophthalmoscopes, direct and indirect
8. Lensometer
9. 20 diopter loop
10. Refraction set and trial frame
11. Vehicle for transport
12. Curtain for darkening the room

5.11.0 Procedure

Study approval was sought from the Ministry of Education (MoE) to conduct the study in Kilungu division of Makueni district. The study was explained in detail to the MoE officials as well as the head teachers of the primary schools and more specifically to the pupils.

Written consent from the head teachers of each school was then obtained on behalf of all the students who participated in the study. A detailed questionnaire in English was then administered. The questionnaire was followed by an eye examination.

Demographic data of each pupil was obtained. History was taken in regard to ocular (eye) complaints. In family history, emphasis was put on immediate family members with regard to use of spectacles. History was also obtained as to whether a pupil had sought medical advice in the past concerning eye problems and if so, whether spectacles were prescribed. Reasons for failure to obtain glasses if previously prescribed were established. Also enquired in the history were previous ocular surgery and its indication.

Visual acuity was assessed using a Snellen's E chart at 6m in a well lit room. Each eye was tested separately. The vision was recorded in the questionnaire. Objective refraction was carried out in all those with VA < 6/18. Cycloplegic Objective refraction was done by retinoscopy in a darkened room after dilating the pupils with 1% cyclopentolate eye drops. This was followed by subjective refraction 24 hours later.

An ocular examination using a torch and magnifying 20 Dioptre loupe was performed. A direct ophthalmoscope was also used for ocular (eye) examination. The subject was the classified as emmetropic, hyperopic, myopic or astigmatic.

6.0.0 Ethical considerations

1. Confidentiality of pupils' records was highly observed.
2. Only medications approved by the Ministry of Health were used for objective refraction and the side effects were explained.
3. Permission from the Ministry of Education (MoE) and the Head teachers was obtained.
4. Pupils with other ocular disorders and needed further management were referred to the Kenyatta National Hospital (KNH) through Machakos General Hospital eye unit.
5. Spectacle prescriptions were issued to all those pupils who needed spectacles and free medical treatment was given those who needed it.

7.0.0 Results

A total of 1439 pupils participated in the study representing a response rate of 94.5%.

The findings of the study are as tabulated below.

Table 1: Overall study participation of pupils **(n = 1522)**

Schools attended	*Present, n (%)*	*Absent, n (%)*	*Total, n (%)*
Kikoko	262 (17.3)	4 (0.3)	268 (17.6)
Musalala	229 (15.0)	10 (0.7)	239 (15.7)
Mutongu	200 (13.1)	11 (0.7)	211 (13.8)
Nunguni	192 (12.6)	8 (0.5)	200 (13.1)
Inyokoni	187 (12.3)	12 (0.8)	199 (13.1)
Kithembe	171 (11.2)	15 (1.0)	186 (12.2)
Mutungu	123 (8.1)	6 (0.4)	129 (8.5)
Kithangathini	75 (4.9)	17 (1.1)	92 (6.0)
Total	**1 439 (94.5)**	**83 (5.5)**	**1522 (100.0)**

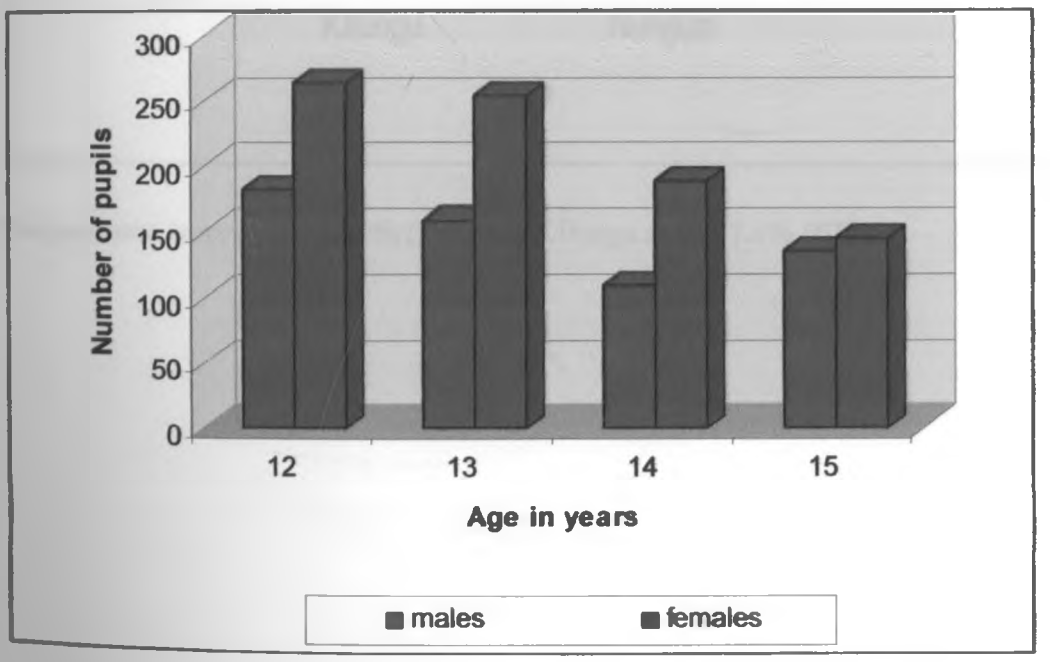
The overall study participation was 94.5%.

Table 2: Age distribution of pupils			n = 1 439
Age in years	*Females, n (%)*	*Males, n (%)*	*Total, n (%)*
12	264 (18.3)	183 (12.7)	462 (31.4)
13	254 (17.7)	159 (11.1)	413 (28.7)
14	189 (13.1)	110 (7.6)	294 (20.4)
15	145 (10.1)	135 (9.4)	280 (19.5)
Total	**852 (59.2)**	**587 (40.8)**	**1 439 (100.0)**

Mean = 13.3 years, Standard deviation = 1.1 years, Median = 13.00 years.

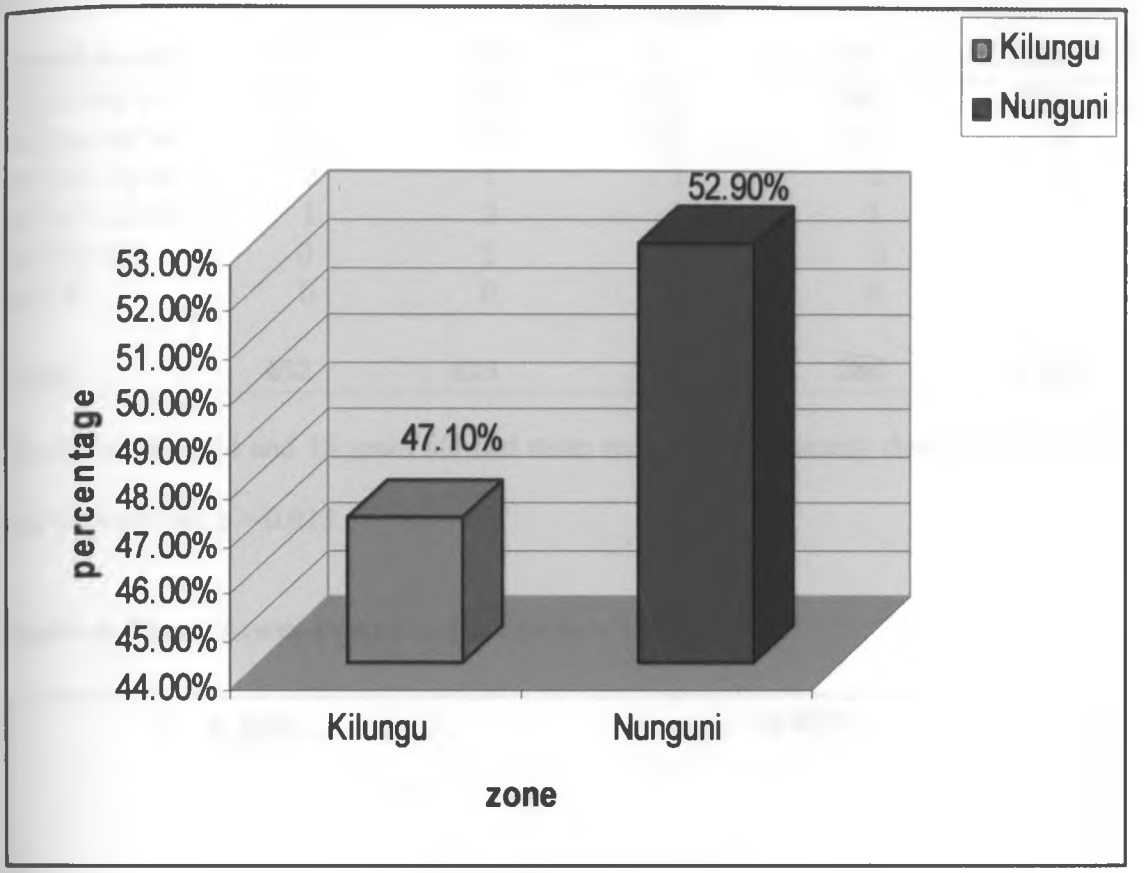
The females comprised 59.2% (852) and males 40.8% (587).

Figure 1: Age distribution of pupils (n = 1439)



There was no statistical difference between the two sexes, p = 0.453. The females were slightly more in ages 12 to 14 years, but for age of 15 years the distribution was almost equal between the two sexes.

Figure 2: Distribution of pupils by zone (n = 1439)



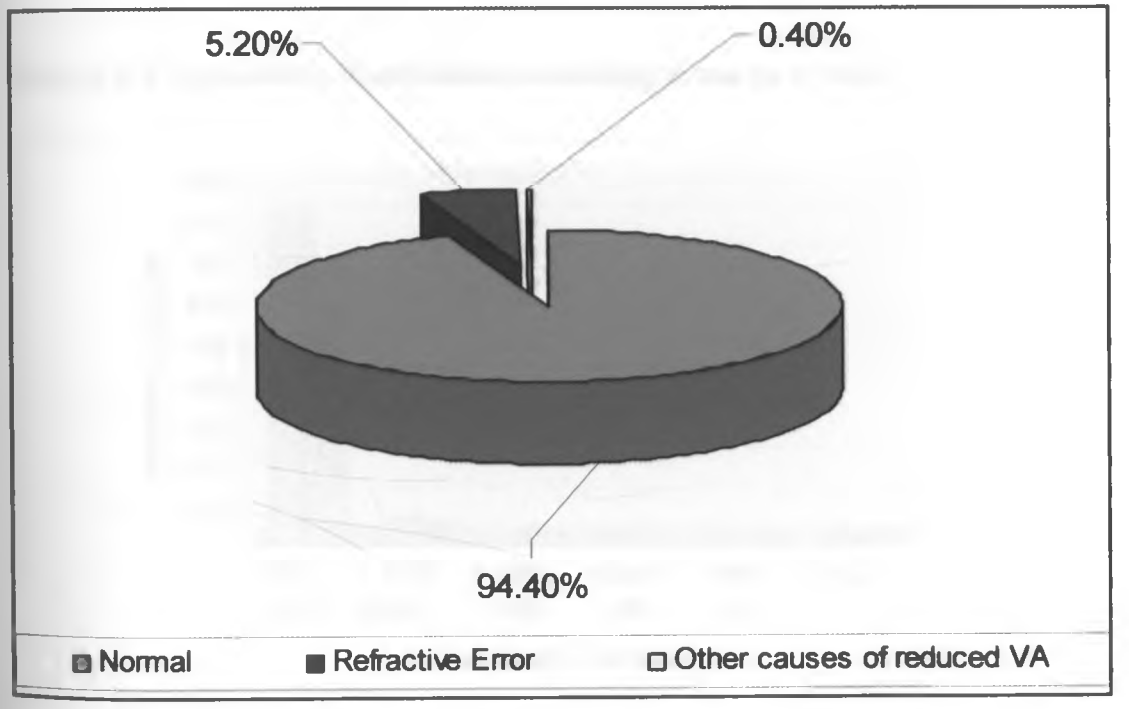
Nunguni zone contributed 52.9% (761) and Kilungu zone 47.1% (678).

Table 4: Visual acuity distribution according to age (n = 1439)

	Age in years				
Visual acuity	**12**	**13**	**14**	**15**	**Total**
6/6 - 6/18	435	392	271	260	1358
<6/18 - 6/60	14	17	18	15	64
<6/60 - 3/60	2	1	1	2	6
<3/60 - 1/60	1	2	2	1	6
<1/60 - LP	0	1	2	2	5
No LP	0	0	0	0	0
Total	**452**	**413**	**294**	**280**	**1 439**

The pupils from 14 and 15 years old had more reduced visual acuity than those aged 12 and 13 years old, p = 0.013.

Figure 4: Visual Acuity (VA) distribution (n = 1439)



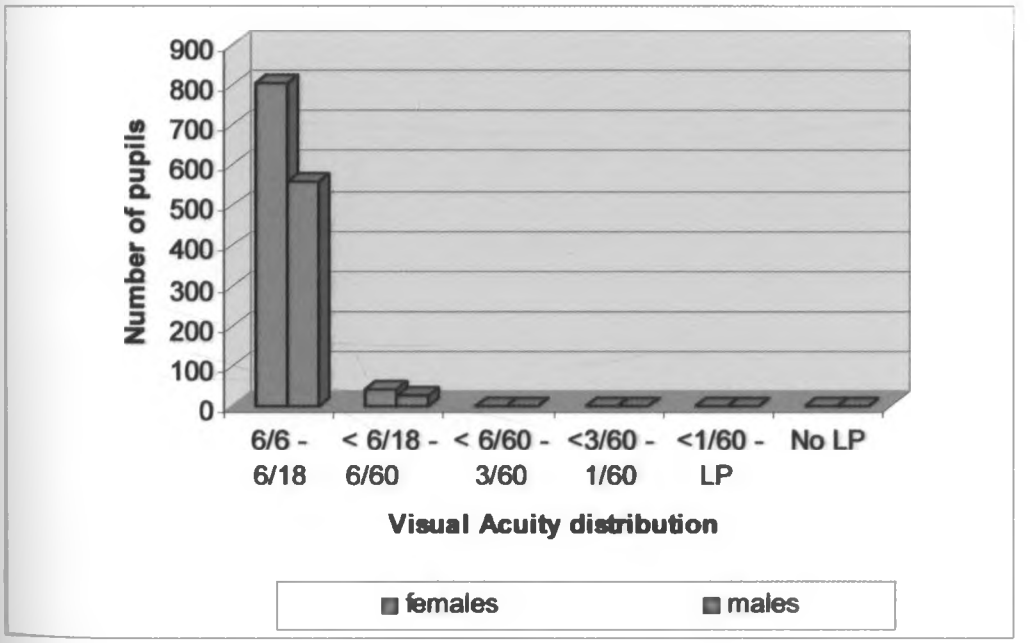
5.2% (75) pupils had refractive errors and the rest 94.4% (1358) had normal vision. Therefore prevalence of refractive errors was 5.2%.

Table 3: Visual acuity distribution according to sex (n = 1439)

Visual acuity	Females, n (%)	Males, n (%)	Total (%)
6/6 - 6/18	797 (93.5)	556 (94.7)	1358 (94.4)
<6/18 - 6/60	43 (5.0)	26 (4.4)	69 (4.8)
<6/60 - 3/60	3 (0.4)	0 (0)	3 (0.2)
<3/60 - 1/60	1 (0.1)	2 (0.3)	3 (0.2)
<1/60 - LP	3 (0.4)	3 (0.5)	6 (0.4)
No LP	0 (0)	0 (0)	0 (0)
Total	**852 (59.2)**	**587 (40.8)**	**1 439 (100.0)**

VA was significantly reduced in the female pupils as compared to the male pupils, p = 0.035.

Figure 3: Visual acuity distribution according to sex (n = 1439)



Majority of pupils had normal vision.

Table 5: Refractive error distribution (n = 75)

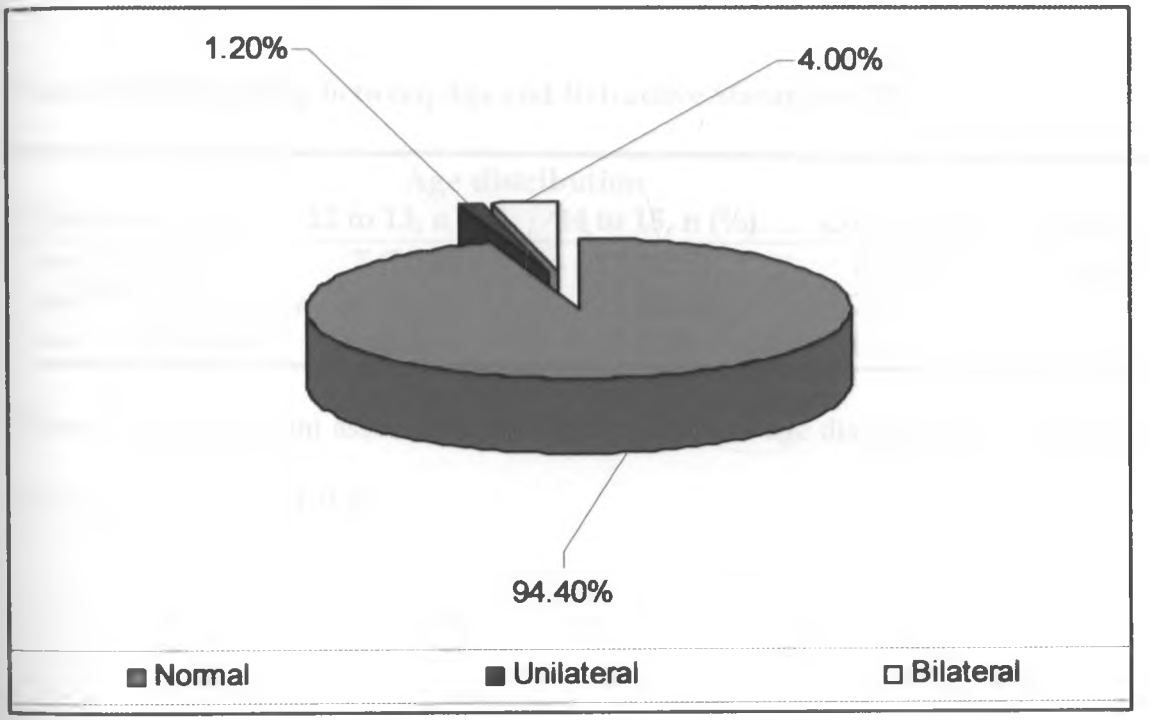
Characteristics	frequency	Percentage
↓ Myopia	24	1.7
↓ Hypermetropia	47	3.2
↓ Astigmatism	4	0.3

6 pupils had poor vision due to other causes. Hypermetropia was the most prevalent refractive error at 62.7% (47) followed by myopia 32.0% (24) and astigmatism at 5.30% (4).

Table 6: Laterality of refractive errors (n = 75)

Characteristic	*Frequency*	*Percentage*
• Bilateral	58	4.0
• Unilateral	17	1.2
Other poor vision causes	6	0.4

Figure 5: Laterality of refractive errors (n = 1439)



77.3% (58) of the pupils with refractive errors had bilateral involvement compared to 22.7% (17) who had unilateral refractive errors.

Table 7: Relationship between Sex and Refractive Status (n = 75)

Characteristics	Sex			
	Females, n (%)	Males, n (%)	OR (95%CI)	P-value
↓ Myopia	14 (29.8)	10 (35.7)	0.8 (0.3-2.1)	0.595
↓ Hypermetropia	30 (63.8)	17 (60.7)	1.0(0.4-18.6)	**0.032**
↓ Astigmatism	3 (6.4)	1 (3.6)	1.8(0.2-18.6)	0.600

There was no significant association between refractive errors and sex of pupil, but the females were 1.8 times more likely to astigmatic compared to male pupils.

Table 8: Relationship between Age and Refractive Status (n = 75)

Characteristics	Age distribution			
	12 to 13, n (%)	14 to 15, n (%)	OR (95%CI)	P-value
↓ Myopia	7 (20.0)	17 (42.5)	2.9 (0.1-9.2)	***0.022***
↓ Hypermetropia	26 (74.3)	21 (52.5)	2.4 (0.9-6.3)	0.083
↓ Astigmatism	2 (5.7)	2 (5.0)	1.2 (0.2-8.6)	0.891

There was a significant association between myopia and age distribution, p = 0.022 and OR = 2.9, 95% CI (0.1-9.2).

Table 9: Relationship between Family history of use of Spectacles and Refractive Status (n = 75)

Characteristics	History of Spectacle use Yes, n (%)	No, n (%)	OR (95%CI)	P-value
Myopia	2 (50.0)	22 (31.0)	2.2 (0.2-24.1)	0.589
Hypermetropia	1 (25.0)	46 (64.8)	0.2 (0.01-2.13)	0.143
Astigmatism	1 (25.0)	3 (4.2)	7.6 (0.0-15.7)	0.200

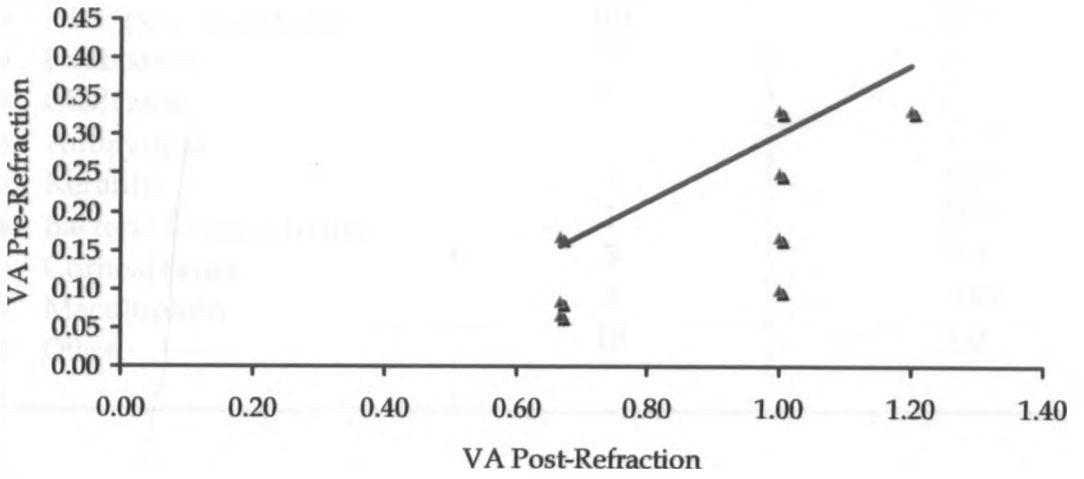
There was no association between the family history of use of spectacles and occurrence of the refractive error in pupils, but pupils who had history of spectacles were 2.2 times likely myopic.

Table 10: Use of spectacles by pupils (n = 75)

Characteristic	*Frequency, n (%)*	*Using spectacles n (%)*
• Yes	9 (0.6)	1 (1.3)
• No	66 (4.6)	0 (0)

9 pupils had been prescribed spectacles previously but only one of them had the spectacles.

Figure 6: Visual acuity improvement following refraction (n = 75)



There was improvement in vision following refraction.

Table 11: Other Ocular findings (n = 1439)

Characteristic	*Frequency*	*Percentage*
• Normal	1268	88.1
• Allergic conjunctivitis	161	11.2
• Strabismus	9	0.6
• Chalazion	1	0.07
• Amblyopia	1	0.07
• Keratitis	1	0.07
• Bacteria Conjunctivitis	1	0.07
• Corneal Scars	5	0.3
• Maculopathy	2	0.07
• Other	15	1.0

Allergic conjunctivitis was the commonest among other ocular findings at 11.2% (161) followed by strabismus at 0.6% (9).

8.0.0 Discussion

A total of 1522 primary school pupils were eligible to participate in the study, but 1439 pupils (94.5%) were screened for refractive errors. 83 (5.5%) of the pupils were absent (table 1). All the pupils eligible who were present participated in the study. The response rate was high at 94.5% (table 1).

59.2% (852) of the pupils examined were female and 40.8% (587) were male pupils (figure 1). There was no statistical difference between the males and females, $p = 0.453$.

The mean age of the overall population was 13.30 years with standard deviation of 1.10 years and the median was 13.0 years. There was no difference in the mean age of males and females, $p = 0.224$ and 95% CI of 0.044 – 0.188.

All pupils examined were Africans and originated from Kilungu division of Makueni district.

Reduced VA considered to be < 6/18 was present in 81 (5.6%) pupils (figure 4). The main cause of reduced VA was refractive error with a prevalence of 5.2% (75), being responsible for 92.6% of all cases of reduced vision (figure 4). Therefore the prevalence of refractive errors in Kilungu division of Makueni district was found to be 5.2% (75), (figure 4). This was almost half of what Nzuki et al found in Nairobi's Langata division where the prevalence of refractive errors was found to be 10.2%.[13]

This could be explained by the fact that urban dwelling pupils tend to have a higher prevalence of refractive errors than those in the rural setting as explained by Wedner et al, Naidoo et al and Garner et al. [5, 15, 20, 26]

Myopia was found in twenty four (24) pupils giving a prevalence of 1.7%, figure 5. Wedner et al and Nzuki et al found a higher prevalence of myopia in their studies at 5.6% and 4.2% respectively. [13, 15] Similarly Naidoo et al in Uganda found an equally higher prevalence of myopia at 9.6%. [20] This could be attributed to the fact that the studies were conducted on urban based pupils who tend to be more myopic due to the occupation they are mostly involved in which involves a lot of near work as explained by Wedner et al, Saw et al, Zhang et al and Garner el al. [5, 8, 17, 26]

The prevalence of myopia in our study was similar between males and females at 1.8% and 1.7% respectively and the difference was not statistically significant, $p = 0.595$, table 7. Kawuma et al and Nzuki et al found myopia more prevalent in the females as compared to males. [13, 14]

Prevalence of myopia in this study was found to be higher in the ages 14 and 15 years which is similar to what Naidoo et al found. [20] There was statistical difference between those pupils aged 12 to 13 years and those aged 14 to 15 years ($p = 0.022$) and OR of 2.9 (0.1-9.2), table 8. This was contrary to what Wedner et al found were myopia was more prevalent in the pupils age 11 to 13 years as compared to those aged 14 to 15 years and mostly female pupils. [15]

Garner et al suggests that in rural setting the prevalence of myopia should not be expected to be different between males and females and would also be expected to be far much lower than in urban setting. [26] This suggestion came about after Garner et al conducted a study on urban and rural pupils and found that myopia was more in the urban children as compared to those in the rural setting. Wedner et al agreed with Garner's view after conducting her study in Mwanza, Tanzania. [15, 26]

Both researchers suggested that myopia and hypermetropia would be equally distributed and in some instances hypermetropia would be expected to be more prevalent in rural based children. [15, 26] In our study hypermetropia were found to be the most prevalent refractive error.

The prevalence of hypermetropia in our study was found to be 3.2% (47) with a distribution of 2.1% (30) females and 1.1% (17) males. The difference between the two sexes was statistically significant ($p = 0.032$), table 7. Nzuki et al found the prevalence of hypermetropia to be 0.3% and there was no statistical difference between the sexes. [13] In our study the prevalence of hypermetropia was found to be 10 times more than the Nzuki study. [13] Wedner et al and Garner et al also found lower prevalence of hypermetropia at 0.4% and 0.2% respectively. [15, 26]

The pupils aged 12 to 13 years were more than twice as likely to be hypermetropic than those aged 14 to 15 years with OR 2.4, (CI, 0.9 – 6.3). However this was not statistically significant, $p = 0.083$, (table 8).

Nzuki et al also found hypermetropia to be more prevalent in the younger age group as compared to the older age group, that is 13 years and older. [13]

In our study, hypermetropia was found more prevalent than myopia unlike what has been reported in other studies where the opposite has been found. This can be explained by the fact that probably in rural setting a hypermetropic trend is expected as put forward by Mclaren, Wedner et al and Garner et al who all have pointed out that school going pupils who are urban dwellers tend to have a myopic shift because they tend to do more near work as compared to their rural counterparts. [15, 19, 26]

In our study hypermetropia was found to range from + 0.75 to + 4.00DS. It was possible to correct all the pupils to 6/9 and better. The child who had hypermetropia of + 4.00DS had correctable accommodative esotropia and it was possible to correct him fully to 6/9.

Those pupils found to have vision of 6/18 and worse and had a scissoring reflex were regarded as having astigmatism. The prevalence of astigmatism in these pupils was found to be 0.3% (4). This was slightly higher than what was found by Wedner et al were the prevalence was found to be 0.1%. [15] Nzuki et al found prevalence of astigmatism to be 0.5%. The prevalence of astigmatism in females and males was 0.2% (3) and 0.1% (1) respectively.[13]

The females were 1.8 times (CI, 0.2 – 18.6) more likely to have astigmatism than their male counterparts but this was not statistically significant (p = 0.600), table 7. The children aged 12 to 13 years were also more likely to be astigmatic as compared to those aged 14 to 15 years, OR 1.2 (CI, 0.2 – 8.6) but this was not statistically significant, p = 0.891, table 8.

Only 1 (1.3%) of pupils with refractive errors already had full spectacle correction. The other 8 (10.7%) did not have the correction which had been prescribed to them (table 10) and this was attributed to the fact that they could not afford to buy spectacles. The other 66 (88.0%) had never been seen at any health facility and therefore did not have any correction. Some of them were not aware that they had refractive errors necessitating correction with spectacles. There was no pupil found to be using contact lenses. One pupil had cataract surgery and had an intraocular lens in situ. The vision in this eye was 6/60 with a refractive error of +3.00 DS. The vision improved to 6/9 but because of high anisometropia spectacles could not be prescribed and he was therefore referred for further management.

Two pupils had severe visual impairment both due to hypermetropia. The other non-refractive causes of reduced VA were strabismus (0.6%) and amblyopia (0.07%), (Table 11). About four per cent, 4.4%, (58) of students had bilateral refractive errors and 1.2%, (17) had unilateral refractive errors (table 6 and figure 6).

Two other pupils had severe visual impairment (uncorrected VA <6/60 in the better eye) due to corneal ulcers. Nine pupils (0.6%) had strabismus (table 10), 0.2% had corneal scars and 0.1% had maculopathy suspected to have been due to chloroquine. Another 0.1% had keratitis. These made up the 6 pupils who had poor vision categorized as others in table 11. Wedner et al found similar prevalence of other ocular findings as we found in this study. [15]

All the pupils who had refractive errors were corrected fully with the majority of them coming to 6/6 (1.0). Figure 6 shows the trend in the improvement of VA as the pupils were refracted. Most of the pupils fall below the line curve which is consistent with improved vision.

Other eye diseases that did not cause reduced VA included chalazion 1, vernal conjunctivitis 11.2 % (161), bacterial conjunctivitis 1, corneal foreign body 1, pterygium 2, and iris coloboma 2, table 11.

9.0.0 Conclusions

1. The prevalence of significant refractive errors in Kilungu division was 5.2%.

2. Hypermetropia was the most prevalent refractive error at 3.2% followed by myopia at 1.7% and astigmatism at 0.3%.

3. Spectacles were found not to be affordable to most primary school pupils.

4. Only one tenth of students had consulted an eye professional in the past and only one pupil of the 9 pupils needing spectacles had them.

10.0.0 Recommendations

1. It is important that more school screening for refractive errors and eye diseases be conducted in order to identify and treat these disorders in as many school children as possible and as early as possible. This would also be very vital in capturing those that could not be examined for various reasons such as lack of finances.

2. It would be important to provide accessibility to affordable spectacles for those pupils who are in need of them. Alternatively, cheaper but quality spectacles should be provided for those pupils in need.

3. The MoH and MoE can come up with a programme at the primary health level meant at screening for refractive errors and other eye diseases. This can probably be incorporated into the school curriculum.

11.0.0 Study Limitations

Lack of adequate finances was the major limitation of the study. This limited the number of schools we had to select from the randomisation for the study.

Lack of electricity in the area hampered the verification of the power of the spectacles in those pupils who had them.

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13.0.0 Appendices

13.1.0 Appendix A

STUDY PROJECT EXAMINATION SHEET

Date: _____ Study #:_____

Name _____ Age _____ Sex _____

Residence: _____

Present ocular complaint: _____

Prescription of spectacles _____ (Yes or No) Duration of use if yes: _____

If no why_____

Power of spectacle: RE _____

LE _____

Family History of spectacle use: Father _____ Mother _____ Sibling _____

Ocular surgery: _____

Visual Acuity: _____ RE _____ LE _____

Refraction: Subjective RE _____ LE _____

Objective RE_____ LE _____

BCVA RE _____ LE _____

Any other ocular findings: _____

_____

Diagnosis: 1. Emmetropia____ 2. Hyperopia ____ 3.Myopia ____ 4.Astigmatism _____

Spectacle prescription: RE _____ LE _____

13.2.0 Appendix B

CONSENT EXPLANATION

I am Dr Muma and would like to give you information on a study of refractive error in pupils attending your primary school.

13.2.1 Refractive errors

Refractive errors are characterized by failure of the eye to focus the image at the back of the eye on a part called the retina. This occurs due to either abnormal curvature of the glass like refracting structure in front of the eye called the cornea or due to the difference in the strength in another structure called a lens. As a result of these aforementioned abnormalities, the image either falls in front of the back of the eye (short sightedness or myopia) or behind the back of the eye (far sightedness or hypermetropia). In another situation the refracting surface of the eye can be irregular and in such a case a condition called astigmatism results. In this case one can have more than one image formed of which the images fail to be focused on the retina.

Complications of refractive errors include amblyopia (a situation were the brain ignores an eye or both eyes due to sustained poor vision) and squinting of the eye(s) – a situation were the eyes are not well aligned due to the refractive error. Other problems that can arise due to refractive errors include poor performance in school because a child cannot read well on the blackboard because of poor eye sight and images are blurred and this tends to affect the social life of the child.

Pupils also strain to see classroom demonstrations, and falling behind on everyday tasks like homework. Even leisure activities such as playing ball or watching movies present difficulties that teachers, family, and friends do not always understand. Frustrated by the inability to see clearly, a child may act out and be labelled as having a learning or behaviour problem.

Poor vision may even lead a child to drop out of school as a result of chronically poor academic performance. For a child with visual impairment, corrective eyeglasses are as academically essential as books, papers, and pencils.

13.2.2 Eye Examination

The eye examination will include how well the child can read the standard chart for measuring vision called the snellen's E chart and if the pupil reads two lines and less of the chart refraction will be done to check for refractive errors. The eyes will also be examined for other eye problems using a direct ophthalmoscope and a torch with a 20D loupe. Pupils found to have significant refractive errors will be written prescriptions and a cheaper source for purchase of spectacles will be recommended. All children with treatable eye problems will be given treatment free of charge.

13.2.3 Confidentiality

All personal information gathered from you as my patient in this study, will be kept confidential and will be used for the purpose of demonstrating the objectives of the study.

13.2.4 Informed Consent

For your pupils to participate in this study, a signed informed consent is required from you. The eye check is free and necessary interventions will be communicated to you.

13.2.5 CONSENT FORM

Name of Head teacher: .....

Name of school: .....

Dr. Mulenga Muma of the University of Nairobi (UON) has requested me to allow my pupils participate in the study on eye assessment. This study is non-invasive and poses no risk to pupil.

Having understood how the study will be done and what it involves;

I ..... Agree that my pupils take part in the study.

Head teacher: ....

Signature: .....

Date: .....

13.3.0 Appendix C

OPHTHALMIC PRESCRIPTION

School screening study project in Makueni by Dr. Mulenga Muma of University of Nairobi (UON).

Dear Parent,

Please note that your child ..... who had an eye examination today was found to have a refractive error and he is hereby prescribed the following spectacles:

Right Eye: .....

Left Eye: .....

Signed: ..... Date: .....

Dr. Mulenga Muma

13.4.0 Appendix D

WHO categories of visual impairment[24]

Category	*Visual Acuity with* *BCVA in the better eye*	*Degree of visual* *Impairment*
0	**6/6 – 6/18**	**Normal Vision**
1	**<6/18 – 6/60**	**Visual Impairment**
2	**<6/60 – 3/60**	**Severe visual impairment**
3	**<3/60 – 1/60**	**Blind**
4	**<1/60 – Light perception**	**Blind**
5	**No light perception**	**Blind**
6	**Undetermined of unspecified**	

If the extent of visual field is taken into account, patients with a field not greater than 10^{o} but greater than 5^{o} around central fixation should be placed in category 3 and patients with a field no greater than 5^{o} around central fixation should be placed in category 4, even if visual acuity is not impaired.

13.5.0 Appendix E

13.4.1 Patient Referral Form in English

Attention: Eye Clinic Number 35, Kenyatta National Hospital

Thro': Machakos General Hospital (Eye Unit)

Dear Parent,

Please note that your child ..... who had an eye examination was found to have .....

Please kindly bring him / her to the Eye clinic number 35 at Kenyatta National Hospital for review.

Thank you.

Dr. Muma.

13.4.2 Patient Referral form in Kiswahili

Barua ya kutuma mgojwa

Kliniki ya macho (nambari 35) Hospitali kuu ya Kenyatta

Kupitia Hospitali ya Machakos (Kliniki ya Macho)

Mpendwa Mzazi,

Tungependa kukujulisha ya kwamba mtoto wako .....

aliyepimwa macho amepatikana kuwa na .....

Kwa hivyo, tafadhali twakuomba umpeleke Kliniki ya macho (nambari 35) katika Hospitali kuu ya Kenyatta kufanyiwa uchunguzi zaidi.

Ahsante,

Daktari Muma.