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Refractive status of primary school children in Mopani district, Limpopo Province, South Africa

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Abstract

This article reports part of the findings of a study carried out to determine the causes, prevalence, and distribution of ocular disorders among rural primary school children in Mopani district of Limpopo Province, South Africa. Three hundred and eighty eight children aged 8 to 15 years were randomly selected from five randomly selected schools. Non-cycloplegic retinoscopy and auto-refraction were performed on each child. The prevalence of hyperopia, myopia, and astigmatism was 73.1%, 2.5% and 31.3% respectively. Hyperopia (Nearest spherical equivalent power (F_{NSE}) ranged from +0.75 to +3.50 D for the right and left eyes with means of +1.05 ± 0.35 D and +1.08 ± 0.34 D respectively. Myopia (F_{NSE}) ranged from –0.50 to –1.75 D for the right eye and –0.50 to –2.25 D for the left eye with means of –0.75 ± 0.55 D and –0.93 ± 0.55 D respectively. Regression model for myopia, shows that age had an odds ratio of 1.94 (1.15 to 3.26), indicating a significant increased risk of myopia with increasing age. Correcting cylinders for the right eyes ranged from –0.25 to –4.50 D (mean = −0.67 ± 0.47 D) and for the left eyes from –0.25 to –2.50 D (mean = −0.60 ± 0.30 D). With-the-rule (WTR) astigmatism (66.5%) was more common, followed by against-the-rule (ATR) astigmatism (28.1%) and oblique (OBL) astigmatism (5.4%). With-the-rule astigmatism was more common in females than males; ATR astigmatism and OBL astigmatism were common in males. Regular vision screening programmes, appropriate referral and vision correction in primary schools in Mopani district are recommended in order to eliminate refractive errors among the children.

Keywords: Refractive error, hyperopia, myopia, astigmatism.

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Introduction

It has been estimated that 2.3 billion people worldwide have refractive error, but only 1.8 billion people have access to eye examinations and affordable correction. This leaves approximately 500 million people (including children), mostly in developing countries (about 1/3 in Africa), with uncorrected refractive error causing avoidable blindness and impaired vision[1]. In view of the increasing realization of the enormous need for correction of refractive error worldwide, this condition has been considered one of the priorities of the global initiative for the elimination of avoidable blindness: Vision 2020 - The Right to Sight, which was launched in 1999 by a coalition of nongovernmental organizations and the World Health Organization[2]. Undetected or under corrected refractive error, particularly myopia, is a problem among school children. This is because poor vision and inability to read what is written on the chalkboard can have a serious impact on children's participation in class and this can negatively affect the children's education, occupation, and socio-economic status for life[3].

The impact of visual impairment due to myopia is not the same as that from hyperopia. This is because people who suffer from myopia are likely to have better near vision than those who suffer from hyperopia. Hyperopia, however, has been thought to be the cause of poor reading as sufferers have trouble forcing their eyes to focus on near tasks, so they are more susceptible to eye strain, headaches and blurred vision when reading. Hyperopes may often not understand what they are reading as more energy is expended to keep the text clear[4].

Avoidable visual impairment due to uncorrected refractive error starts at a younger age if compared to avoidable visual impairment for example due to cataracts, which manifests at an older age[5]. It follows that an individual who is visually impaired due to uncorrected refractive error would suffer more years of dysfunction than the one who is visually impaired due to cataract. Visual impairment in children poses particular challenges that are different from those of adults. Children are born with an immature visual system and for normal visual development to occur; they need clear images to be focussed on the retina. Failure of normal visual maturation cannot be corrected in adult life; so, early detection and compensation of refractive errors will undoubtedly have a positive effect on children's education and life in general[6].

There are reports on refractive errors in children that have been carried out in developing countries. In the rural population of India, myopia in one or both eyes was present in 4.1% of the children. Myopia risk was associated with female gender and having a father with higher level of schooling. Hyperopia in at least one eye was present in 0.8% of the children[7]. In a study conducted in New Delhi, India, the prevalence of hyperopia (7.7%) was the highest, followed by myopia (7.4%) and amblyopia (4.4%)[8].

Vision screening performed around Kuala Lumpur, Malaysia in 1990, to assess the prevalence of visual disorders in Chinese school children found that the prevalence of myopia –0.50 D or greater and hyperopia +0.50 D or greater was 42% and 14%, respectively. No significant difference was found between myopia in males and females. Myopia was more common among Chinese school children than among Malays and other ethnic groups[9]. In a study carried out in Gombark District, Malaysia, next Kuala Lumpur, the prevalence of myopia (−0.50 D or greater) in either eye was 9.8% in children 7 years of age, increasing to 34.4% in 15-year-olds. Myopia was associated with older age, female gender, Chinese ethnicity, and higher parental education. Hyperopia (+2.00 D or greater) varied from 3.8% in 7-year-olds to less than 1% by age 15. Hyperopia was associated with younger age. The prevalence of astigmatism was present in 15.7% of the children[10].

A refractive error study among school-age children to assess the prevalence of refractive error and visual impairment in Shunyi district, North East of Beijing, China, found refractive error was the cause in 89.5% of the eyes with reduced visual acuity, amblyopia in 5%, and other causes in 15% with unexplained causes in the remaining 4%. Myopia –0.50 D or greater in either eye was essentially absent in five year olds, but increased to 36.7% in males and 55% in females by age 15. Over the same age range, hyperopia, +2.00 D or greater decreased from 8.8% in males and 19.6% in females to less than 2% in both males and females. Females had a significantly higher risk

of both myopia and hyperopia than males[11].

A study to determine the prevalence, type, and progression of astigmatism in Chinese preschool children conducted by Fan *et al*[12] found astigmatic error of −0.50 D or greater in 55.8% of the children, −1.00 D or greater in 21.1% and 2.2% and error of −2.00 D or greater was present in 2.2% of the subjects. Distribution of with-the-rule (WTR), against-the-rule (ATR), and oblique (OBL) astigmatism was 53.0%, 7.9%, and 39.1% respectively. In a Suburban area of Santiago, Chile, myopia –0.50 D or greater in either eye was present in 3.4% of five year old children, increasing to 19.4% in males and 14.7% in females by age 15. Over the same age range, hyperopia of +2.00 D or greater decreased from 22.7% to 7.1 % in males and from 26.3% to 8.9% in females. Females had a higher risk of hyperopia than males[13].

A survey of the prevalence of refractive error among lower primary school children in Kampala district, Uganda, found the prevalence of refractive error to be 11.6%. Astigmatism (52%) was the most prevalent refractive error, followed by hyperopia (37%) and myopia (11%)[14].

Despite the reported prevalence of vision problems in school children and the grave consequences that go with such problems, very few reports concerning this issue have been published in South Africa. In a retrospective study of refractive status of a South African black sample, conducted by Raliavhengwa and Oduntan[15], myopia (48.15%) was found to be more common than hyperopia (35.67%) and emmetropia (16.18%). The occurrence of myopia was found to be higher (51.3%) than hyperopia (32.4%) in males; however, hyperopia was higher (39.9%) than myopia (38.4%) in females.

In a study conducted by Naidoo *et al*[16], refractive error (63.6%) was the main cause of the visual disorders in Durban. The prevalence of hyperopia, myopia, and astigmatism was reported to be 2.6%, 4%, and 9.2% respectively). Other than these two, no recent reports of the refractive status among children in South Africa could be found in the literature.

The purpose of this study was to investigate the refractive status of rural primary school children in the Mopani district of Limpopo Province. Findings from this study will help from an informed position to make appropriate recommendation relating to intervention programs to the Provincial Government. In addition, early detection and compensation of refractive error would reduce the impact of visual impairment among the children.

Method

The proposal to conduct this study was approved by the Ethics Committee of the University of Limpopo, Turfloop Campus. The consent form was given to every eligible child for parental consent. Also, permission to carry out the study was obtained from the Department of Education, Limpopo Province. Three hundred and eighty eight black South African children of both sexes were examined. The sample size was calculated to estimate an anticipated 20% prevalence (ρ) of refractive error within an error bound (B) of 20% with 95% confidence interval (Z). The calculated sample size requirement for the study was 384, from the formula: $N = Z^2 (\boldsymbol{\rho}) (1- \rho)/ B^2$. Five primary schools were randomly selected from a list of all schools present in the district. Also, the children were randomly selected using systematic sampling from the five schools. Unaided visual acuity was measured with a LogMAR illiterate chart[17]. The refractive errors were measured by retinoscopy and auto-refraction. To assess the validity of the tests included in the study, sensitivity and specificity of the tests were calculated based on the values obtained from the test and re-test procedures done on 40 subjects using the following formulae:

$$\text{Sensitivity} = \frac{TP}{TP+FN}$$

$$\text{Specificity} = \frac{TN}{TN + FP}$$

Where TP = true positive, FP = false positive, TN = true negative, FN = false negative. Sensitivity of the tests was 100% and Specificity was 78.6%. Based on these findings, the tests were considered to be reliable and valid.

Myopia was defined as the Nearest Spherical Equivalent power (F_{NSE}) of −0.50 D or greater, hyperopia (F_{NSE}) as +0.75 D or greater, emmetropia was defined as F_{NSE} of from -025

to +0.50 D and astigmatism as a cylindrical correction of –0.25 D or greater. WTR astigmatism was defined as cylindrical axis of 30 degrees or less from the horizontal meridian, ATR astigmatism as cylindrical axis of 30 degrees or less from the vertical meridian, and OBL astigmatism as cylindrical axis of greater than 30 degrees from either the horizontal meridian or vertical meridian.

Data analysis was done using Statistical Package for Social Sciences (SPSS), Statistical Analysis System (SAS), and Microsoft Excel software packages. Auto-refraction results were found to give more minus power which were unreliable and inconsistent. The differences between the retinoscopy and auto-refraction were as high as –1.50 D, and in every case, the auto-refractor gave more minus values. The auto-refractor data were therefore discarded. Thus the data analyzed and reported here are those of the retinoscopy.

Results

The subjects included in the study were 388 black primary school children. They included 193 (49.7%) males and 195 (50.3%) females. Their ages ranged from 8 to 15 years with a mean of 11.72 ±1.66 years. Most of the subjects, 368 (94.8%) were between the ages of nine and fourteen years. There were seventeen (4.4%) children aged fifteen and only three (0.8%) were eight years old.

Visual acuities

The percentage of eyes with unaided visual acuity (UVA) of 6/6 or better was 88.3%, and only 3.1% had unaided visual acuity of 6/10 or worse. Of the 3.1% of the subjects with UVA of 6/10 or worse, 99.5% improved to 6/7.5 or better with pinhole and retinoscopic corrections. There were no subjects who wore spectacles; hence, no results for aided visual acuities are given.

Refractive Errors

Nearest spherical equivalent power (F_{NSE})

In the total sample, 566 (72.9%) eyes had hyperopia and only 19 (2.5%) had myopia. Others 191 (24.6%) had emmetropia. F_{NSE} for the right eyes ranged from –1.75 to +3.50 D (mean = 0.88 ± 0.52 D, median = +1.00 D and

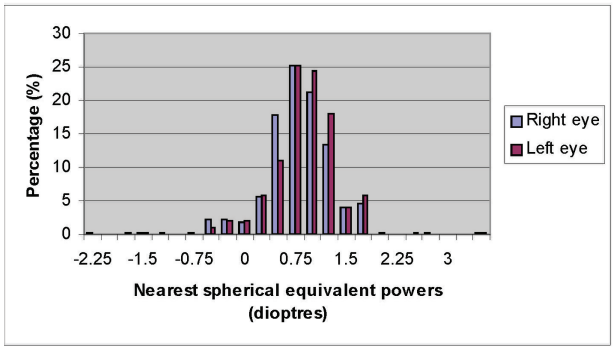

Figure 1 Frequency distribution of the nearest spherical equivalent powers (F_{NSE}) among the subjects. The graph peaks at 25% and most of the powers were between +0.75 and +1.75 D.

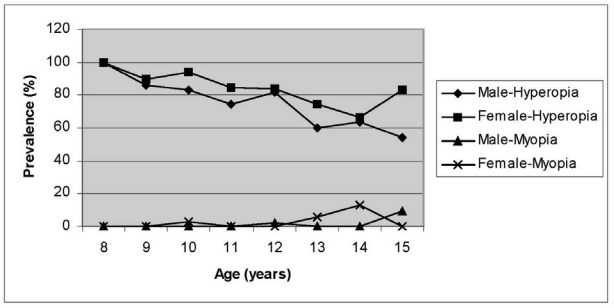

Figure 2 Graphical representation of the prevalence of refractive powers by age in the right eyes of the male and female subjects. Hyperopia was more prevalent in both genders.

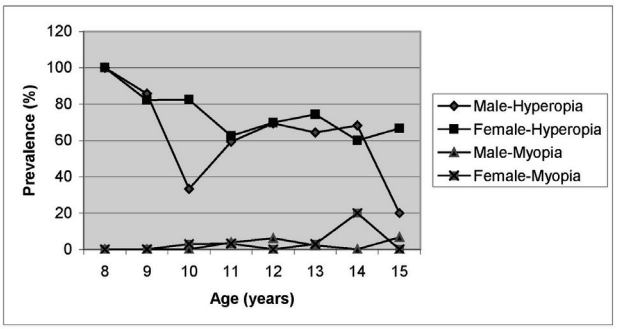

Figure 3 Graphical representation of the prevalence of refractive powers by age in the left eyes of the male and female subjects. Hyperopia was more prevalent in both genders.

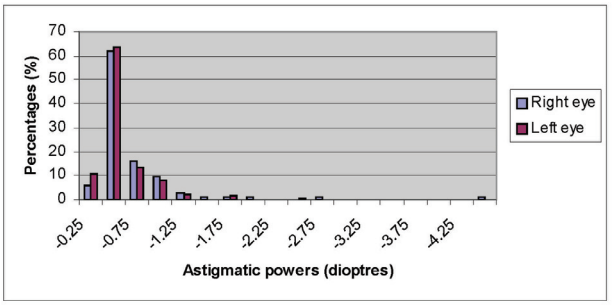

Figure 4 Graphical representation of the distribution of the cylindrical powers in the right and left eyes of the subjects. The graph peaks at 60% and most powers were ≤1.25 D.

mode = +1.00 D). For the left eyes, the range was from –2.25 to +3.50 D (mean = 0.80 ± 0.53 D, median = +0.75 D and mode = +0.75 D). The NSE powers for all the eyes ranged from -2.25 to +3.00 D (mean = 0.84 ± 0.52) D. Hyperopia (NSE) ranged from +0.75 to +3.50 D for both the right and left eyes with means of +1.05 ± 0.35 D and +1.08 ± 0.34 D respectively. Myopia (NSE) ranged from –0.50 to –1.75 D for the right eye and –0.50 to –2.25 D for the left eye with means of –0.75 ± 0.55 D and –0.93 ± 0.55 D respectively.

The frequency distributions of NSE powers in the right and left eyes are shown in Figure 1. The curve peaks at +0.75 D (25%) and is skewed toward the hyperopic side with a greater area under the curve in the region of +0.50 to +1.50 D. Powers of +0.75 D or less were more common in the left than the right eyes; and powers of +1.00D or greater were more common in the right than the left eyes.

Nearest spherical equivalent powers (F_{NSE}) and age

The prevalence of hyperopia was higher than that of myopia both in the right and left eyes of males and females among all age groups (Figures 2 and 3). Hyperopia (NSE, +0.75 D or greater) decreased from 100% among the 8 year olds to 53.1% among the 15 year olds. Myopia (NSE, −0.50 D or greater) increased from 1.7% among the 10 year old to 6.8% among the 14 year old group.

The means of F_{NSE} for the right eyes decreased from +1.50 D in the 8-year-olds to +0.59 D in the 15-year-old subjects. For the left eyes, the means decreased from +1.42 D in the 8-year-olds to +0.53 D in the 15-year-olds. The difference between the powers on the right and left eyes was statistically insignificant (*F*-test, p=0.298). Hyperopia (73.1%) was more prevalent than myopia (2.5%) or emmetropia (F_{NSE}, −0.25 to +0.50 D) (24%). Using logistic regression to assess the relationship between age and prevalence of hyperopia, age had an odds ratio (OR) of 0.73 (95% CI, 0.63 to 0.85), reflecting a decreased risk of hyperopia with increasing age. The association of hyperopia with age was statistically significant (p= 0.00). In a regression model for myopia, age had an odds ratio of 1.94 (1.15 to 3.26), indicating a significant increased risk of myopia with increasing age. Children aged 12-15 years (OR, 2.29; 95% CI, 1.09 to 4.81) had 1.4 times higher risk of myopia than those aged 8-11 years (OR, 0.91; 95% CI, 0.09 to 9.38) old. The association of myopia with age was statistically significant (p = 0.00).

Nearest spherical equivalent powers (F_{NSE}) and gender

Hyperopia, 302 (77.4%) eyes was more common in females than in males 264(68.4%); while 2.8% and 2.1% eyes respectively had myopia. Emmetropia was more common in males (29.2%) than females (19.8%) (see Table 1 and 2). The prevalence of myopia was 0% in 8, 9, 10-year-old males and 6.7% in the 15-year-old male children, and increased from 0% in 8 and 9- year-old females to 20% in the 14-year-olds. In the left eyes, there was no steady decrease in hyperopia or increase in myopia in males and females with increasing age. The prevalence of spherical refractive error by age in male

Table 1
Distribution of the low, medium and high positive refractive powers (F_{NSE}) among the male and female subjects (percentages in brackets). Most of the powers were ≤ +2.00 D.

	HYPEROPIA		
Nearest spherical equivalent powers	Male	Female	Total
+0.75 to +2.00 (Low hyperopia)	262 (46.6)	300 (53.4)	562
+2.25 to +5.00 (Medium hyperopia)	2 (50)	2 (50)	4
> +5.00D (High hyperopia)	0	0	0
Total	264 (46.6)	302 (53.4)	566 (100)

Table 2
Distribution of low, medium and high negative refractive powers (F_{NSE}) among the male and female subjects (percentages in brackets). All the powers were low myopia types ≤ −3.00 D.

	MYOPIA		
Nearest spherical equivalent powers	Male	Female	Total
–0.50 to –3.00 (Low hyperopia)	8 (42.1)	11 (57.9)	19
–3.25 to –6.00 (Medium myopia)	0	0	0
> –6.00D (High myopia)	0	0	0
Total	8 (42.1)	11 (57.9)	19

and female subjects is shown in Figure 2 (for the right eyes) and Figure 3 (for the left eyes)

Among males and females, low hyperopia (+0.75 to +2.00 D) (99.3%) was more common than medium (+2.25 to +5.00) (0.01%) and high (+5.00 D or greater) (0%) hyperopia. All the subjects with myopia had low myopia (−0.50 to –3.00 D). Low hyperopia and low myopia were more common than other magnitudes (medium and high) of spherical errors. The distributions of the various magnitudes of refractive powers are shown in Table 1 (for hyperopia) and Table 2 (for myopia).

Many, 262 (99.2%) of the hyperopia in males were of low magnitude, others, two (0.8%) were medium. Among the females, many, 300 (99.3%) of the hyperopia were of low magnitude. Others (0.7%) were medium types (see Table 1). Among the males, all (8) the myopia were low magnitude types and among the females, all (11) the myopia were of low magnitude (see Table 2).

The mean refractive error for males and females was +1.02 ± 0.48 D and +1.06 ± 0.44 D respectively. Among males (right eyes), the prevalence of hyperopia was 100% in 8-year-olds and 54.5% in the 15-year-olds. In 8-year-old females (right eyes), the prevalence of hyperopia was also 100% and 83.3% in the 15-year-olds. The prevalence of myopia was 0% in 8, 9, and 10-year-old males and 9.1% in the 15-year- old male children, and increased to 13% in the 14-year-olds. Among males (left eyes), the prevalence of hyperopia was 100% in 8-year-old and 20% in the 15-year-olds. In 8-year-old females (left eyes), the prevalence of hyperopia was also 100% and 66.7% in the 15-year-olds.

Logistic regression used to assess the relationship between hyperopia prevalence and gender showed odds ratio for gender of 1.82 (95% CI, 1.13 to 2.94). This reflects a higher risk for hyperopia in females. The association of hyperopia with gender was statistically significant (p = 0.03). The association between myopia and gender was not statistical significant (p= 0.15).

Astigmatic powers

Astigmatism occurred in 242 (31.2%) of the eyes. The astigmatic powers for the right eyes ranged from – 0.25 to – 4.50 D (mean = − 0.67 ±0.48 D, median = − 0.50 D and mode = − 0.50 D). For the left eye it ranged from – 0.25 to – 2.50 D (mean = − 0.60 ± 0.30 D, median = − 0.50 D and mode = − 0.50 D). The astigmatic powers for all eyes ranged from – 0.25 to – 4.50 D (mean = 0.63 ± 0.39) D. The frequency distribution of astigmatic powers for the right and left eyes is shown in Figure 4. The curve peaks at –0.50 D and is skewed toward the medium to higher astigmatic powers. However, there is a greater area under the curve in the region of – 0.25 and –1.00 D.

Table 3
Distribution of astigmatic powers according to their magnitudes in the right and left eyes of the subjects. Most of the powers were of low magnitude (−0.25 to −0.75).

Astigmatic powers	Right eye	Left eye
Low (−0.25 to –0.75D)	88 (83.8)	120 (87.6)
Medium (−1.00 to –3.00D)	16 (15.2)	17 (12.4)
High (>−3.00D)	1(1.0)	0
Total	105 (100)	137 (100)

Table 4
Distribution of magnitudes of astigmatic powers (percentages in brackets) in the right and left eyes of the subjects. Low astigmatic powers were more common than the other categories.

Cylindrical Powers	Number of eyes (Males)			Number of eyes (Females)		
	OD	OS	Total	OD	OS	Total
− 0 .25 to –0.75	50 (8 0 . 7)	68 (9 0 . 7)	118 (8 6 . 1)	38 (8 8 . 4)	52 (8 3 . 9)	90 (8 5 . 7)
− 1 .00 to –150	10 (1 6 . 1)	6 (8)	16 (1 1 . 7)	4 (9 . 3)	8 (1 2 . 9)	12 (1 1 . 4)
− 1 .75 to –2.25	1 (1 . 6)	0	1 (0 . 7)	1 (2 . 3)	2 (3 . 2)	3 (2 . 9)
− 2 .50 to –3.00	0	1 (1 . 3)	1 (0 . 7)	0	0	0
− 3 .25 and over	1 (1 . 6)	0	1 (0 . 7)	0	0	0
Total	62 (100)	75 (100)	137	43 (100)	62 (100)	105

Table 5
Distribution of various types of astigmatism (according to their axes) in relation to gender. With - the-rule astigmatism (66%) was more common than the other types.

Type of astigmatism	No. of eyes/ (%) Male	No. of eyes/ (%) Female	Total
WTR	82 (59.9)	79 (75.2)	161
ATR	47 (34.3)	21 (20)	68
OBL	8 (5 . 8)	5 (4.8)	13
TOTAL	137 (100)	105 (100)	242

Low astigmatic powers were more common than medium and high astigmatic powers (Table 3). Powers of between – 0.25 and – 0.75 D (low astigmatic powers) were 83.8% and 87.6%,

for the right and left eyes respectively. Powers of between –1.00 and –3.00 D (medium astigmatic powers) were 15.2% and 12.4%, for the right and left eyes respectively. Powers greater than –3.00 D (high astigmatic powers) were 1% and 0% for the right and left eyes respectively (Table 3). Astigmatic powers ranged from 0% among the 8-year-old to 50% among the 15-year-olds. There was, however, no consistent increase in astigmatism with increasing age.

Astigmatic powers and gender

The prevalence of astigmatism was higher in males (56.6%) than females (43.4%). Low astigmatic powers were more common than medium and high astigmatic powers in both males and females. The prevalence of low and medium powers was similar in both male and female children. The occurrence of high power cylinders were uncommon in males (1.5%), and absent in females (Table 4).

Types of astigmatism

The prevalence of WTR astigmatism was the highest (66.5%), followed by ATR astigmatism (28.1%) and then by OBL astigmatism (5.4%). WTR astigmatism was more common in females than males; ATR and OBL astigmatism were common in males than females (Table 5). There was no obvious relationship pattern between age and types of astigmatism.

Discussion

Uncorrected refractive errors and other ocular disorders can hinder education, personality development, and career opportunities, in addition they can cause economic burden on society. It is therefore, necessary that these disorders are detected and treated or corrected in time to avoid problems of ocular disorders. Also, in order for the health authorities to deliver proper eye care services to the communities, data on the prevalence of ocular disorders in children is needed. This study provides useful data to Mopani district municipality which will assist in planning for eye care service delivery.

Refractive errors were measured by non-cycloplegic retinoscopy and auto-refraction. Only the retinoscopy results were analyzed. This is because auto-refraction results were inconsistent and unreliable in certain cases. This observation agrees with reports by Naidoo and Govender[18] that non-cycloplegic auto-refraction has limited role in vision screening in a paediatric population. The authors[18] reported that even though the target has been set at infinity, the accommodative system does not remain at rest as previously assumed by researchers. The authors reckoned that it is possible that the nearness of the instrument target induces proximal accommodative response and instrument myopia. In the present study, there were differences as high as –1.50D between retinoscopy and auto-refraction results; and in all cases, auto-refraction results gave more myopia. This was attributed to the theory of proximal accommodative response and instrument myopia as previously suggested by Govender and Naidoo[18].

The greater occurrence of hyperopia in the study is in agreement with the findings reported by several authors[8, 13, 19, 20, 21]. It is, however, at variance with the findings in other studies[9, 11, 14-16] where the prevalence of myopia was greater than that of hyperopia. The differences may be attributed to the differences in the methods, definitions, and demographics in the various studies. For instance, in this study, non-cycloplegic retinoscopy was used to determine refractive error; hyperopia was defined as powers of +0.75 D or greater; and subjects were rural primary school children. In the other studies[8, 11, 13, 16], however, cycloplegic retinoscopy was used to determine refractive error; hyperopia was defined as powers of +2.00 D or greater, and subjects were school-age children in both rural and urban settings.

There is a general agreement that the prevalence and distribution of refractive status varies greatly with age. Hyperopia was the most common refractive error in this study; with increasing age, however, there was a steady shift in the distribution of refractive error towards less hyperopia. The prevalence of myopia appeared to increase with age. The statistically significant association of hyperopia and myopia with increasing age observed in this study agrees with earlier reports[10, 11, 13]. This could be explained by the fact that younger subjects have smaller eyes hence the high prevalence of hyperopia among the younger subjects. The size

of the eye increases with increasing age; hence increase in myopia prevalence with increasing age. This agrees with the views of Grosvenor[22] that refractive error distributes normally at birth, but early in infancy, the majority of the children are found to be somewhat hyperopic, with a tendency toward myopia up to 20% or more in the 20-year-old population.

In the present study, there was a statistically significant association between hyperopia and female gender. This finding agrees with the findings of Maul *et al*.[13]; Phokarel *et al*.[21]; Raliavhegwa and Oduntan[15]; and Raju *et al*.[23] where hyperopia was more common in females than males, but disagrees with the findings of Ritchler and Bear[24], where the contrary was the case. The association between myopia and gender (male and female) was not statistically significant.

That hyperopia was more common in females than males could be explained probably by the fact that females have smaller eyes than males as reported by Kondo *et al*.[25]. The higher prevalence of hyperopia in this study may further be explained by the greater number of females than males in the younger age group.

The prevalence of myopia (2.5%) found in this study was low compared to 6.8% found in Chile[13], 16.2% in China[11] and 7.4% in New Delhi[8]. Higher level of education, better housing, and higher individual income has been associated with higher odds of myopia and higher degrees of myopia, after adjusting for age and sex[26]. Educational attainment of the father has also been found to be associated with increased risk of myopia among children aged 11 to 13 years (OR, 1.69; 95%CI, 1.29-2.23), and 14 to 15 years (OR, 1.49; 95% CI, 1.17-1.90)[8]. That children in this study live in rural areas may explain the low prevalence of myopia. The children in rural areas probably do not engage in a lot of reading to the same extent as those in urban areas. Most households do not have access to electricity, so most, if not all reading must be done at school; hence few hours are spent reading.

The multi-country survey of refractive errors in children "The refractive error study in children (RESC)", conducted by the World Health Organization (WHO) in different regions revealed that there are significant geographical differences in the prevalence of refractive errors. The prevalence of refractive errors in Chile[13], China[11], Nepal[21], rural India[7], New Delhi[8] and Durban[16], were 56.3%, 89.5%, 56%, 61%, 81.7% and 63.6%, respectively. In the present study, the prevalence of refractive error was 76%. However, direct comparisons with the above studies are not possible because of the differences in examination protocol and populations studied.

The prevalence of astigmatism in the present study (31.3%) was lower than 34.8% reported by Wedner *et al*.[27], but higher than the 2.8% reported by Dandona *et al*.[7], 2.2% by Phokarel *et al*.[21], 5.4% by Murphy *et al*.[8]; 19% by Maul *et al*.[13]; 15.7% by Goh *et al*.[10] and 9.2% by Naidoo *et al*.[18]. Again, meaningful comparisons between these findings and data from previous studies are difficult because of differences in the methodology, definitions, and demographics in the various studies.

The lower prevalence of astigmatism in the younger group compared to the older group suggests an increase in the values of astigmatism with age. This agrees with the report by Raliavhengwa and Oduntan[15], but disagrees with others[8, 11, 13] who reported an association between astigmatism and younger age.

Studies on children samples have reported high prevalence of with-the-rule astigmatism while those of adults and aged population[28] have reported that most of the subjects had against-the-rule astigmatism. The changes associated with age may be explained by the hypothesis that eyelid tension is responsible for with-the-rule astigmatism by steepening the vertical corneal meridian and flattening the horizontal meridian[29]. The greater prevalence of with-the-rule astigmatism in this study is in agreement with previous reports[12, 19, 22], but disagrees with others[15, 18, 23] who reported greater prevalence of against-the-rule astigmatism in the populations studied. The differences in the age distribution of the subjects studied may have played a role in the differences in these reports. The subjects in Raliavhengwa and Oduntan[15], and Raju *et al*.[23] included more adults than younger subjects, in contrast to the study which included younger subjects only.

Astigmatism was more common in males than females in this study. This is in disagreement with report by Murphy *et al*.[8] who reported greater prevalence of astig-

matism in females than males. Differences in methods and population studied may be responsible for difference in the association between astigmatism and gender.

Conclusion and recommendation

Refractive error can be treated easily with spectacles and as such, the detrimental impact of visual impairment on a child's education and development could be prevented. Unfortunately, none of the children were wearing spectacles. Lack of eye care services, poor knowledge of vision problem awareness and cost of spectacles may be the reasons for children not wearing spectacles. Population-based vision screening or at least school screening in the rural communities of South Africa is, therefore recommended. The outcome of such interventions will improve the children's academic life and quality of life in general.

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