PREVALENCE OF REFRACTIVE ERRORS AMONG PRIMARY SCHOOL CHILDREN (7-14 YEARS) IN MOTHERWELL TOWNSHIP, EASTERN CAPE, SOUTH AFRICA.

BY

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DECLARATION

"I declare that the mini-dissertation hereby submitted to the University of Limpopo, for the degree of Master of Public Health on Prevalence of refractive errors among primary school children (7 – 14 years) in Motherwell Township, Eastern Cape, South Africa, has not previously been submitted by me for a degree at this university or any other university, that it is my work in design and in execution, and that all the material contained herein has been duly acknowledged"

_____ _____

Akuta G C [redacted] **Date**

DEDICATION

To my entire family, especially Chief and Lolo Akuta for their prayers, love, encouragement and support all through the period of the study.

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ABSTRACT

Background: Uncorrected refractive errors remain a public health problem among different population and age groups worldwide, including South Africa. Refractive error has serious visual and functional impacts on those affected. In children, refractive errors may negatively affect the academic pursuits and activities of daily living such as reading.

Aims and Objectives: To determine and document the prevalence, types and magnitude together with age and gender differences of refractive errors among primary school children in Motherwell Township, Eastern Cape Province, South Africa.

Methods: This was a quantitative, cross sectional refractive error study. Four hundred and twenty one (421) school children aged 7 – 14 years were randomly selected from five randomly selected schools in Motherwell Township, Eastern Cape Province, South Africa. Visual examination which included unaided and aided visual acuity (with LogMAR E chart), non-cycloplegic autorefraction, subjective refraction, internal and external examination of the eye using an ophthalmoscope was conducted. Refractive errors were measured with an autorefractor, refined subjectively and findings presented in spherical form. Hyperopia was defined as a spherical equivalent (SE) of +0.50 D or greater, myopia as spherical equivalent of -0.50 D or greater. A cylindrical power of -0.50 DC (D cylinder) or greater was considered as astigmatism.

Results: The prevalence of hyperopia, myopia and astigmatism among the children were 25.2%, 18.7% and 58.0% respectively. Hyperopia ranged from +0.50 to +3.62 D and myopia ranged from -0.50 D to -20.25 D in the right eyes with a mean of -0.17 ± 1.7 D. In the left eye, hyperopia ranged from +0.50 to +2.62 D and myopia ranged from -0.50 to -20.62 D with a mean of -0.12 ± 1.7 D. Astigmatism in the right eyes ranged from -0.50 to -5.50 D with a mean of -0.6 ± 0.52 D and in the left eye ranged from -0.50 to -4.00 D with a mean of -0.6 ± 0.45 D respectively. Association between hyperopia and age was not statistically significant (p = 0.839), also refractive error and gender was statistically insignificant (p = 0.120). Against-the-rule (ATRA) astigmatism (43.4%) was more common, followed by with-the-rule (WTRA) astigmatism (39.0%) and oblique, (all other meridians) (17.6%). There was a significant association between types of astigmatism and age (p = 0.05), more so inter-gender difference in the prevalence of different types of astigmatism was not statistically significant (p = 0.774).

Conclusion: The study concludes that refractive error has high prevalence of 43.9% in this children population. Astigmatism (58.0%) was more common followed by hyperopia (25.2%)

and myopia (18.7%). Although hyperopia was not age dependent, there was obvious relationship pattern between female genders and hyperopia in the present study. Population-based vision screening or at least school visual screening in the rural communities of Motherwell Township is, therefore recommended. Vision screening and proper eye examination with appropriate optical compensation will improve the activity of daily living and quality of life of those affected.

Key words: Refractive error, hyperopia, myopia, astigmatism, school children.

DEFINITION OF TERMS

Refractive error: Is a condition in an ametropic eye (condition other than emmetropia-normal eye condition), with accommodation relaxed, parallel rays of light fail to converge to a sharp focus on the retina (Grosvenor, 1996).

Myopia (Near-sight): Myopia is the state of refractive error in which the image of an object located at infinity is formed by the eye (at its relaxed state) in front of the retina. The person with uncorrected myopia sees distant objects as blurred but can see close objects clearly, they are 'sighted' at 'short' range (Essilor, 2008).

Hypermetropia (Long–sight): Otherwise known as hyperopia, which is the state of refractive error in which the image of an object located at infinity is formed by the eye (in it's relaxed state) behind the retina (Essilor, 2008).

Ametropia: A refractive condition other than emmetropia (a refractive anomaly) in which, with accommodation relaxed, parallel rays of light fail to converge to a sharp focus on the retina (Grosvenor, 1996).

Emmetropia: The normal refractive state of the eye in which, with accommodation relaxed, parallel rays of light will converge to a sharp focus on the retina (Grosvenor, 1996).

Astigmatism: Astigmatism is a refractive condition in which the eye's optical system is incapable of forming a point image for a point object. This is because the refracting power of the optical system varies from one meridian to another (Grosvenor, 1996).

Against-the-rule astigmatism: Against-the-rule astigmatism is the situation when the axis of the correcting cylinder is within 30 degrees of the vertical meridian (60 – 90 – 120), (Raliavhgwa and Oduntan, 2000).

With-the-rule astigmatism: With-the-rule was referred to axis of the correcting cylinder located within 30 degrees of the horizontal (0 – 30 degrees or 150 – 180 degrees), (Raliavhgwa and Oduntan, 2000).

Oblique astigmatism: While all other meridians were classified as oblique, (Raliavhgwa and Oduntan, 2000).

Nystagmus: Is a repetitive, involuntary, to-and-fro eye oscillation of the eyes, which may be physiological or pathological (Kanski, 2007).

Cataract: The normal lens is transparent; any congenital or acquired opacity in the lens capsule or substance, irrespective of the effect on vision, is a cataract (Kanski, 2007).

Conjunctivitis: Is an inflammation of the conjunctiva (Grosvenor, 1996).

Visual acuity: Is the resolving power of the eye, or the ability to see two separate objects as separate (Grosvenor, 1996).

Spherical equivalent power (SEP) is defined as sphere power plus half cylinder power (Raliavhgwa and Oduntan, 2000).

LogMAR chart is an acuity chart that expresses visual acuity in terms of the logarithm of the angular limb width (in minutes of arc) of the smallest letters recognized at six meter (Rabbetts, 2007).

Prevalence: Number of persons affected by a condition, in a population at a specific time divided by the number of persons in the population at that time (Gordis, 2004).

LIST OF ABBREVIATIONS

VA = Visual acuity

CVA = Corrected visual acuity

OD = Right eye

OS = Left eye

OU = Both eyes

D = Dioptre

VI = Visual impairment

WHO = World Health Organization

N = Number of participants

PAS = Predictive Analysis Software

SEP = Spherical equivalent power

URE = Uncorrected refractive errors

ATRA = Against-the-rule

WTRA = With-the-rule

OBLA = Oblique

TABLE OF CONTENTS

CHAPTER 3

METHODOLOGY

CHAPTER 4

RESULTS

CHAPTER 5

DISCUSSION

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

1.1 INTRODUCTION

In a normal eye, the structural dimensions such as the anterior to posterior length (axial length), powers of the optical components (crystalline lens and cornea) as well as the accommodative powers of the eye are of accurate values, therefore, light from a distant object will focus directly on the retina resulting in normal clear vision. This condition is termed emmetropia. However, in most people, these dimensions and or powers are not usually accurate, resulting in a condition called refractive error (ametropia). According to Grosvenor (1996), ametropia is a term for any refractive condition other than emmetropia (no refractive error) or a condition in which there is a refractive error or refractive anomaly. Refractive error can simply be defined as the inability of the optical system of the eye to focus an image accurately and clearly on the retina and examples of refractive errors include myopia, hyperopia, astigmatism and others.

1.1.1 Myopia, hyperopia and astigmatism (Explaining different forms of Ametropia)

If the axial length of the eye is too long, or the optical powers are too strong, light is focused before it reaches the retina, causing near-sightedness (myopia) (Marilyn and Gary, 2010). If the axial length is too short, or the optical powers are too weak, light focuses behind the retina resulting to hyperopia (Marilyn and Gary, 2010). If the surfaces of the cornea and or the crystalline lens are not perfectly spherical, the image formed is distorted, a condition called astigmatism which may or may not be associated with hyperopia or myopia (Marilyn & Gary, 2010). When astigmatism is in association with either myopia or hyperopia, it can result in compound astigmatism (CA), explained as astigmatism in which, with accommodation relaxed, both focal lines are located in front of the retina (compound myopic astigmatism) (CMA) or behind the retina (compound hyperopic astigmatism) (CHA) or simple astigmatism (SA), which is, with accommodation relaxed, one focal line is located on the retina and the other is located in front of the retina (simple myopic astigmatism) (SMA) or behind the retina (simple hyperopic astigmatism) (SHA), (Grosvenor, 1996). Mixed astigmatism (MA) in which case, one principal meridian is focused in front of the retina and the other is focused behind (Marilyn and Gary, 2010) may also occur.

Astigmatism can also be classified based on the axis, as with-the-rule astigmatism (WTRA), against-the-rule (ATRA) and oblique astigmatism (OBLA). With-the-rule is referred to axis of the correcting cylinder located within 30 degrees of the horizontal (0 – 30 degrees or 150 – 180 degrees). Against-the-rule astigmatism is the situation when the axis of the correcting cylinder is within 30 degrees of the vertical meridian (60 – 90 – 120), while all other meridians were classified as oblique. This classification has been applied in a previous study (Raliavegwa and Oduntan, 2000).

Refractive errors can be easily diagnosed, measured and corrected with spectacles or other refractive corrections to attain normal clear vision. If however, the errors are not corrected or the correction is inadequate, refractive error can lead to low vision (partial sight) and even blindness (Serge et al., 2004). Refractive error is easily measured objectively with retinoscope or autorefractor (with or without cycloplegics) and may or may not be followed with subjective refraction. In subjective refraction, the objective refraction values are refined by asking the patient to respond to changes in vision due to lenses being changed in front of him or her, until he or she reports the lens or lenses that provide the best vision. (Explaination and continuation by the author).

A large proportion of the people worldwide have refractive errors, irrespective of age, sex and ethnic group. According to the World Health Organization (WHO, 2011), 285 million people are visually impaired worldwide; 39 million are blind, 246 have low vision while 90% of the world's visually impaired live in developing countries and globally uncorrected refractive errors are the main causes of visual impairment. According to Smith et al. (2009) uncorrected refractive errors (URE) for distance vision including under-corrected refractive error are the main causes of low vision globally and is the second leading cause of blindness after cataract. An estimated 153 million people worldwide had visual impairment (VI) from UREs in 2004 and 8 million of them were blind, the magnitude of this uncorrectable burden of VI has been overlooked because epidemiological studies have tended to focus on 'best corrected' sight rather than presenting visual acuity (Smith et al., 2009). In their report on the global estimate of visual impairment resulting from uncorrected refractive error, Dandona and Dandona (2008) estimated that globally there were 5 million persons (range 4-6 million) who were blind (distance vision worse than 3/60 in the better eye) due to uncorrected refractive error. More recently, Maharaj et al. (2011) estimated that 300 million people are visually impaired globally

and uncorrected refractive errors with the associated visual impairment result in global economy losing $269 billion in productivity annually.

For several reasons, children are at a greater risk of having visual impairment, however, many of the causes are correctable and preventable if treated early. World Health Organisation (WHO, 2011), estimated that 19 million children are visually impaired globally, of these 12 million are visually impaired due to refractive errors, a condition that could be easily diagnosed and corrected while 1.4 million are irreversibly blind. Uncorrected refractive errors have several implications especially in children. Dandona and Dandona (2001) indicated that blindness due to uncorrected or inadequately corrected refractive errors start at a younger age as such it hinders education, personality development and career opportunities in addition to causing an economic burden on society. The authors further pointed out that the impact of blindness from myopia may be different from that of hyperopia since those that are blind due to myopia are likely to have better near vision than those with hyperopia. Therefore, they can read at near, where most reading is done. Ovenseri-Ogbomo and Assien (2010) indicated that uncorrected refractive errors remains a public health problem which has a considerable impact on learning and academic achievement especially in underserved and under-resourced communities. Detecting ocular disorders in children including refractive errors are important as such disorders can present serious health problems. In South Africa, the lack of appropriate child eye care strategies has posed a serious problem to the visual health of children, and there is a dire need for comprehensive services in the provinces and a roll-out nationally was suggested (Maharaj et al., 2011). A few studies have reported on visual impairment and refractive errors in South Africa. In their study to determine the refractive status of primary school children in the Mopani district of Limpopo, Mabaso et al (2006), found that the prevalence of hyperopia was higher than myopia in the right and left eyes of both genders. However, no previous studies reporting on refractive errors in Port Elizabeth could be found in the literature. It was therefore, of interest to study refractive error among children in Motherwell area.

1.2 PROBLEM STATEMENT

Refractive error is a common eye problem in every age group especially in children, therefore needs great attention from different health care stakeholders. This is because refractive errors may adversely affect the academic pursuit and activities of daily living (ADL) of the children. Also, it may lead to visual impairment and blindness, which may have socioeconomic and

psychological implications for the children. The prevalence of refractive errors among children have not been reported in many areas of South Africa, including Port Elizabeth. Therefore, there is a dire need for research to document the prevalence, types and magnitude of refractive errors among children in these areas, so that attention of the Government and Non-governmental organizations could be drawn to this health issue. Evidence from outreach activities and hospital records (where the researcher works) indicate that refractive errors are common among children in the Motherwell Township, Eastern Cape. It was therefore decided to carry out this project in that area with the aim of establishing the prevalence, types and magnitude of refractive errors among the sampled children population.

1.3 AIM OF THIS STUDY

The aim of the study was to establish the prevalence, types and magnitude of refractive errors among primary school children in the Motherwell Township, Eastern Cape.

1.4 OBJECTIVES

The objectives of the study are:

a) To measure and document the prevalence of refractive errors among primary school children in the Motherwell Township, Eastern Cape.
b) To document the types and magnitude of refractive errors among this target population.
c) To determine if there is an age and gender differences in refractive error types and magnitude in the study population.

1.5 RESEARCH QUESTIONS

The research questions for this study are:

a) What was the prevalence of refractive errors among school children population in Motherwell Township, Eastern Cape?
b) What were the types and magnitude of refractive errors among these children population?
c) Were there gender difference in the prevalence, types and magnitude of refractive errors among these children population?

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND

Refractive errors are refractive anomalies of the eye and include myopia, hyperopia and astigmatism. Refractive error can be detected through routine examination of persons who present to eye clinics or through vision screening of a population, the former approach may work satisfactorily in developed countries but the latter is necessary in developing countries because large majority of the population do not have access to reasonable quality eye care services (Dandona and Dandona, 2001). Visual impairment, including refractive errors have several causative factors. According to Saad and El-Bayoumy (2007), refractive errors are believed to result from a combination of genetic and environmental factors.

It is often difficult to compare the prevalence values of refractive errors in different geographic locations for a number of reasons including the following; definitions of emmetropia, myopia and hyperopia are not uniform across studies; populations with limited representativeness have been studied (surveys have generally dealt with convenience samples, such as school children); procedures used to assess refraction status might be different (refractions may have been performed with or without cycloplegia); the demographic make-up of the studied populations is often dissimilar such as age and sex composition in particular (Negrel et al., 2000). Different guidelines for result interpretations for example method of using nearest spherical power (sphere + ½ cylinder), which was an appropriate method that represents power as a single entity rather than separate components (reporting in other forms such as spheres and cylinders separately) (Raliavegwa and Oduntan, 2000). Also, there are several methods of measurements which may influence reports. Measurement of refractive errors in young myopes using the Complete Ophthalmic Analysis System (COAS) Shack-Hartmann aberrometer for accuracy and repeatability, Salmon et al. (2003) found out that without cycloplegia, both the COAS autorefractor had a mean power vector error of 0.3 to 0.4 D. In that study, cycloplegia improved autorefractor accuracy by 0.1 D but COAS accuracy remained the same. In conclusion, COAS accuracy, repeatability and instrument myopia (difference between cycloplegic and non-cycloplegic refractions for the same eyes) were similar to those of the autorefractor and error margins for both were better than the accuracy of subjective refraction.

Population and gender prevalence of refractive errors differ worldwide. Different studies from different countries or districts of the same country may report inconsistent refractive error findings which may be due to different population samples. Also as refractive error is partly genetically determined, the differences would be expected to vary from continent to continent, country to country and among different ethnic groups within a country. Therefore, result comparison should be done with caution. It has been reported that female children had higher risk of myopia greater than hyperopia: Gombak District study, Malaysia (Pik-pin et al., 2005); urban children population in Southern China (Mingguang et al., 2004); school age children in Shunyi District China (Jialiang et al., 2002); children in rural population in India (Rakhi et al., 2002) and Durban children in South African (Naidoo et al., 2003). However, contrary findings were reported by Akbar et al. (2007) among school children in Dezful, Iran and Mabaso et al. (2006) among rural primary school children in Tzaneen, Limpopo Province, South Africa.

The databases searched included, Science direct, Pub MED, Medline, EBSCO and Google scholar using the term *refractive errors among school children.* Additional articles on reference lists were identified and collected from electronic or print journals. Most importantly, a manual search of tables of contents of print and electronic versions of optometry journals at the University of Limpopo library was also conducted. More than 85% of the reviewed articles were obtained through manual identification on reference lists of published articles and was considered for review if it reported on prevalence of refractive errors. This articles were published in a peer-reviewed journal and reported in English language.

2.1.2 Method of measurement of refractive errors

Many researchers used different method of measuring refractive error in their studies. Cycloplegic method with autorefraction only was used in vision impairment study in Ba Ria, Vietnam (Prakash et al., 2014); school age children in Shunyi District China (Jialiang et al., 2002); in two Provinces, Bangkok and Nakhonpathom (Yingyong, 2010) and refractive errors study among school children in Northeastern Iran (Rezvan et al., 2012).

Retinoscopy and autorefraction combined with cycoplegia were used in visual impairment study in Gombak District, Malaysia (Pik-pin et al., 2005); in Urban and rural school children in Hyderabad, India (Uzma et al., 2009) and in private school children in Ghana (Ben et al., 2013). Retinoscopy only under cycloplegia was used in patterns of refractive errors study in

Nepal (Pokharel et al., 2010); in lower primary in Kampala District (Kawuma and Mayeku, 2002).

Autorefraction alone was used by Muzakir et al. (2008); Dutch school children and hospital employees (Hendricks et al., 2009); while retinoscopy alone was used by Zelalem and Abdirahman (2013) in school children study in rural central Ethopia; and in school children in Agona, Swedru, Ghana (Ovenseri-Ogbomo and Assien, 2009). These differences in methodology may introduce some degree of differences in the reports, hence data comparison should be done with caution.

2.1.3 Method of reporting refractive errors

In reporting refractive error values, various gradings are used by different authors. Refractive errors of -0.50 D or more for myopia; +2.00 D or more for hyperopia and ≥0.75 DC for astigmatism has been used in several studies such as in an urban population study in New Delhi (Murthy et al., 2002); in a rural population study in India (Rakhi et al., 2002); in South African study (Naidoo et al., 2003). Spherical equivalent value of ≥-0.75 D for myopia, +2.00 D for hyperopia and ≥1.00 DC for astigmatism has been used among urban and rural school children in Maharashtra, India (Padhye et al., 2009); among primary school children of Al Hassa, Saudi Arabia (Wadaani et al., 2013). However, classification (≥-0.50 D for myopia, +1.00 D or more for hyperopia and ≥0.75 DC for astigmatism) was used in school children in Jhapa, Nepal (Gauri et al., 2011). In a study in Bangalore (Pavithra et al., 2013) used ≥-0.50 D for myopia, +1.00 D for hyperopia and ≥1.00 DC for astigmatism. Mabaso et al. (2006) defined myopia as spherical equivalent (SE) refractive error of ≥-0.50 D, hyperopia as (SE) spherical refractive error of ≥+0.75 D with astigmatism being ≥0.25 DC in school children study in Mopani district, Limpopo, South Africa. These varying classifications or gradings may introduce some degree of differences in refractive errors reporting, therefore findings comparison should be done with caution.

2.2 PREVALENCE AND OCCURRENCE OF REFRACTIVE ERRORS WORLD WIDE

It has been estimated that globally 153 million people over 5 years of age are visually impaired as a result of uncorrected refractive errors of whom 8 million are blind, there was no evidence of visual impairment caused by uncorrected refractive errors in children age less than 5 years

(Serge et al., 2004). Therefore, refractive errors has a high occurrence among children worldwide. In a study to determine the prevalence of refractive error among preschool children aged 6 to 71 months in an urban America (Baltimore) population, Giordano et al. (2009) reported that the prevalence of myopia of 1.00 diopters (D) or more in the eye with the lesser error was 0.7% in white children and 5.5% in African-American children. The prevalence of hyperopia of +3.00 D or more in the eye with lesser refractive error was 8.9% in white children and 4.4% in African-American children. There was a low prevalence of astigmatism of -3.00 D or more. No significant ethnic differences in the prevalence or type of astigmatism were reported. In Northern Ireland, Donoghue et al. (2010) in a population based cross-sectional study found that in 7 to 13 year old children, myopia was 2.8% (95% CI 1.3% to 4.3%) in younger and 17.7% (95% CI 13.2% to 22.2%) in older children. Hyperopia were 26% (95% CI 20% to 33%) and 14.7% (95% CI 9.9% to 19.4%) respectively. No data was reported for astigmatism. Hendricks et al. (2009) found that among Dutch school children (11-13 years), 28% of the right eyes were myopic (0.50 D) and 8% hyperopic. In a population-based study, to describe the patterns of spectacle use in Australian year one school children (mostly aged 6 years), Dana et al. (2005) found that astigmatism was the most common refractive errors causing visual impairment, accounting for 46.5%. Hyperopia, with or without astigmatism, was the most frequent reason for spectacle (40.3%), while myopia was 11.7%. In another study, to examine the prevalence of refractive error in a population based sample of 11-15 year old Australia children, Ip et al. (2008) reported that the most frequent refractive error was mild hyperopia (59.4%, 95% CI, 53.2-65.6), myopia was found in 11.9%, (95% CI, 6.6-17.2). Children in the European Caucasian and Middle Eastern subgroups had lower prevalence rates of myopia (4.6% and 6.1% respectively) than those of East Asian and South Asian ethnicity (39.5% and 31.5% respectively). No significant ethnic differences in the prevalence or type of astigmatism were reported (Lp et al., 2008).

Prevalence and demographic distribution of refractive error study in school children aged 6-16 years in Pune, India, Kumar et al. (2014) reported that myopia (94.44%) was the most common type of refractive error, followed by hyperopia (2.78%) and astigmatism (2.78%) respectively. Pavithra et al. (2013) in their study of uncorrected refractive errors, among school children of 7-15 years in the field practice area of a medical college in Bangalore, India, found that the prevalence of myopia, hyperopia and astigmatism were 4.4%, 1.03% and 1.6% respectively.
In a refractive error study among school children (6-17 years) in North Eastern Iran, Rezvan et al. (2012), found that the prevalence rate of myopia, hyperopia and astigmatism were 4.3%

(95% CI: 3.3-5.3), 5.4% (95% CI: 4.3-6.5) and 11.5% (95% CI: 9.9-13.1) respectively and were not gender related. The prevalence of myopia with astigmatism increased significantly with age (p<0.0001) while that of hyperopia significantly decreased with age (p<0.0001).
Wadaani et al. (2013) reported that the overall prevalence of refractive error among the primary school children aged 6-14 years in Al Hassa, Saudi Arabia was 13.7% (n=274) (95% CI =12.2%-15.2%), higher among females (n=161) than males (15.5% vs 11.7%; Odds ratio, OR= 1.39, p=0.012) and significantly more among students of rural residence (123/561, 23.71%) compared to urban (151/1441, 10.5%), (OR=2.40, p=0.001). The prevalence of myopia, myopic astigmatism, hypermetropia and hypermetropic astigmatism among those with refractive errors were 65.7%, 12.4%, 9.9% and 12.1% respectively (Wadaani et al., 2013).

In a study in a rural central Ethiopia among school children aged 7-18 years, Zelalem and Abdirahman (2013) reported that of the 4,238 children, 405 (9.5%) were visually impaired, myopia is the most prevalent refractive error; accounting for 6.0%, followed by compound myopic astigmatism 1.2%, then simple myopic astigmatism 0.5%, mixed astigmatism 0.26% and finally hyperopia 0.33%. Adegbehingbe et al. (2005) in their study among children and adolescent aged 8 to 22 years in Osun State, Nigeria found that myopia (51.9%) was the most common spherical refractive error detected while myopic astigmatism (17.3%) was the most common type of astigmatic error, mixed astigmatism (3.9%) was the least common error observed, hypermetropia (17.3%), while hypermetropic astigmatism was 9.6%. Only 13.6% had refractive errors that was at least ± 0.75 sphere or ± 0.50 cylinders or both. In a school based cross-sectional study to estimate the prevalence and distribution of refractive error among school children aged 11-18 years in Agona Swedru Municipality of central region, Ghana. Non-cycloplegic refraction was performed and the prevalence of hyperopia, myopia and astigmatism was 5.0%, 1.7% and 6.6% respectively (Ovenseri-Ogbomo and Assien, 2010). In another study in Ghana by Ben *et al.,* (2013) to assess the prevalence of refractive error and visual impairment in private school children age 12-15 years in the Ashanti region (cycloplegic refraction with autorefraction and retinoscopy were used). With retinoscopy, the prevalence of myopia ranged from 1.7% in 13 year olds to 5.4% in 15 year olds. With autorefraction, the prevalence of myopia was approximately 3.4%. The prevalence of hyperopia ranged between 0.1 and 0.4% when measured with retinoscopy and autorefraction. Significant astigmatism in either eye was present in 9.8% of children with retinoscopy and in 13.7% of children with autorefraction.

In a refractive error study in three communities of Cape Town, South Africa (*n* = 176, aged 16-74 years), Otutu et al. (2012) reported refractive error prevalence (31%) among school children. In a study to determine the refractive status of primary school children aged 8 to 15 years (*n* = 368) in the Mopani district of Limpopo, Mabaso et al. (2006) found that the prevalence of hyperopia, myopia and astigmatism was 73.1%, 2.5% and 31.3% respectively. The prevalence of hyperopia was higher than myopia in the right and the left eyes of both males and females among all age groups. The prevalence of astigmatism was higher in males (56.6%) than females (43.4%). Naidoo et al. (2003) in the study to assess the prevalence of refractive error and visual impairment in school-age African children 5-15 years in Durban, South Africa reported the prevalence of myopia (at least -0.50 D) in one or both eyes in 2.9% of children when measured with retinoscopy and in 4.0% measured with autorefraction, while hyperopia (+2.00 D or more) in at least one eye was present in 1.8% of children when measured with retinoscopy and in 2.6% measured with auto refraction.

2.3 REFRACTIVE ERRORS IN RELATION TO GENDER

Several studies had reported higher occurrence of refractive errors among the females, for example among Egyptian school children (Saad and El-Bayoumy, 2007); in 11-15 year old Australian children (Ip et al., 2008); among schoolchildren in Cairo (El-Bayoumy et al., 2007); among school children in Agona Swedru, Ghana (Ovenseri-Ogboma and Assien, 2010) and among school children in rural central Ethiopia (Zelalem and Abdirahman, 2013). Contrary to the greater occurrence of refractive errors among females, different studies reported more errors among males for example; among school children in Jhapa, Nepal (Gauri et al., 2011); among rural and urban settings in Nepal (Pokharel et al., 2010), in Nigerian high school children (Adegbehingbe et al., 2005). Others, however, have reported no gender difference among school children in Ghana (Ben et al., 2013) and school children in Northeastern Iran (Rezvan et al., 2012).

The purpose for this study was to establish the prevalence, types and degree of refractive errors among primary school children in Motherwell Township of Eastern Cape Province. Spherical equivalent powers will be used to describe myopia and hyperopia, while the correcting cylinders will be used to define astigmatism. Findings presented in this study will help in suggesting appropriate intervention strategies to the Provincial authorities from an informed

position especially with regard to management of refractive error problems in Motherwell Township of Eastern Cape.

CHAPTER 3

METHODOLOGY

3.1 STUDY SITE

Motherwell Township is one of the two townships in the Eastern Cape and one of the eight Urban Renewal Programmes (URP) noted in President Thabo Mbeki's URP, that was announced during the President's State of the Nation Address in February 2001. In 1975, Motherwell Township was formally declared a residential area, although the planning of the Motherwell Township dates back to 1972, when the greater Algoa Bay Planning Authority indicated the need to develop a residential area north of Swartkops river to cater for squatter families due to be relocated from Zwide and Veeplaas. In recent years, the Township has developed into an urban settlement in the Nelson Mandela Bay Municipal area (NMBM), which is situated about 20 kilometers from Port Elizabeth. The Township is made up of 8-9 wards (classified into units; NU 1 to 12 and 29), have a shopping complex, community hall, police stations, clinics and a stadium. With regards to Education, most wards are sufficiently provided with primary and secondary schools, with a total of fifteen primary schools and a population of over seven thousand and forty three children (*Development partners,* 2010).

3.2 STUDY DESIGN

This was a cross-sectional quantitative study in which the primary school children were examined at their respective schools to measure their refractive errors and determine the prevalence, types and the magnitude of refractive errors as well as their relationship with age and gender.

3.3 STUDY POPULATION

The study population consists of children attending primary schools within Motherwell Township, Eastern Cape, South Africa. Currently, there are 7,043 children in the primary schools (*Development partners,* 2010).

3.4 SAMPLE AND SAMPLING METHOD

The study sample included 421 randomly selected primary school children between the ages of 7 and 14 years (Grades one to seven). This sample size was chosen based on the 375 recommended by the Morgan and Krejcie table for sample size estimation (1990), based on the study population of 7,043 (p = 0.05). The Morgan and Krejcie table provided sample sizes for different population sizes. Sample sizes were extracted from the table based on the population sample of the target population. The method of using the nearest equivalent spherical power (SEP) often called spherical equivalent (SE) (sphere + ½ cylinder) was applied to describe and present the myopia and hyperopia. This is a method that represents power as a single entity rather than separate components (sphere, cylinder and axis) as recommended by Harris (2000). The method has been used in the studies of refractive errors in the previous studies in South Africa (Raliavegwa and Oduntan, 2000); Mabaso et al.,(2006). Several others authors such as Wong et al., (2000) and Tan et al., (2011) had used SE in representing myopia and hyperopia and correcting cylinders in their studings. The range of ages used in this study was chosen because this is the age group likely to be found in the rural primary school. Five schools were systematically selected from the 20 primary schools that are currently in Motherwell Township. The schools were listed and participants were systematically selected from each school. Eighty four to eighty five children were selected from each school. Eleven to twelve children were systematically selected from the class register of each grade to arrive at the N=84 or more required for each school. The systematic selection was done such that nearly equal number of male and female participants was chosen from each school.

3.5 INCLUSION AND EXCLUSION CRITERIA

All children of both gender, aged 7-14 years attending primary school in the Motherwell Township and were willing to partake in the study were targeted for this study. Children whose parents or guardians gave consent were included in the study. It was proposed that only those childen who were not willing to participate or whose parents did not give consent will be excluded from the study.

3.6 RELIABILITY

Joppe (2000, as cited in Nahid, 2003) showed that reliability is the extent to which results are consistent over time and an accurate representation of the total population under study, and if the results of a study can be reproduced under a similar methodology, then such a research

work is considered to be reliable. To achieve reliability of this study, the school children were examined using the standardized optometric tests and equipment. Only the researcher conducted all the tests in this study, hence there was no possibility of inter-examiner variability. Also, all test distances were kept constant and environmental conditions such as illumination were similar in the different study sites. However, light meter was not available to measure the illumination levels. A pilot study was conducted on 20 children in a school that was not chosen for the study to standardize testing procedures and logistics. Findings from the pilot study were not included in the main study.

3.7 VALIDITY

According to Gordis (2004), validity of a test is it's ability to distinguish between who has a disease and who does not. Does the research instrument permit the achievement of the real objective of the research? To achieve validity of this study, school children were examined using appropriate standard optometric testing equipment and distances. Standard testing distances were used. The researcher is skilled in performing all the tests included in the study and is registered with the Health Professions Council of South Africa (HPCSA).

3.8 TESTS AND EQUIPMENT

Tests performed include distance unaided and aided visual acuity of each participant. Also, autorefraction and subjective refraction was conducted to measure refractive errors. Equipment used include the logarithm of Minimum angle of resolution (LogMAR) visual acuity chart. This is the standard chart for measurement and scoring visual acuity values. Autorefractor (electronic device for refractive error measurement), trial lenses and trial frame were used to measure the refractive errors and ophthalmoscope was used to evaluate whether or not there was any disease in the eye. All equipment used for the project were borrowed from the Government hospital where the researcher was working.

3.9 PROCEDURE

Before and after refraction, visual acuity was measured at a distance of 4 meters under appropriate illumination. LogMAR charts designed for four meter test distances was used. Non-cycloplegic refraction was used so as not to interfere with normal school function of the children. All data were recorded in a specially designed table (Appendix A). The procedures for the various tests conducted are briefly described below.

3.9.1 Visual acuity (VA) measurement

The child was seated four meters from the VA chart and acuity was measured monocularly (one eye closed) and binocularly (both eyes open) using a logMAR chart. For those wearing glasses already, the VA was taken monocularly and binocularly with and without the glasses. Acuity values was recorded in the data table (Appendix A).

3.9.2 Autorefraction

The child was comfortably seated and instructed to focus on a small target inside the autorefractor. The test was done monocularly. Findings were recorded in the data collection form (Appendix A). Autorefraction values were refined subjectively.

3.9.3 Subjective refraction

This was a technique for determining the refractive error of the eye and involved the person examined indicating changes in clarity of his or her vision when different lens powers were placed in the trial frame placed in front of his or her face. This procedure involved determination of the two components of the refractive errors, namely the sphere and cylinders. After determination of these, binocular balance was done, to balance the vision on both eyes by adjusting the lenses on both eyes to values that made the eyes work comfortably together.

3.9.4 Ophthalmoscopy

This was a test done to evaluate the health status of the anterior and posterior segments of the eye. The child was comfortably seated and instructed to look at a large letter on the VA chart. Under dim illumination, the ophthalmoscope was used to examine the outside and inside parts of the eye. This test was done monocularly. Findings were recorded in the data sheet.

3.9.5 Data presentation

According to Harris (2000) although, sphere, cylinder and axis are unambiguous and meaningful together as a representation of power, when separated, they are not invariant under sphero-cylinderical transpositions. An appropriate method, therefore, is that which represents power as a single entity rather than separate components (sphere, cylinder and axis) (Harris (2000). The multivariate statistical (Matrix) methods developed by Harris (2000) have the advantages of representing dioptric power as a single entity, and therefore, are appropriate for analysis of refractive data. The problem with that approach, however, is that most practitioners and researchers are not conversant with the mathematical and statistical methodology involved in that approach (Raliavhgwa and Oduntan, 2000) and Mabaso et al., (2006). Therefore, the method of using the nearest equivalent spherical power (sphere + ½ cylinder) which is commonly referred to as spherical equivalent (SE) and has been used by previous authors such as Wong et al., 2000; Murthy et al., 2002; Pik-pin et al., 2005; Mabaso et al., 2006; Mohammad et al., 2009; Tan et al., 2011; Zelalem and Abdirahman, 2013; and Pavithra et al.; 2013 was used in this study. Hyperopia in this study was defined as a spherical equivalent (SE) of +0.50 D or greater, myopia as spherical equivalent of -0.50 D or greater. A cylindrical power of -0.50 DC (D cylinder) or greater was considered as astigmatism. Refractive error magnitudes (hyperopia and myopia) with astigmatism in this study are presented in relationship to ages and genders of the participants.

It has been advised that some degree of symmetry exists between the right and left eyes of individuals when considering refractive state (Mckendrick and Brennan, 1997). According to Karakosta et al. (2012), when analysing measurements obtained from both eyes of an individual one needs to take into account, the correlation that often exits between the two eyes, because the right and left eyes of individuals are more likely to be similar to each other than measurements obtained from an unrelated person. Hence, Oberholzer et al. (2014) recommended that, to allow for the possible existence of mirror symmetry between right and left eyes, one may either use only right or only left eye for a study, or right and left eyes are analysed separately or one may adjust the signs of some of the Zernike coefficients for one of the eyes investigated usually the left. In view of this advice, although the right and left eyes refractive errors were analysed separately, only the right eye findings will be used under discussion. In order to facilitate acuity analyses, visual acuity 0.00 (6/6) or better were recorded as 0.0 (6/6).

3.9.6 Data Analysis

Data were analyzed using the Predictive Analysis Software (PAS) (formerly known as the Statistical Package for Social Sciences (SPSS). Descriptive statistics was used to establish the range, means, standard deviations (SD) of the demographic data of the children and the refractive error values. Also, Correlation test (Chi Squared test) was utilized to investigate relationships between variables such as age and gender with refractive errors. Statistical significance was set at 0.05 (p <0.05). A statistician was consulted for data analysis.

3.10 SIGNIFICANCE OF THE STUDY

This study provides information on prevalence, types and magnitude of refractive errors among primary school children in Motherwell Township which was not available. Such information is currently not present and would be useful to the Provincial Health department for eye care planning, resources allocation and effective management of refractive error problems in the Motherwell Township of Eastern Cape. In addition it would serve reference purposes for similar studies in the future in the province and other places.

3.11 ETHICAL CONSIDERATIONS

a) The proposal was approved by the Senior Degree Committee of the University of Limpopo.
b) Approval to conduct the study was obtained from the Eastern Cape Department of Health and Education as well as the principals of the schools for permission to conduct the study (Letters attached as Appendices B to F).
c) A consent form was issued to the school children that was well explained and returned after signing by the parents (Appendix G), only those whose parents consented participated in the study.
d) All procedures involved in the study are within the scope of optometric practice in South Africa and none of the tests could cause injury or discomfort to the children. The researcher is registered with the Health Professions Council of South Africa (HPCSA) as an Optometrist.
e) All procedures in the study are painless and non-invasive.
f) Participants were informed of the purpose of the study, and that declining would not affect their getting eye care and other related health services in future.
g) Results of the eye examination and test were made available to each participant confidentially.

h) Confidentiality of the data was maintained. No participant was identified by name. Results was presented in group format.

i) Data sheets are kept in a secured place during and after the study and would be destroyed by shredding five years after the study.

j) Any serious ocular disease detected during the project, was referred to a nearby government hospital for evaluation and management.

CHAPTER 4

RESULTS

4.1 DEMOGRAPHIC PROFILES

The participants in this study were 421 primary school (African) children at Motherwell Township, Eastern Cape. The number of participants from each of the school ranged from 84-85 as shown in table 4.1. Their ages range from 7 to 14 years with a mean of 9.9 ± 2.2 years. They included 50.8% males and 49.2% females. Out of the 421 children in the study, only 6 (1.4%) were wearing spectacles at the time of the study.

Table 4. 1: Illustrating the names of schools, number (N) and percentages (%) of participants from each school.

Name of school	Participants (N)	Participants (%)
Dumani	84	20.0
Enkwenkwezini	84	20.0
Enqileni	85	20.2
Ikwezelihle	84	20.0
Siyaphambili	84	20.0
Total	**421**	**100.2**

A greater proportion (33.5%) of the children were in the age group 7 - 8 years. The age and gender distributions are illustrated in figure 1 below.

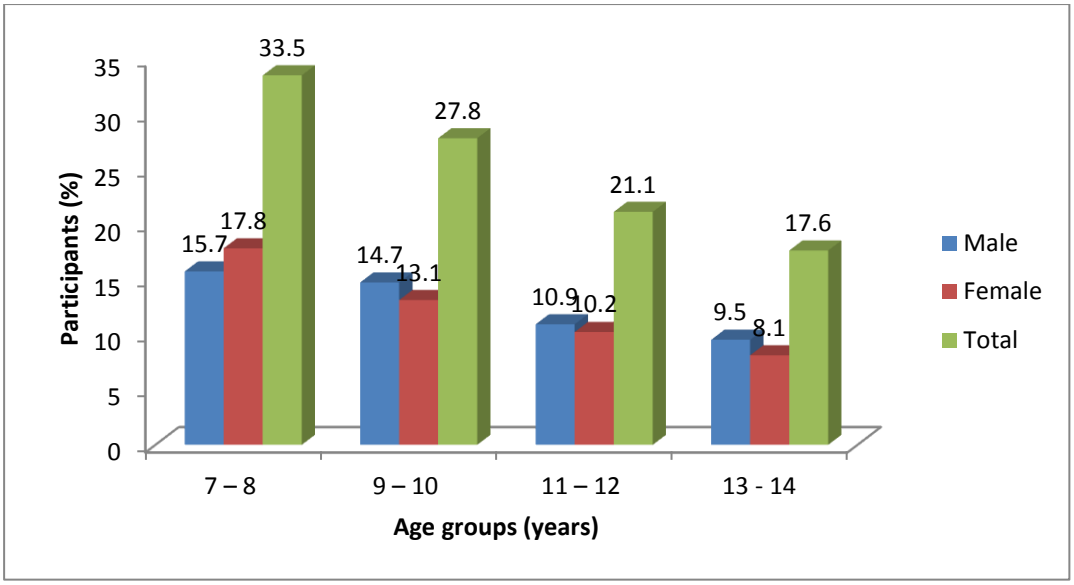

Figure 4. 1: Illustrating the distribution of ages of the children by gender

4.2 OCULAR DISEASES AND ANOMALIES

The ocular diseases and anomalies found in this study (right and/ or left eyes) include strabismus 8 (1.9%), conjunctivitis 10 (2.4%), cataract 3 (0.7%), nygstamus 3 (0.7%), and several others including ptosis, and injuries 14 (3.3%).

4.3 PRESENTING (UNAIDED) VISUAL ACUITIES (VA) OF THE CHILDREN

The presenting visual acuity of the participants (n = 421) ranged from 0.0 – 1.0 LogMAR (6/6 – 6/60) with a mean of 0.11 ± 0.16 LogMAR in both eyes. The VA of the right eye ranged from 0.0 – 1.0 LogMAR (6/6 – 6/60) with mean of 0.17 ± 0.21 LogMAR, and the VA of the left eye ranged from 0.0 – 1.0 LogMAR (6/6 – 6/60) with mean of 0.15 ± 0.18 LogMAR.

4.4 UNAIDED VISUAL ACUITIES BY AGE

4.4.1 Right eye

The visual acuity and age distributions are shown in table 4.2 below. There was a higher occurrence of visual acuity values of ≤0.0 LogMAR among participants aged 7 – 8 and 9 – 10 years accounting for 12.8% and 10.7 % respectively.

Table 4. 2: Distribution of visual acuity (LogMAR) values of the right eye by age

Age range (years)	Visual acuity range (LogMAR), N (%)					
	≤ 0.0	**0.1 – 0.1**	**0.2 – 0.2**	**0.3 – 0.3**	**0.4 – 1.0**	**N (%)**
7 – 8	12.8	5.2	6.4	3.6	5.6	33.6
9 –10	10.7	5.0	7.4	2.6	2.1	27.8
11– 12	7.8	4.0	5.5	2.4	1.4	21.1
13 - 14	5.7	3.1	5.5	2.4	0.9	17.6
N (%)	**37.1**	**17.3**	**24.7**	**11.0**	**10.0**	**100.1**

4.4.2 Left eye

There was higher occurrence of visual acuity values of ≤0.0 LogMAR among participants aged 7 – 8 and 9 – 10 years accounting for 12.6% and 12.1 % respectively. The visual acuity and age distributions are shown in table 4.3 below.

Table 4. 3: Showing distribution of visual acuity (LogMAR) values of the left eye by age

Age range (years)	Visual acuity range (LogMAR), N (%)					
	≤ 0.0	**0.1 – 0.1**	**0.2 – 0.2**	**0.3 – 0.3**	**0.4 – 1.0**	**N (%)**
7 – 8	12.6	6.2	6.2	4.8	3.8	33.5
9 –10	12.1	5.7	6.2	2.1	1.7	27.8
11– 12	7.8	4.3	6.4	1.4	1.2	21.1
13 - 14	4.5	4.5	4.5	2.4	1.7	17.6
N (%)	**37.0**	**20.7**	**23.3**	**10.7**	**8.4**	**100.0**

4.4.3 Visual acuity values with both eyes

There was higher occurrence of visual acuity values of ≤ 0.0 LogMAR among participants aged 7 – 8 and 9 – 10 years accounting for 17.1% and 15.2 % respectively. The visual acuity values in relation to age distributions are shown in table 4.4 below.

Table 4. 4: Illustrating the distribution of visual acuity (LogMAR) values in both eyes by age

Age range (years)	Visual acuity range (LogMAR), N (%)					
	≤ 0.0	**0.1 – 0.1**	**0.2 – 0.2**	**0.3 – 0.3**	**0.4 – 1.0**	**N (%)**
7 – 8	17.1	3.1	6.9	2.9	3.6	33.5
9 –10	15.2	4.3	5.2	2.1	0.9	27.8
11– 12	11.2	3.6	4.8	1.0	0.7	21.1
13 - 14	7.8	2.4	5.0	1.7	0.7	17.6
N (%)	**51.3**	**13.3**	**21.9**	**7.6**	**5.9**	**100.0**

4.5 PRESENTING VISUAL ACUITY (VA) BY GENDER

The presenting visual acuity of male participants (n = 214) in the right eyes ranged from ≤0.0 – 1.0 LogMAR (6/6 – 6/60) with a mean of 0.16 ± 0.22 LogMAR. The visual acuity of the left eyes ranged from ≤0.0 – 1.0 LogMAR (6/6 – 6/60) with a mean of 0.13 ± 0.16 LogMAR. In both eyes, the visual acuity ranged from ≤0.0 – 1.0 LogMAR (6/6 – 6/60) with a mean of 0.09 ± 0.13 LogMAR.

The visual acuity of female participants (n = 207) in the right eye ranged from ≤0.0 – 1.0 LogMAR (6/6 – 6/60) with a mean of 0.17 ± 0.21 LogMAR and the visual acuity of the left eye ranged from ≤0.0 – 1.0 LogMAR (6/6 – 6/60) with a mean of 0.17 ± 0.19 LogMAR. In both eyes, the visual acuity ranged from ≤0.0 – 1.0 LogMAR (6/6 – 6/60) with a mean of 0.14 ± 0.18 LogMAR. The gender difference in VA of the right eye was found to be significant (χ^2 (df = 4, n = 421) = 7.72; p = 0.021). Males had higher occurrence of VA values of ≤0.0 – 0.2 LogMAR (6/6 – 6/9.5) (Normal and minimum visual impairment, according to the International Classification of Diseases 10th revision (ICD-10), (World Health Organisation [WHO], (2008) accounting for 43% in males and 38% in females.

4.6 CORRECTED VISUAL ACUITY VALUES OF THE PARTICIPANTS BY AGE

4.6.1 Right eye

Following optical compensation there was a high occurrence of visual acuity range of 0.0 LogMAR (6/6) or better among all ages groups of the participants. The distributions of

corrected VA of ≤0.0 LogMAR (6/6) and worse than 0.0 LogMAR (6/6) by age range are shown in figure 4.2 below.

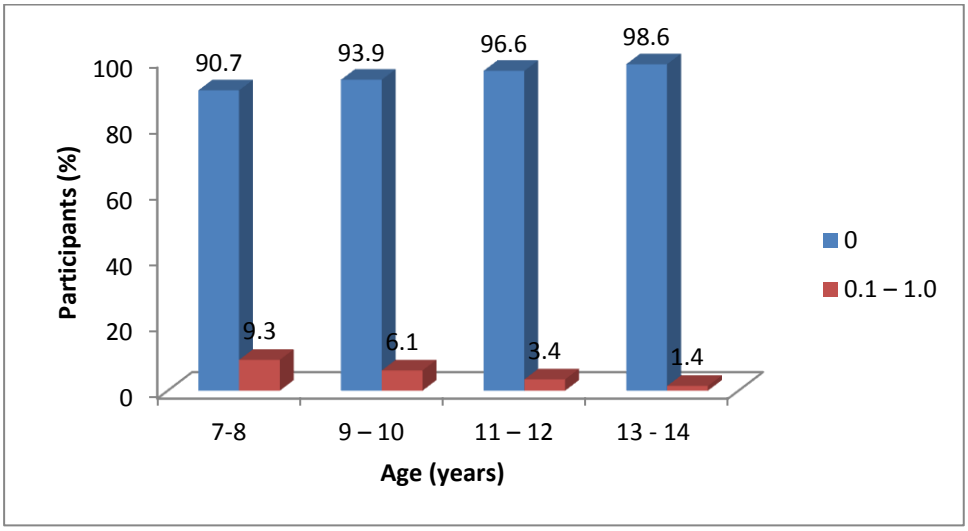

Figure 4. 2: Illustration of the corrected visual acuity of the right eye by age

4.6.2 Left eye

Following optical compensation there was a high occurrence of visual acuity range of 0.0 LogMAR (6/6) or better among all ages groups of the participants. The distributions of corrected VA of ≤0.0 LogMAR (6/6) and worse than 0.0 LogMAR (6/6) by age range are shown in figure 4.3 below.

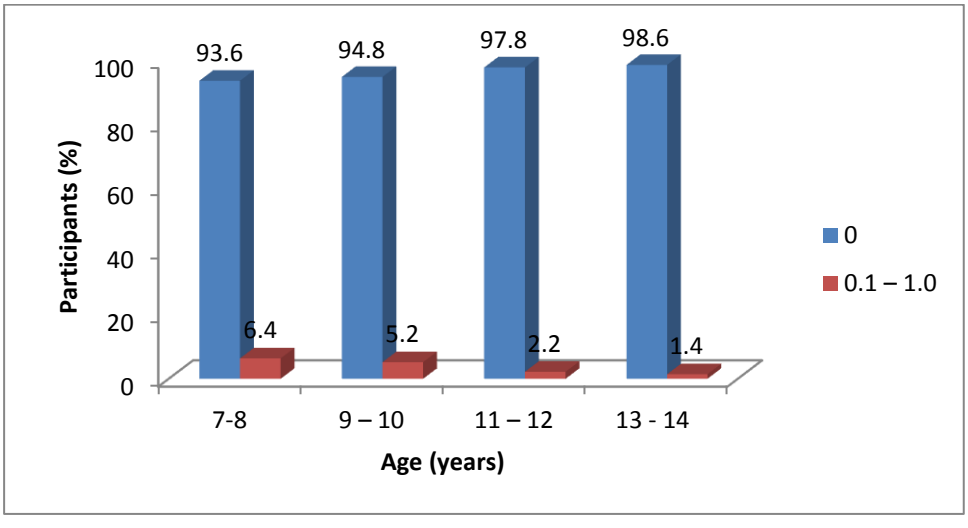

Figure 4. 3: Illustration of the corrected visual acuity of the left eye by age

4.7 CORRECTED VA VALUES OF THE PARTICIPANTS BY GENDER

4.7.1 Right eye.

Most participants 94.3% showed corrected visual acuity of 0.0LogMAR (6/6) or better. The percentage distributions of the corrected visual acuity values (CVA) of the right eye is illustrated below in figure 4.4

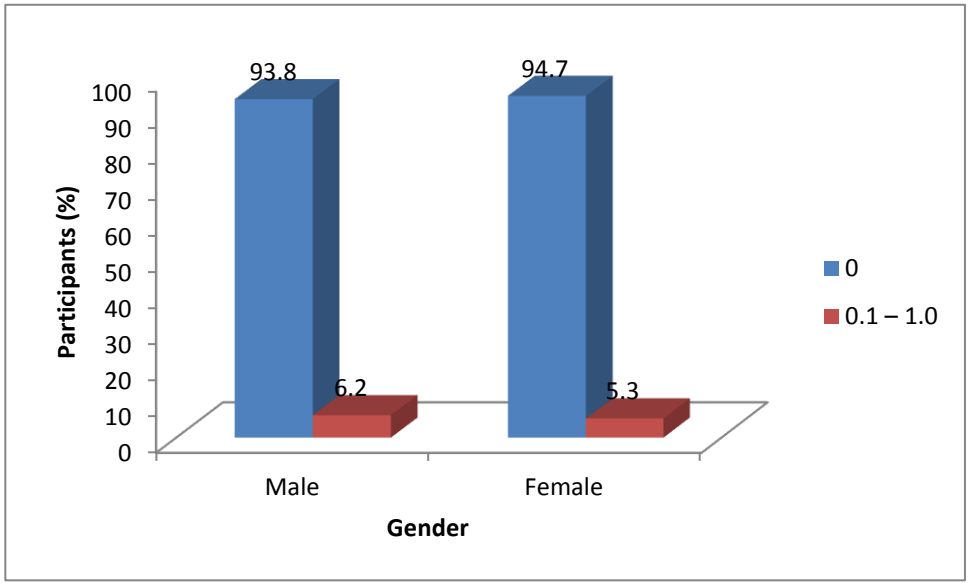

Figure 4. 4: Illustration of the corrected visual acuity of the right eye by gender

4.7.2 Left eye

Most participants 95.7% showed corrected visual acuity of 0.0LogMAR (6/6) or better. The distributions of the corrected visual acuity values (CVA) of the left eye is show below in figure 4.5.

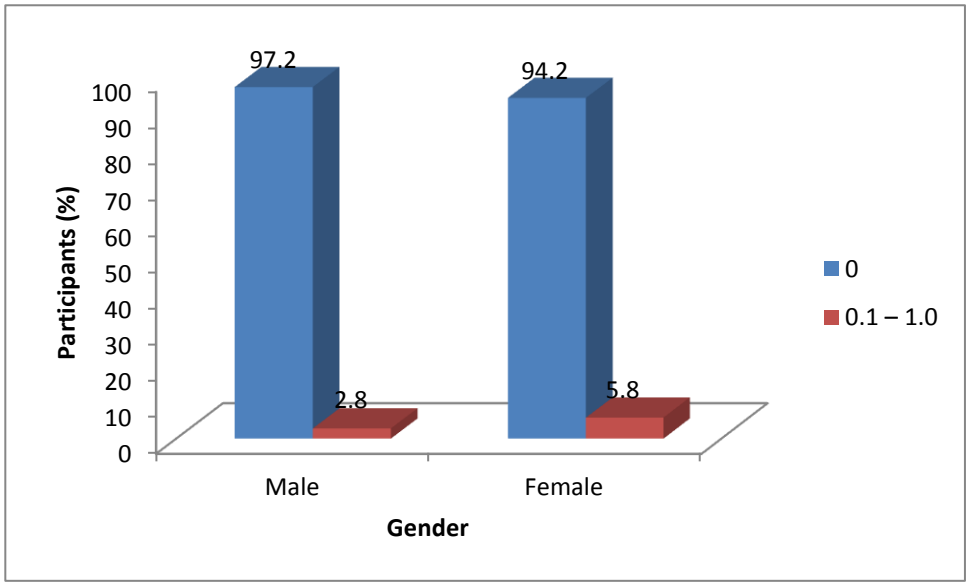

Figure 4. 5: Illustration of the corrected visual acuity of the left eye by gender

4.8 REFRACTIVE ERRORS

4.8.1 Prevalence and magnitude

The prevalence of refractive errors in the right eyes was 43.9% and in the left eyes it was 40.0%. The magnitude of refractive errors in the right eyes ranges from -3.63 to -20.25 D with a mean of -0.17 ± 1.74 D and in the left eyes ranged from -2.63 to -20.63 D with a mean of -0.12 ± 1.66 D. There was a significant relationship between the spherical errors values in the right and left eyes (p <0.01). There was no statistically significant relationship between refractive errors and age and in the right eye (χ^2 (df = 2, n = 419) = 1.43; p = 0.839). There was no significant association between refractive errors and gender in the right eye (χ^2 (df = 2, n = 419) = 7.15; p = 0.120). There was no statistically significant relationship between refractive errors and gender in the left eye (χ^2 (df = 2, n = 419) = 4.23; p = 0.120). The prevalence of hyperopia in the sample population was 25.2% and the prevalence of myopia was 18.7%. Hyperopia defined as (SE of +0.50 D or more) and myopia (SE of -0.50 D or greater).The prevalence of hyperopia in the left eyes among the children was 22.6%, while the prevalence of myopia was 17.4%. The prevalence of the various components (hyperopia, myopia and astigmatism) in the right, left are presented below.

4.8.2 Spherical Powers (Spherical Equivalent, SE)

4.8.2.1 Right eye distribution of refractive errors by age

Hyperopia and myopia were highest among participants aged 11 - 12 years old than all other age ranges accounting for 35.0% and 25.0% respectively. Hyperopia had higher occurrences in the total population than myopia. The distributions of spherical equivalent power (SEP) by age in the right eyes are shown in table 4.5.

Table 4. 5: Showing the distributions of SEP (D) in the right eye by age

SEP (D), Age (years)	**Myopia**				**Hyperopia**			
	7-8	9-10	11-12	13-14	7-8	9-10	11-12	13-14
0.50 – 1.00	7.8	9.6	15.0	13.7	17.9	22.3	27.5	26.1
1.25 – 1.75	2.8	4.8	7.5	5.5	2.8	0.6	7.5	0.0
2.00 – 2.50	2.8	0.6	0.0	2.8	1.4	0.6	0.0	1.4
2.75 – 3.25	1.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0
3.50 – 4.00	0.0	0.0	2.5	0.0	0.0	0.6	0.0	0.0
>4.25	3.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0
Total (%)	**18.3**	**16.8**	**25.0**	**22.0**	**22.1**	**24.1**	**35.0**	**27.5**

4.8.2.2 Left eye distribution of refractive errors by age

There was higher occurrence of hyperopia (32.5%) and myopia (20.5%) among the participants aged 13 – 14 years. The distributions of spherical equivalent power by age are shown in table 4.6.

Table 4. 6: Showing the distributions of SEP (D) in the left eye by age

SEP (D), Age (years)	Myopia				Hyperopia			
	7-8	9-10	11-12	13-14	7-8	9-10	11-12	13-14
0.50 – 1.00	7.7	10.2	7.5	12.2	18.4	15.6	27.5	25.7
1.25 – 1.75	3.5	4.8	12.5	8.3	4.2	1.2	0.0	5.4
2.00 – 2.50	1.4	0.6	0.0	0.0	0.0	0.0	0.0	1.4
2.75 – 3.25	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
3.50 – 4.00	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>4.25	2.8	1.2	0.0	0.0	0.0	0.0	0.0	0.0
Total (%)	**16.1**	**16.8**	**20.0**	**20.5**	**23.3**	**16.8**	**27.5**	**32.5**

4.8.3 Spherical Equivalent Power and Gender

4.8.3.1 Right eye distribution of spherical equivalent by gender

Following calculation of spherical equivalent (SE), it was found that females had a higher occurrence of both hyperopia and myopia accounting for 29.0% and 20.0% respectively.
Both males (59.9%) and females (51.1%) had SEP of <0.50 D. The distributions of spherical equivalent power in the right eye in relation to gender are shown below in table 4.7.

Table 4. 7: Percentage distributions of SEP (D) in the right eye by gender

SEP (D), Gender	Female		Male	
<0.50	51.1		59.9	
	Hyperopia (%)	**Myopia (%)**	**Hyperopia (%)**	**Myopia (%)**
0.50 – 1.00	24.6	10.1	19.8	10.3
1.25 – 1.75	2.9	5.9	1.0	3.3
2.00 – 2.50	1.5	0.5	0.5	2.9
2.75 – 3.25	0.0	1.0	0.0	0.5
3.50 – 4.00	0.0	0.5	0.0	0.0
>4.25	0.0	2.0	0.5	1.5
Total (%)	**29.0**	**20.0**	**21.8**	**18.5**

4.8.3.2 Left eye distribution of spherical equivalent by gender

Females had higher occurrence of hyperopia (25.7%) than myopia (16.1%). The distributions of spherical equivalent (SEP) in the left eye are shown in table 4.8.

Table 4. 8: Percentage distributions of SEP (D) in the left eye by gender

SEP (D), Gender	**Female**		**Male**	
<0.50	58.4		60.7	
	Hyperopia (%)	**Myopia (%)**	**Hyperopia (%)**	**Myopia (%)**
0.50 – 1.00	20.7	7.4	18.2	11.7
1.25 – 1.75	4.0	5.2	1.9	6.2
2.00 – 2.50	0.5	1.0	0.0	0.5
2.75 – 3.25	0.5	0.0	0.0	0.0
3.50 – 4.00	0.0	0.5	0.0	0.0
>4.25	0.0	2.0	0.0	1.0
Total (%)	**25.7**	**16.1**	**20.1**	**19.4**

4.8.4 Astigmatism

The prevalence of astigmatism in the sample population was 58.0% while the prevalence of astigmatism in the right eyes was 60.3% and for the left eyes was 55.8%. The magnitude of astigmatism in the right eyes ranges from -0.50 to -5.50 D with a mean of -0.6 ± 0.52 D and in the left eyes ranged from -0.50 to -4.00 D with a mean of -0.6 ± 0.45 D. There was a significant relationship between the astigmatic powers in the right and left eyes (p = 0.0005). The prevalence in relation to age and gender are presented in tables 4.9 and 4.10 below.

4.8.4.1 Astigmatic powers in the right eye in relation to age

Astigmatism were highest among participants aged 13 - 14 years old, than all other age groups accounting for 64.4%. The distributions of astigmatic power by age are shown in table 4.9. The astigmatic errors relationship with age in the right eye was not statistically significant (χ^2 (df = 2, n =320) =1.96; p = 0.741).

Table 4. 9: Illustrating astigmatic power distribution in the right eyes by age.

Cylindrical powers (D)	Age range (years), N (%)			
	7 – 8	**9 – 10**	**11 – 12**	**13 - 14**
0.50 – 1.00	54.0	48.8	46.4	60.7
1.25 – 1.75	4.5	5.6	7.1	3.6
2.00 – 2.50	1.8	1.6	0.0	0.0
2.75 – 3.25	2.7	0.8	0.0	0.0
>3.50	0.9	0.0	0.0	0.0
N (%)	**63.9**	**56.8**	**53.5**	**64.3**

4.8.4.2 Astigmatic powers in the right eyes in relation to gender.

Males had higher occurrence of astigmatism than females, 62.1% and 58.2% respectively. There was no significant association between astigmatic errors and gender in the right eye (χ^2 (df = 2, n =320) =2.66; p = 0.263). The distributions of astigmatic powers in the right eye are illustrated in figure 4.6.

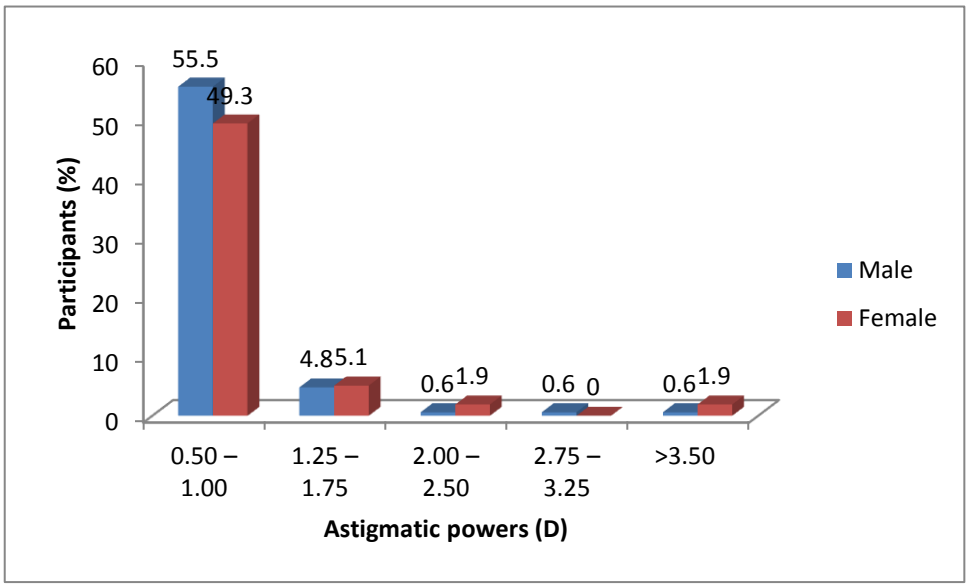

Figure 4. 6: Illustrating the distributions of astigmatic power of the right eye by gender

4.8.4.3 Astigmatic powers in the left eyes in relation to age

Astigmatism were highest among participants aged 11 - 12 years old, than all other age ranges accounting for 68.8%. The distributions of astigmatic power by age are shown in table 4.10. There was no significant association between astigmatic errors and age in the left eye (χ^2 (df = 2, n =342) =2.15; p = 0.708).

Table 4. 10: Illustrating astigmatic power distribution in the left eye by age.

Cylindrical powers (D)	**Age range (years), N (%)**			
	7 – 8	**9 – 10**	**11 – 12**	**13 - 14**
0.50 – 1.00	47.0	45.5	62.6	52.5
1.25 – 1.75	6.0	5.2	6.2	1.7
2.00 – 2.50	1.7	0.7	0	1.7
2.75 – 3.25	0.9	0.7	0	0
>3.50	0.9	0	0	0
N (%)	**56.5**	**52.1**	**68.8**	**55.9**

4.8.4.4 Astigmatic powers in relation to gender in the left eye.

Females had higher occurrence than males accounting for 58.3% and 53.5% respectively. There was no significant association between astigmatic errors and gender in the left eye (χ^2 (df = 2, n =320) =4.87; p = 0.08). The distributions of astigmatic powers in the left eye are illustrated in figure 4.7.

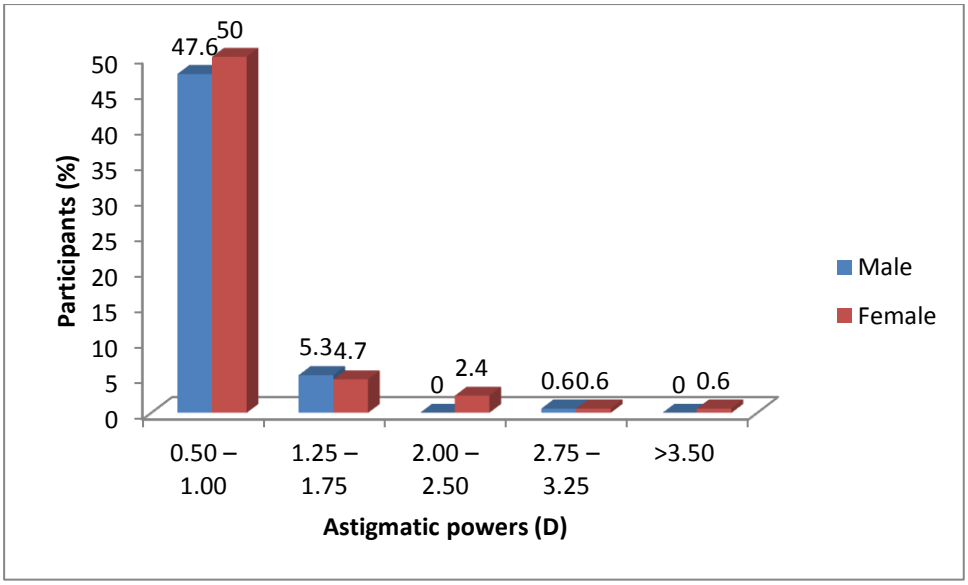

Figure 4. 7: llustrating the distributions of astigmatic power of the left eye by gender

4.8.5 Axes of Astigmatism in the right eye

The distribution of axes of astigmatism in the right eyes among the population are shown in Figure 4.8 below.

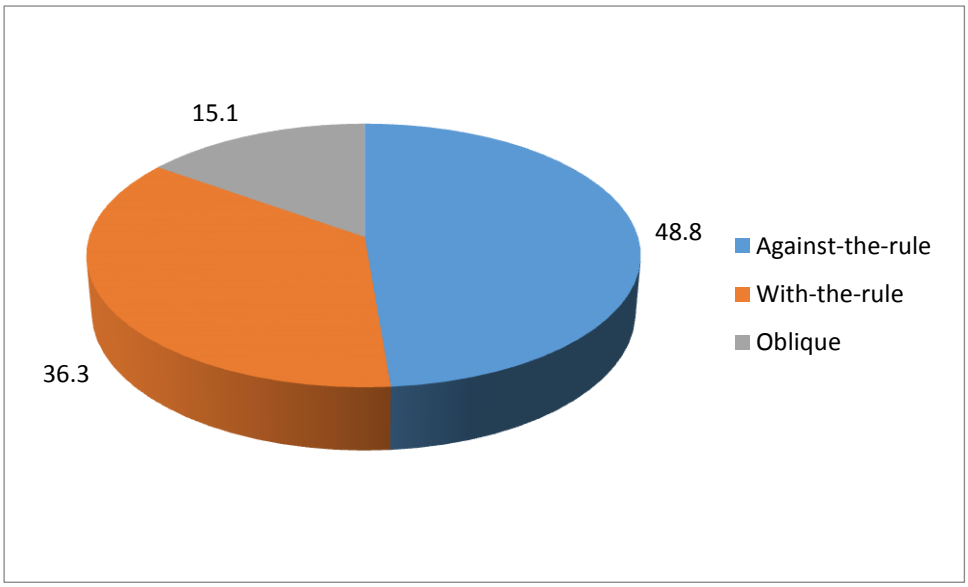

Figure 4. 8: Illustrating the distribution of axes of astigmatism in the right eye

4.8.5.1 Axes of Astigmatism by age in the right eyes

Against-the-rule (ATRA) and with-the-rule (WTRA) astigmatisms were mostly common among participants aged 9 -10 and 7 - 8 years than other age ranges accounting for 52.3% and 40.5% respectively. Obligue (OBLA) astigmatism was higher among the age range 11 – 12 years accounting for 24.6%. The distribution of astigmatism among participants is shown in table 4.11 below.

Table 4. 11: Showing the distributions of axes of astigmatism by age in the right eye

Types of Astigmatism	**Age (years), (%)**			
	7-8	9-10	11-12	13-14
With-the-rule	40.5	37.5	26.2	37.5
Against-the-rule	47.7	52.3	49.2	44.6
Oblique	11.7	10.2	24.6	17.9
N (%)	**100**	**100**	**100**	**100**

4.8.5.2 Axes of astigmatism by gender in the right eyes

Against-the-rule astigmatism was higher in the females (49.4%) than in males (48.2%) in the right eyes, while Oblique astigmatism had higher occurrence in males (16.5%) than in females (13.5%). There was no significant association between axes of astigmatism and gender in the right eye (χ^2 (df = 2, n = 419) = 0.513; p = 0.774). The distributions of axes of astigmatism by gender in the right eye is shown in figure 4.9 below.

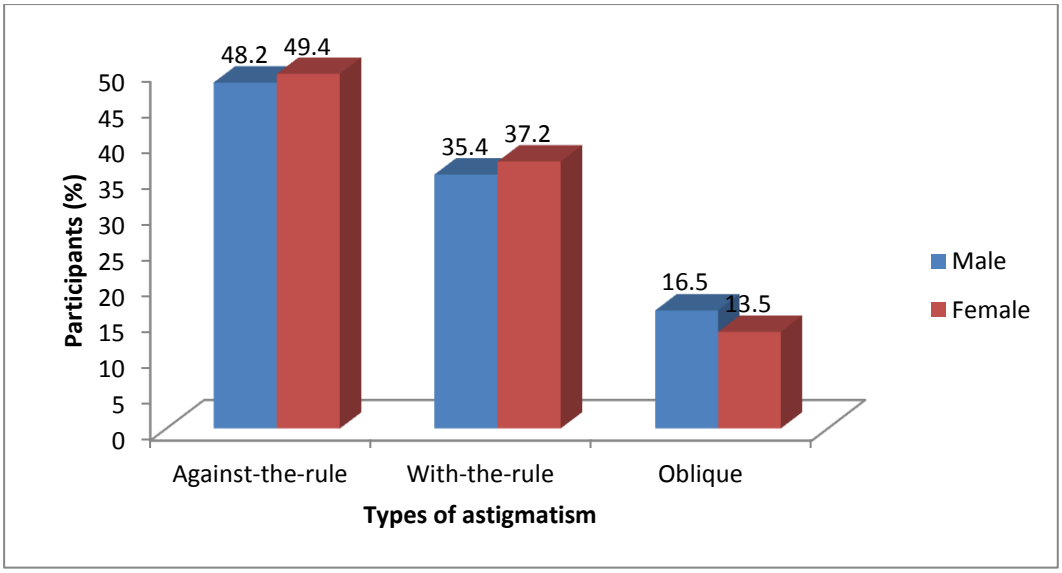

Figure 4. 9: Showing the distributions of axes of astigmatism by gender in the right eye

4.8.6 Axes of Astigmatism in the left eye .

The percentage distributions of axes of astigmatism in the left eyes of the children are shown in figure 4.10 below.

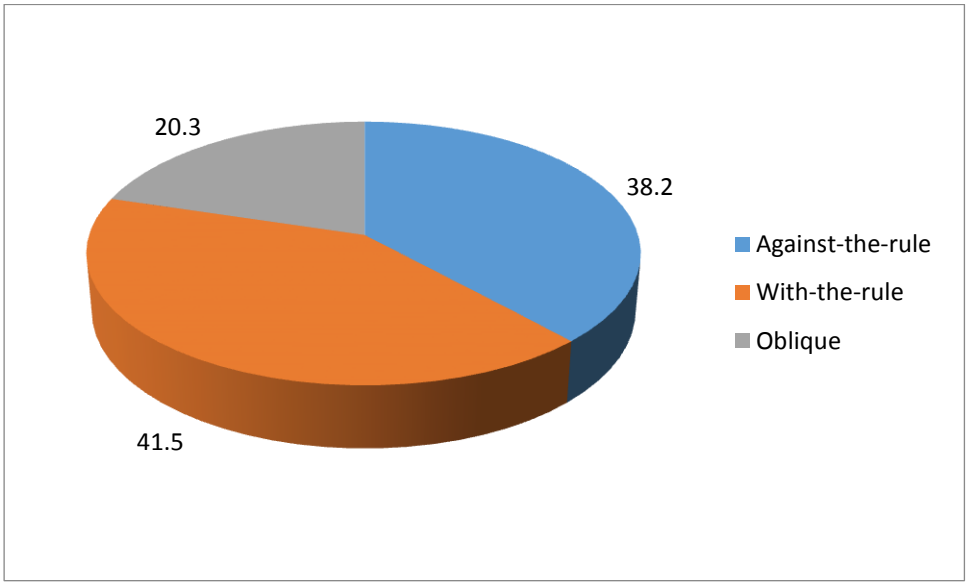

Figure 4. 10: Illustration of the distribution of axes of astigmatism in the left eye

4.8.6.1 Axes of Astigmatism by age in the left eyes

Against-the-rule astigmatism was most common among participants aged 7 - 8 years accounting for 49.4%. With-the-rule astigmatism was prevalent among participants aged 13 – 14 years accounting for 47.5%. Obligue (OBLA) astigmatism was higher among the age range 11 – 12 years accounting for 25.0%. The distribution of axes of astigmatism in the left eye is shown in table 4.12.

Table 4. 12: Showing the distributions of axes of astigmatism by age in the left eye

Types of Astigmatism	**Age (years), (%)**			
	7-8	9-10	11-12	13-14
With-the-rule	42.7	37.8	39.7	47.5
Against-the-rule	49.4	42.9	35.3	35.6
Oblique	13.5	19.4	25.0	16.9
N (%)	**100**	**100**	**100**	**100**

4.8.6.2 Axes of astigmatism by gender in the left eyes

Against-the-rule was higher in males (39.4%) than in females (37.2%) in the left eyes. With-the-rule astigmatism was higher in females (41.9%) than in males (41.2%) in the left eye. Oblique astigmatism was higher in females (20.9%) than in males (19.4%). There was no significant association between axes of astigmatism and gender in the left eye (χ^2 (df = 2, n = 419) = 1.50; p = 0.473). The distributions of axes of astigmatism by gender in the left eye is shown in figure 4.11.

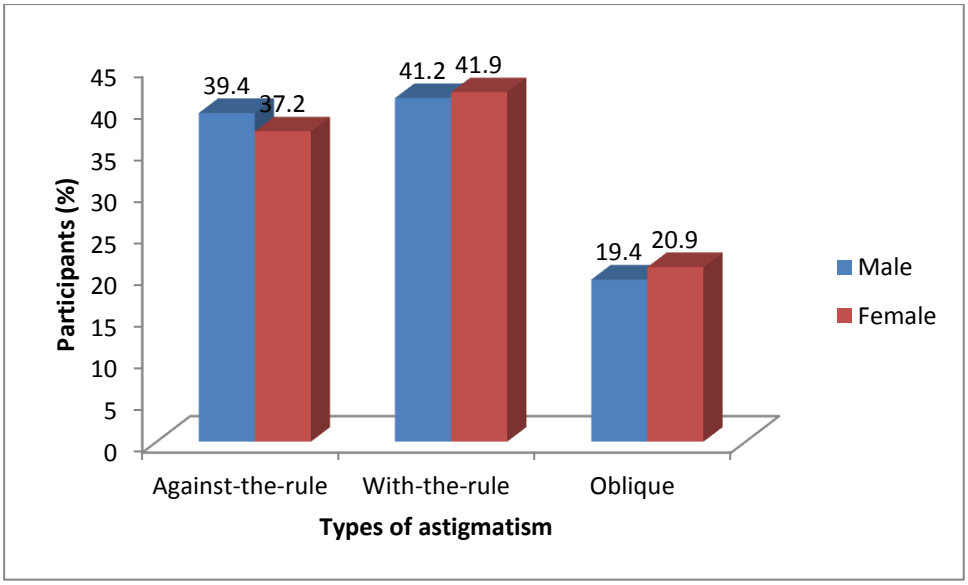

Figure 4. 11: The distributions of axes of astigmatism by gender in the left eye.

CHAPTER 5

DISCUSSION

5.1 INTRODUCTION

Uncorrected refractive errors remains a public health problem among different population and age groups in many parts of the world including South Africa. Among school children, it has a huge impact on learning and academic achievement. To address this problem effectively, data on prevalence of refractive error in children is needed in different settings in different countries. This study provides information on refractive errors which may be useful to the Nelson Mandela Bay Municipality (NMBM), Eastern Cape, South Africa in eye care planning. Data comparisons are made only with studies conducted on similar age groups for relevance appropriateness. Discussions of refractive error findings concentrates on the objectives of the study namely, to document the prevalence, types of refractive error and their magnitudes among primary school children and to determine if there are age and gender differences in refractive error types.

5.2 NON-REFRACTIVE FINDINGS

The aim of this study was to establish the prevalence, types and magnititude of refractive errors among primary school children in the Motherwell Township, Eastern Cape, South Africa. However, during the study, there were tests performed (to highlight the ocular status of the participants), which included visual acuity measurement, autorefraction, ophthalmoscopy and the findings are presented in the result, but will not be discussed except where they are necessary to explain relevant results. For example, the percentage of children with visual acuity 6/6 (20/20) or better after optical compensation was 98.6%, the balance (1.4%) could not be improved presumably due to ocular diseases or anomalies such as strabismus, cataract *et cetera* reported in the results.

5.3 REFRACTIVE FINDINGS

The refractive findings in this study could not be compared with those from several previous studies in children because of differences in methodology. For example, non-cycloplegic refraction was used in this study, therefore findings cannot be compared to those that used

cycloplegic refraction method like school age children in Shunyi District China (Jialiang et al., 2002); rural population in India (Rakhi et al., 2002); in South Africa (Naidoo et al., 2003); Gombak District study, Malaysia (Pik-pin et., 2005); in two Provinces, Bangkok and Nakhonpathom (Yingyong, 2010); refractive errors study among school children in Northeastern Iran (Rezvan et al., 2012) and in Ba Ria, Vietnam (Prakash et al., 2014) . Also, as spherical equivalent was used in this study, findings cannot be compared with those that used sphere and cylinder seperately for data presentation such as the Nigeria study, Adegbehingbe et al., (2005) and children in Jhapa, Nepal (Gauri et al., 2011). Similarly, data could not be compared with studies where the ages of the children differed from those of the children in this study. For example, among school children aged 11-18 years in Agona Swedru Municipality of central region, Ghana (Ovenseri-Ogbomo and Assien, 2010). However, findings in this study could be compared with several other studies due to similar ages of the children, for example, 7 – 15 years in Urban Area of Gujarat, (Trivedi et al., 2006); 6 – 16 years in Pune, India Kumar et al. (2014); 7 – 18 years in rural central Ethiopia, Zelalem and Abdirahman (2013); 8 – 15 years in Tzaneen, Limpopo Province, South Africa (Mabaso et al., 2006).

5.4 PREVALENCE OF REFRACTIVE ERROR

As indicated in the methodology, only the refractive errors of the right eye will be compared in the discussion. This method is justified because correlation coefficient between the right and left eye was 0.899 (p = 0.000). The prevalence of refractive error in this study (right eye) (43.9%) was higher than 6.3% reported in 7 – 18 years in rural central Ethiopia, Zelalem and Abdirahman (2013). The reason for this may be due to the differences in diagnostic criteria, hyperopia (spherical equivalent of +2.00 D or more) was used instead of +0.50 D used in the current study. Among children 6 – 16 years in Pune, India Kumar et al. (2014), the prevalence of refractive error was 6.22%, the reason for the lower prevalence could be due to socioeconomic status because the study was done in an urban municipal schools. However, lower than 61% in children 7 – 15 years in rural and urban Area of Gujarat (Trivedi et al., 2006), the reason could be attributed to socioeconomic factors. Mabaso et al. (2006) in children aged 8 – 15 years in Tzaneen, Limpopo province, reported a prevalence of 76% in all eyes. The differences may be attributed to the differences in methods and definitions in the studies.

5.5 PREVALENCE (HYPEROPIA)

Prevalence of hyperopia in this study (25.2%) is higher than the prevalence of 0.33% reported by Zelalem and Abdirahman (2013) among school aged children 7 – 18 years in rural central Ethiopia. It is also higher than 2.78% in children 6 -16 years, Pune India, Kumar et al. (2014); and 0.8% among children 7 – 15 years in rural and urban Area of Gujarat (Trivedi et al., 2006). Contrarly, it is lower than 73.1% in school children aged 8 – 15 years in Tzaneen, Limpopo Province, South Africa (Mabaso et al., 2006). These differences may be due to methods and use of different dioptric values to determine refractive errors.

5.6 PREVALENCE (MYOPIA)

The prevalence of myopia (18.7%) reported in this study is high compared to 6.0% reported by Zelalem and Abdirahman (2013) and 4.1% reported by Trivedi et al. (2006), as well as 2.5% reported by Mabaso et al. (2006). It is however, lower than 94.44% reported by Kumar et al. (2014). These differences might be due to ethnic and socioeconomic differences between the children.

5.7 PREVALENCE (ASTIGMATISM)

The prevalence of astigmatism (cylindrical power of -0.50 D or greater) (60.3%) in the present study was higher than 31.3% reported by Mabaso et al. (2006); 1.12% reported by (Zelalem and Abdirahman, 2013) and 2.78% in Pune India, Kumar et al. (2014). Trivedi et al. (2006) did not report the prevalence of astigmatism, hence the prevalence in this study could not be compared to the prevalence in that study. The differences above may be attributed to the differences in methods and definitions of astigmatism in the different studies. For example, astigmatism was defined as cylindrical correction of -0.25 D or greater by Mabaso et al. (2006).

5.8 REFRACTIVE ERROR TYPES AND MAGNITUDES

In the current study, low hyperopia (+0.50 to +1.75 D) (20.8%), medium hyperopia (+2.00 to +4.25 D) (1.0%) among males was lower than 46.6% and 50% repectively reported by Mabaso et al., 2006. Similarly among females low hyperopia (27.5%), medium hyperopia (1.5%) in this study was lower than 53.4% and 50% (Mabaso et al., 2006). Low myopia (-0.50 to -3.25) (17%) in males and 17.5% in females was lower than 42.1% and 57.9% reported by Mabaso et al. (2006). Contrarily medium myopia (-3.25 to -6.00 D) of 1.5% and 2.5% was higher than

zero reported by Mabaso et al., 2006. Astigmatic powers (low) (-0.50 to -1.00 D) (50.6%), medium (-1.25 to -3.25 D) (7.2%) and high (>-3.25 D) (0.4%) were lower than 83.8%, 15.2% and 1.0% reported by Mabaso et al. (2006). The differences may be attributed to the differences in methods and definitions in the studies. Astigmatism was defined as cylindrical correction of -0.25 D or greater by Mabaso et al. (2006) while in the current study it was defined as cylindrical power of -0.50 D or greater. In the rural central Ethiopia (Zelalem and Abdirahman, 2013), refractive errors ranged from -22.00 to +10.00 D which was similar to the present study but at variance with Mabaso et al. (2006) where the range was from -2.25 to +3.00 D. This findings could be due to differences in methods and definitions in the studies.

5.9 REFRACTIVE ERRORS (HYPEROPIA, MYOPIA AND ASTIGMATISM) IN RELATION TO AGE

In this study, with increasing age (see Table 5), myopia prevalence increases with age, which is similar to the findings by previous authors (Zelalem and Abdirahman, 2013; Trivedi et al.; 2006; Mabaso et al. 2006). The age related shift towards myopia could be related to the increased intensity of schooling with age (Trivedi et al.; 2006). Also a non-uniform definition of hyperopia could be the reason for the differences (Zelalem and Abdirahman, 2013). Younger participants having smaller eyes may be associated with higher prevalence of hyperopia and increase in the eye size with increasing age may explain shifts towards myopia. (Mabaso et al., 2006). There was a decrease in prevalence of astigmatism with age in the current study (see Table 9) and association between astigmatic error and age was statistically insignificant (p = 0.74). However, Mabaso et al., (2006) reported no consistent increase in astigmatism with increasing age.

5.10 REFRACTIVE ERRORS POWERS IN RELATION TO GENDER

In this study, hyperopia was more common in females than in males (see Table 7). This findings agree with the report of Mabaso et al., (2006) where hyperopia was more common in females than males. Similarly findings were found by Zelalem and Abdirahman, 2013; Kumar et al. (2014) where it was found to be more common in females than males. 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. (1985). However, astigmatism was more common in males than in females (see Figure 6). However, there was no statistically significant association of astigmatism and gender (p = 0.33). This findings of greater occurrence in males

agrees with the report by Mabaso et al., 2006, where astigmatism was more common in males than females. It is, however, at variance with the report in rural central Ethiopia (Zelalem and Abdirahman, 2013) where there was no gender difference with astigmatism.

5.11 AXES OF ASTIGMATISM

The present study reports higher occurrence of against-the-rule astigmatism (48.8%) than 28.1% reported by Mabaso et al., (2006). Contrarily, the occurrence of with-the-rule astigmatism (36.3%), (see figure 8) was lower than 66.5% reported by Mabaso et al., (2006).

5.12 AXES OF ASTIGMATISM IN RELATION TO AGE

There was no obvious relationship pattern between age and types of astigmatism in the present study (see Table 11), which is in agreement with the findings by Mabaso et al., (2006). Other authors (Trivedi et al., 2006; Zelalem and Abdirahman, 2013; Kumar et al. 2014) did not report the axes of astigmatism.

5.13 AXES OF ASTIGMATISM IN RELATION TO GENDER

The inter-gender difference in the prevalence of different types of astigmatism was not statistically significant in the current study (see Figure 9), which is in disagreement with the study by Mabaso et al., 2006, which reported a greater occurrence of with-the-rule-astigmatism (75.2%) among females. No gender differences in relation to axes of astigmatism was reported by Zelalem and Abdirahman, (2013) and in Pune India, Kumar et al. (2014) hence comparison was not made with the present study.

5.14 LIMITATIONS AND RECOMMENDATIONS

A limitation of this refractive error study on children, is that only school going children were included in the current study. It is therefore, recommended that a population-based study involving all children should be conducted in the future studies. Another limitation of this study is that, non-cycloplegic refraction was used and this was done in other to minimise interference with the normal activities of children at school. In future, a population-based study using cycloplegic refraction is recommended. This could be done between the school holidays.

5.15 CONCLUSION

Findings in the present study agreed with certain existing information while disagreeing with others. The prevalence of refractive errors in this study was (43.9%), as reported in certain existing studies, hyperopia and astigmatism are more common in this South African population. Similarly, in agreement with certain previous studies, hyperopia was common after astigmatism, and this type of refractive error was not age dependent. There was obvious relationship pattern between female genders and hyperopia in the present study. Population-based vision screening or at least school screening in the rural communities of South Africa is therefore recommended. The outcome of such program will improve vision of school children and may improve school achievements.

REFERENCES

1. Abdullah, M.G., & Rihab, A. (2003). Refractive errors among school children in Aqaba/Jordan. *Journal of Research in Medical Science, 10*(1), 29-32.

2. Adegbehingbe, B., Oladehinde, M., Majemgbasan, T., Onakpoya, H., & Osagiede, E. (2005). Screening of adolescents for eye diseases in Nigeria high schools. *Ghana Medical Journal, 30,* 138-142.

3. Akbar, F., Hassan, H., Mehdi, K., & Kazem, M. (2007). The prevalence of refractive errors among school children in Dezful, Iran. *British Journal of Ophthalmology, 91,* 287-292.

4. Ben, D., Anne, E., Mohammed, A., Abdul, K., Abdul, A., Nana, Y., et al. (2013). Refractive error and visual impairment in private school children in Ghana. *Optometry and Vision Science Journal, 90,* 1456-1461.

5. Dana, R., Kathryn, R., Annette, K., & Paul, M. (2005). Patterns of spectacle use in young Australian school children: Findings from a population based study. *Journal of American Association for Pediatric Ophthalmology and Strabismus, 9,* 579- 583.

6. Dandona, R., & Dandona, L. (2001). Refractive error blindness. *Bulletin of the World Health Organisation, 79*(3), 237-243.

7. Dandona, R., & Dandona, L. (2008). Estimation of global visual impairment due to uncorrected refractive error. *Bulletin of the World Health Organisation, 86*(1), 63-70.

8. *Development Partners [A ward-Based skills development strategy for Motherwell]*. (n.d.). Retrieved May 16, 2012, from http://www.dpart.co.za

9. Donoghue, L., McClelland, J.F., & Logan, S. (2010). Refractive error and visual impairment in school children in Northern Ireland. *British Journal of Ophthalmology, 94,* 1155-1159.

10. Essilor [Practical Refraction]. (n.d.). Retrieved January 10, 2012, from http://www.varilux-university.org

11. El-Bayoumy, B. M., Saad, A., & Choudhury, H. (2007). Prevalence of refractive error and low vision among schoolchildren in Cairo. *Eastern Mediterranean Health Journal, 13,* 575- 579.

12. Gauri, S., Digen, S., & Purushottam, J. (2011). Refractive error among school children in Jhapa, Nepal. *Journal of Optometry, 4*, 49-55.

13. Giordano, L., David, S., Repka, X., Katz, J., Ibironke, J., Hawes, P., et al (2009). Prevalence of refractive error among preschool children in an urban population; the Baltimore Pediatric Eye Disease Study. *Ophthalmology*, *116,* 739-46.

14. Gordis, L. (Ed). (2004). *Epidemiology*. Philadelphia: Elsevier Saunders.

15. Grosvenor, T. (Ed) (1996). *Primary Care Optometry.* Oxford: Butterworth- Heinemann.

16. Harris, W. (2000). Astigmatism. *Ophthalmic and physiological Optics, 20,* 11-30.

17. Hendricks, W.J., Brabander, D.J., Hendricks, M.H., Host, G.F., Hendrikse, F, & Knottnerus, J. (2009). Prevalence of habitual refractive error and anisometropia among Dutch school children and hospital employees. *Ophthalmologica, 87*, 538- 534.

18. Jialiang, Z., Jin, M., Rong, L., Fengrong, L., Sergio, R, & Leon, B. (2002). The progression of refractive error in school age children; Shunyi District China. *American Journal of Ophthalmology, 134*, 735-43.

19. Kanski, J. (Ed) (2007). *Clinical Ophthalmology: A systematic Approach.* Oxford: Butterworth- Heinemann.

20. Karakosta, A., Vassilaki, M., Plainis, S., Elfadl, N., & Tsilimbaris, M. (2012). Choice of analytic approach for eye-specific outcomes: one eye or two. *American Journal of Ophthalmology, 153*, 571-579.

21. Kawuma, M., & Mayeku, R. (2002). A survey of the prevalence of refractive errors among children in lower primary schools in Kampala District. *African Health Sciences, 2*(2), 69-72.

22. Kondo, T., Miura, M., & Imamichi, M. (1985). Anterior chamber volume in normal eye. *Acta Societatis Ophthalmologicae Japonicae, 89,* 1099-1103.

23. Kumar, P., Pore, P., Dixit, K., & Singh, N. (2014). Prevalence and demographic distribution of refractory error in school of Pune, India. *International Journal of Medical Research & Health Sciences, 2,* 58-67

24. Lp, J. M., Huynh, C., Robaei, D., Kifley, A., Rose, K.A., Morgan, I.G., et al 2008. Ethnic differences in refraction and biometry in a population based sample of 11- 15 year old Australian children. *Eye, 22*, 649-656.

25. Mabaso, R., Oduntan, A., & Mpolokeng, M. (2006). Refractive status of primary school children in Mopani District, Limpopo Province, South Africa. *The South African Optometrist, 65,* 125- 133.

26. Maharaj, Y. I., Naidoo, K.S., Dabideen, R., & Ramson, P. (2011). The KwaZulu-Natal child eye care programme; Delivering refractive error services to primary school learners. *The South African Optometrist, 70,* 61-68.

27. Marilyn, H., & Gary H.(n.d). Refractive errors and refraction. *How the eye sees.* Retrieved January 23, 2012, from http://www.allaboutvision.com

28. McKendrick, A.M., & Brennan, A. (1997). The axis of astigmatism in right and left eye pairs. *Optomotry and Vision Science Journal, 74,* 668-675

29. Mingguang, H., Junweng, Z., Yizhi, L., Jingjing, X., & Gopal, P. (2004). Refractive error and visual impairment in urban children in Southern China. *Investigative Ophthalmology & Visual Science, 45,*793-799.

30. Mohammad, K., Mohammadreza, G., & Isa, Z. (2009). Prevalence of refractive errors in primary school children (7-15years) of Qazvin City. *European Journal of Scientific Research, 28,* 174- 185.

31. Morgan, D.W., & Krejcie, V. (1970). Determining sample size for research activities. *Educational and Psychological measurement, 30,* 607-610.

32. Murthy, G. V., Gupta, S. K., Ellwein, L. B., Munoz, R., Pokharel, P., Sanga L., et al. (2002). Refractive error in children in an urban population in New Delhi. *Investigative Ophthalmology & Visual Science, 43,* 623-631.

33. Muzakir, M., Cathy, W., & Yoav B. (2008, May). Are there inequilities in the utilization of childhood eye care services in relation to socioeconomic status? *Evidence from the ALSPAC cohort.* Retrieved March 10, 2013, from http://www.bjo.bjm.com

34. Nahid, G. (2003). Understanding Reliability and Validity in Qualitative Research, *The Qualititative Report, 8*(4), 597-607.

35. Naidoo, K. S., Avesh, R., Mashige, K. P., Govender, P., Holden, B. A., Pokharel, G. P., et al. 2003. Refractive error and visual impairment in Africa children in South Africa. *Investigative Ophthalmology & Visual Science, 44,* 3764-3770.

36. Negrel A, Maul E, Gopal P, Zhao J, & Ellwein L. 2000. Refractive error study in children; Sampling and measurement methods for a multi-country survey. *American Journal of Ophthalmology, 129,* 421-26.

37. Oberholzer, M., Gillan, W., & Rubin, A. (2014). Mirror symmetry of higher order aberrations between right and left eyes. *The South African Optometrist, 73*, 39- 44.

38. Otutu, M., Nachega, J., Harvey, J., & Meyer, D. (2012). The prevalence of refractive error three Communities of Cape Town, South Africa. *The South African Optometrist, 71*, 32-38.

39. Ovenseri-Ogboma, G.O., & Assien, R. (2010). Refractive error in school children in Agona Swedru, Ghana. *The South African Optometrist*, *69*(2), 86-92.

40. Padhye, A. S., Khandekar, R., Dharmandhikari, S., Dole, K., Gogate, P., & Deshpande, M. 2009. Prevalence of uncorrected refractive error and other eye problems among urban and rural children. *Middle East African Journal of Ophthalmology, 16,* 69-74.

41. Pavithra, M. B., Maheshwaran, R., & Rani, M. A. (2013). A study on the Prevalence of refractive errors among school children of 7-15 years age group in the field practice areas of medical college in Bangalore. *International Journal of Medical Sciences*, *2,* 641-645.

42. Pik-Pin, G., Yahaya, A., Gopal, P., & Leon, B. (2005). Refractive error and visual impairment in school age children in Gombak District, Malaysia. *Ophthalmology, 112,* 678-685.

43. Pokharel, A., Pokharel, K., Das, H., & Adhikari, S. (2010). The patterns of refractive errors among the school children of rural and urban settings in Nepal. *Nepalese Journal of Ophthalmology, 2,* 114- 120.

44. Pokharel, G., Negrel, D., Munoz, S., & Ellwein L. (2000). Refractive error study in children, results from Mechi zone, Nepal. *American Journal of Ophthalmology, 129,* 436-444.

45. Prakash, P., Prasidh, R., Thomas, N., David, W., Ha, T., Suit M., et al. 2014. Prevalence of vision impairment and refractive error in school children in Ba Ria - Vung Tau province, Vietnam. *Clinical & Experimental Ophthalmology, 42*, 217-226.

46. Rabbetts, B. (Ed) (2007). *Clinical Visual Optics.* Oxford: *Butterworth-Heinemann*.

47. Rakhi, D., Lalit, D., Marmamula, S., Prashant, S., Saggam, N., Sergio R, et al. 2002. Refractive error in children in rural population in India. *Investigative Ophthalmology & Visual Science, 43,* 615-622.

48. Raliavegwa, M., & Oduntan, A. (2000). A retrospective study of refractive status of a South African black population. *The South African Optometrist, 59*(3), 72-77.

49. Rezvan F, Khabazkhoob M, Fotouhi A, Hashemi H, Ostadimoghaddam H, Heravian J., et al. (2012). Prevalence of refractive errors among school children in Northeastern Iran. *Ophthalmic and physiological Optics, 32,* 25-30.

50. Saad, A., & El-Bayoumy, B. (2007). Environmental risk factors for refractive error among Egyptian school children. *Eastern Mediterranean Health Journal, 13*(4), 819-828.

51. Salmon, T., West, R., Gasser, W., & Kenmore, T. (2003). Measurement of refractive error in young myopes using the COAS Shack-Hartmann Aberrometer. *Optometry and Vision Science Journal, 80,* 6-14.

52. Serge, R., Donatella, P., Silvio, P. M., & Gopal, P. (2004). Global magnitude of visual impairment caused by uncorrected refractive errors. *Bulletin of the World Health Organisation, 86,* 63-70.

53. Smith, T. S., Frick, K. D., Holden, B. A., Fricke, T. R., & Naidoo, K. S. (2009). Potential lost productivity resulting from global burden of uncorrected refractive error. *Bulletin of the World Health Organisation, 87,* 431-7.

54. Tan, C.S., Chan Y. H., Wong, T. Y., Gazzard, G., Niti, M., Ng, T. P, et al. 2011. Prevalence and risk factors for refractive errors and ocular biometry parameters in an elderly Asian population: the Singapore longitudinal aging study (SLAS). *Eye, 25,* 1294-1301.

55. Trivedi, V., Zalawadiya, S., Bhatt, J., Pawar, T., & Kupmavat, B. (2006). Prevalence of refractive errors in children (Age 7-15years) of rural and urban Area of Gujarat: A population based study. *International Journal of Applied Basic Medical Science, 8,* 128-135.

56. Uzma, N., Kumar, B., Salar, M. K., Zafar, A. M., & Reddy, V. 2009. A comparative clinical survey of the prevalence of refractive errors and eye diseases in urban and rural school children. *Canadian Journal of Ophthalmology, 44,* 328-333.

57. Wadaani, F. A., Amin, T.T., Ali, A., & Khan, R. (2013). Prevalence and pattern of refractive errors among primary school children in Al Hassa, Saudi Arabia. *Global Journal of Health Sciences, 5,* 123-134.

58. Wong, T. Y., Foster, J. P., Hee, J., Ng, P. T., Tielsch, M. J., Chew, J. S, et al. 2000. Prevalence and risk factors for refractive errors in adult Chinese in Singapore. *Investigative Ophthalmology & Visual Science, 41,*2486-2494.

59. *World Health Organization. [Visual impairment and blindness]*. (n.d.). Retrieved October 25, 2011, from http:// www.who.int

60. *World Health Organisation. [Cumulative official updates to ICD-10]*. (n.d.). Retrieved November 14, 2012, from http:// www.who.int

61. Yingyong, P. (2010). Refractive errors survey in primary school children (6-12 years old) in 2 provinces; Bangkok and Nakhonpathom. *Journal of the Medical Association of Thailand,, 93*(10), 1205-1210.

62. Zelalem, M., & Abdirahman, Y. (2013). Prevalence of refractive errors among school children in rural central Ethiopia. *Clinical & Experimental Ophthalmology, 96*(1), 65-69.

APPENDICES

APPENDIXA : DATA COLLECTION FORM

School Name……..

Examination Date……/…….……/……..

PART A: PARTICIPANT IDENTIFICATION

Participant Name……Grade…….

Date of birth……

Age……Sex (M: male; F: female) ……..

PART B: VISION ASSESSMENT

B1: Is the participant currently using spectacles?.....

Yes [ ] No [ ]

(If no, move to B3)

B2: Aided visual acuity:

OD:…….. OS:……

Visual acuity cannot be ascertained (reason)

……..

B3: Unaided visual acuity

OD:……. OS:……

Pinhole acuity

OD:……. OS:……

PART D: EXTERNAL/ANTERIOR SEGMENT EXAMINATION

Normal [ ] Abnormal [ ]

Comment:……..

PART E: REFRACTION

E1: Autorefraction

EYE	SPHERE	CYL	AXIS
OD			
OS			

E3: Subjective refraction (Best corrected visual acuity)

OD:……. OS:…….

PART F: OPHTHALMOSCOPY

Normal [ ] 1: Abnormal [ ]

Comment……

APPENDIX B: COPY OF THE LETTER TO THE MANAGER HUMAN RESOURCE DEVELOPMENT, DEPT OF HEALTH. PORT ELIZABETH.

P O Box 858
Port Elizabeth
6000
4th June 2012

The Manager: Human Resource Development
Department of Health (Port Elizabeth)
Eastern Cape Province.
Dear Sir/Madam

Re: **PERMISSION TO CONDUCT A RESEARCH STUDY**

I hereby request permission from the Department of Health to conduct a research study. I am currently studying for Master of Public Health (MPH) degree at the University of Limpopo and am expected to conduct a research study as a partial fulfilment of the qualification.

The title of the study is: Prevalence of refractive errors among primary school children between the ages of 7-14years in Motherwell Township. The study has been given ethical clearance and approval by the University of Limpopo Senior Degrees Committee. Written consent will be obtained from the parents of the children before including the children in the study. Please find attached the study proposal and ethical clearance approval letter.
It will be appreciated if permission is granted.
Thanking you in advance.
Yours faithfully

Akuta G C (Researcher) .....
W: 041 392 3302
C: 072 333 3104
Supervisor: Prof O A Oduntan ..... .
W: 031 260 8156
C: 082 826 3967

APPENDIX C: COPY OF THE LETTER TO THE MANAGER HUMAN RESOURCE DEVELOPMENT, DEPT OF EDUCATION.

P O Box 858
Port Elizabeth
6000
4th June 2012

The Manager: Human Resource Development
Department of Education (Port Elizabeth)
Eastern Cape Province.
Dear Sir/Madam

Re: **PERMISSION TO CONDUCT A RESEARCH STUDY**

I hereby request permission from the Manager: Human Resource Development, to conduct a research study. I am currently studying for Master of Public Health (MPH) degree at the University of Limpopo and I am expected to conduct a research study as a partial fulfilment of the qualification. The title of the study is: Prevalence of refractive errors among primary school children between the ages of 7-14years in Motherwell Township. The study has been given ethical clearance and approval by the University of Limpopo Senior Degrees Committee. Written consent will be obtained from the parents of the children before including the children in the study. Please find attached the study proposal and ethical clearance approval letter.
It will be appreciated if permission is granted.

Thanking you in advance.
Yours faithfully
Akuta G C (Researcher) .....
W: 041 392 3302
C: 072 333 3104
Supervisor: Prof O A Oduntan ..... .
W: 031 260 8156
C: 082 826 3967

APPENDIX D: COPY OF THE LETTER TO THE CEO, PORT ELIZABETH HOSPITAL COMPLEX.

P O Box 858
Port Elizabeth
6000
4th June 2012

The Chief Executive Officer
Port Elizabeth Hospital Complex (Walton Building)
Eastern Cape Province.
Dear Sir/Madam

Re: **PERMISSION TO CONDUCT A RESEARCH STUDY**

I hereby request your permission to conduct a research study required in partial fulfilment of Master of Public Health (MPH) degree. I am currently studying for MPH degree at the University of Limpopo and I am expected to conduct a research study as a partial fulfilment of the qualification. The title of the study is: Prevalence of refractive errors among primary school children between the ages of 7-14years in Motherwell Township. The study has been given ethical clearance and approval by the University of Limpopo Senior Degrees Committee. Written consent will be obtained from the parents of the children before including the children in the study. Please find attached the study proposal and ethical clearance approval letter.

It will be appreciated if permission is granted.

Thanking you in advance.

Yours faithfully

Akuta G C (Researcher) .....
W: 041 392 3302
C: 072 333 3104
Supervisor: Prof O A Oduntan ..... .
W: 031 260 8156
C: 082 826 3967

APPENDIX E: COPY OF THE LETTER TO THE HOD, EYE DEPT PEPH.

P O Box 858
Port Elizabeth
6000
4th June 2012

The Head of Department (Eye Clinic)
Port Elizabeth Provincial Hospital
Eastern Cape Province.

Dear Sir

Re: **PERMISSION TO CONDUCT A RESEARCH STUDY**

I hereby request permission to conduct a study. I am currently studying for Master of Public Health (MPH) degree at the University of Limpopo and am expected to conduct a research study as a partial fulfilment of the qualification.

The title of the study is: Prevalence of refractive errors among primary school children between the ages of 7-14years in Motherwell Township. The study has been given ethical clearance and approval by the University of Limpopo Senior Degrees Committee. Written consent will be obtained from the parents of the children before including the children in the study. Please find attached the study proposal and ethical clearance approval letter.

It will be appreciated if permission is granted.

Thanking you in advance.

Yours faithfully

Akuta G C (Researcher) .....
W: 041 392 3302
C: 072 333 3104
Supervisor: Prof O A Oduntan ..... .
W: 031 260 8156
C: 082 826 3967

APPENDIX F: COPY OF LETTER TO THE PRINCIPAL OF EACH SCHOOL

The Principal,

…….

Motherwell, Eastern Cape.

Dear Sir/Madam

Re: **PERMISSION TO CONDUCT A RESEARCH STUDY**

I hereby request permission (Principal) to conduct a research study from your school. I am currently studying for Master of Public Health (MPH) degree at the University of Limpopo and am expected to conduct a research study as a partial fulfilment of the qualification.

The title of the study is: Prevalence of refractive error among school children between the ages of 7-14years in Motherwell Township. The study has been given ethical clearance and approval by the University of Limpopo Senior Degrees Committee. Written consent will be obtained from the parents of the children before including the children in the study.

Please find attached the study proposal and ethical clearance approval letter.

Thanking you in advance.

Yours faithfully

Akuta G C (Researcher) .....

W: 041 392 3302

C: 072 333 3104

Supervisor: Prof O A Oduntan ..... .

W: 031 260 8156

C: 082 826 3967

APPENDIX G: CONSENT FORM

I,……hereby give consent for my child to participate in the study as indicated in the information sheet by the researcher; to determine the prevalence of refractive errors among primary school children in Motherwell Township. I understand that the information obtained from my child will be used strictly for the study and will remain confidential.

Also, I understand that participation is voluntarily and no remuneration will be paid to my child. Further, I am aware that my child may withdraw from the study at any time.

Signature of the parent..... Date……

Name and signature of the child…… ... …….