REFRACTIVE ERRORS, VISUAL IMPAIRMENT AND UTILIZATION OF SPECTACLES AMONG PRIMARY SCHOOL CHILDREN IN ONITSHA, ANAMBRA STATE, NIGERIA

BY

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DECLARATION

I declare that the, **REFRACTIVE ERROR, VISUAL IMPAIRMENT AND UTILIZATION OF SPECTACLES AMONG PRIMARY SCHOOL CHILDREN IN ONITSHA, ANAMBRA STATE, NIGERIA** dissertation hereby submitted to the University of Kwa Zulu-Natal, for the degree of Master of Optometry has not been submitted by me for a degree at this or any other university; that it is my own work in design and in execution, and that all material contained herein has been duly acknowledged.

Ezinne N.E

March 2018

DEDICATION

I dedicate this study to the Almighty God, my father Hon Hyacinth Nwabueze Ezinne, my late mother Mrs Jacinta Chioma Ezinne and all my siblings for their wonderful support.

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ABSTRACT

Aim: To establish the visual status and utilization of spectacles among primary school children in Onitsha, Anambra State, Nigeria.

Methods: A stratified random cluster sampling procedure was used to select children aged 5-15 years old from grades 1 to 6 in primary schools, with 1020 children in 102 clusters being enumerated, of whom 998 (97.8%) were examined. The examination included visual acuity, retinoscopy, auto-refraction under cycloplegia, and examination of the anterior segment, media and fundus.

Results: The 998 children consisted of 554 (55.5%) females and 444 (44.5%) males, with their mean age being 9.01± 2.5 years. The prevalence of uncorrected, presenting and best corrected visual acuity of 20/40 or worse in the better eye was 9.7%, 7.7% and 1.3% respectively. Refractive error accounted for 86.6% of all causes of visual impairment (best corrected visual acuity of 20/40 or worse in the better eye). Myopia was the most prevalent refractive error (46.4%), followed by astigmatism (36.1%) and hyperopia (17.5%). Myopia (of at least −0.50 D) in one or both eyes was present in 46.4% of the children when measured with retinoscopy, and 49.5% when measured with auto-refraction. Astigmatism (of –0.50DC or less) was present in 36.1% of the children when with retinoscopy and auto-refraction. Hyperopia (+2.00D or more) in at least one eye was present in 21.6% of children with auto-refraction and 17.5% with retinoscopy. Refractive error and visual impairment were significantly more prevalent in females than in males (P = 0.04).Refractive error was highest among children 11−13year old, while visual impairment was highest among children 5−7 years old. The rate of wearing spectacles among children with visual acuity of 20/40 or worse in one or both eyes was 20.6%. The major reason for non-compliance with spectacle wear among the children was disapproval from their parents.

Conclusion: The prevalence of refractive error and visual impairment among primary school children in Onitsha was high while spectacle utilization rate was low. This highlights the need for services and strategies to address refractive error, visual impairment and compliance with spectacle utilization in this region.

Definition of terms

- **Accommodation:** The eye's ability to automatically change focus from seeing at one distance to seeing at another (Johnstone, 2008).
- **Albinism**: is a genetically determined heterogeneous group of disorders of melanin synthesis in which either eye alone (ocular albinism) may be affected (Kanski, 2000).
- **Amblyopia**: is a unilateral or bilateral decrease of visual acuity caused by form deprivation and or abnormal binocular interaction for which no organic causes can be detected by the physical examination of the eye (Maake, 2015).
- **Best corrected visual acuity**: The best vision you can achieve with correction (such as glasses), as measured on the standard visual acuity chart (Boaitey, 2014).
- **Catarac**t: is the loss of transparency of the crystalline lens or its capsule where there is light scattering reduction in transparency in the lens due to disorganization of the lens fiber, or disorganization of cytoplasm within the fiber, causing scattering (Brown, 2001)
- **Diopter**: is a unit by which the strength of lenses is measured (Brown, 2001).
- **Emmetropia**: A condition whereby with accommodation relaxed, parallel rays of light coming from infinity falls on the retina (Johnstone, 2008).
- **LogMAR E 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 meters (Maake, 2015)
- **Ophthalmoscope**: is an instrument which allows for the visual examination of the external and internal structures of the eye (Maake, 2015)
- **Optometrist**: is an eye care practitioner who diagnoses and manages eye problems but does not perform surgery (Boaitey, 2014).
- **Refraction**: The process of determining the refractive power of the patient’s eye by using lenses for the purpose of correcting the error (Maake, 2015).
- **Retinoscopy**: The process of using a retinoscope for the objective determination of the patient’s refractive status (Ahuama &Atowa, 2004)
- **Retina:** The sensory membrane that lines the inside of the eye; it is composed of several layers and functions as the immediate instrument of vision by receiving images formed by the lens and converting them into signals which reach the brain by way of the optic nerve (Boaitey, 2014).

- **Visual acuity**: is a measurement of a patient's ability to resolve fine details and usually involves directing a patient to identify targets of decreasing sizes at a set distance. It is the measurement of the ability to discriminate two stimuli separated in space at high contrast compared with the background (Kniesteddt & Stamper, 2003).
- **Prevalence**: is defined as the number of cases of a disease that exist in a defined population at a specified point in time (Mann, 2003)
- **Pinhole disc**: is an opaque disc with a central circular aperture of about 1mm in diameter (Dhaliwali, 2017).
- **Spherical Equivalent (SEP)** is defined as sphere power plus half cylinder power (Raliavhegwa & Oduntan, 2000).
- **Subjective refraction**: is the determination of the patient's refractive status based on the patient's response (Dhaliwali, 2017).

LIST OF ABBREVIATIONS

VA = Visual acuity

BCVA = Best corrected visual acuity

OD = Right eye

OS = Left eye

D = Diopter

VI = Visual impairment

RE = Refractive errors

URE = Uncorrected refracted errors

WHO = World Health Organization

NCVI = Non correctable visual impairment

CVI = Correctable visual impairment

MSVI = Moderate severe visual impairment

SVI = Severe visual impairment

WTR = With-the-rule

AR = Against-the-rule

OU = Both eyes

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CHAPTER 1: INTRODUCTION

1. Introduction

While Nigeria is one of the richest countries in Africa, it is classified by the World Bank as a low-income country, and faces similar challenges as other resource limited countries to provide comprehensive health services to its over 250 million inhabitants. Essential to providing such services, is understanding the extent of the problems that need to be addressed within each region, in this instance, in Onitsha Anambra State, which is in the southeastern part of the country. The World Health Organization (WHO) recommends that children should have their eyes tested before they begin their schooling at age five years, this requirement makes it important to provide the necessary services to conduct the tests and treatment options, including referrals to specialized centers of care for those in need of more than corrective spectacles. For many children, spectacles are adequate to enable them to participate in school activities, both academic and social. Providing relevant services therefore requires data about the visual status (refractive error and visual impairment) and utilization of spectacles in school children. This chapter reviews the background to the study, provides a rationale for this research, outlines the aim and objectives, the study design, and the thesis structure.

1.2 Background

Vision is one of the five senses, and it provides people with the ability to see, this being important for normal development and daily functioning. Two eyes are required to see things clearly and the eyes act as the receiver that sends signal through the optic nerves to the brain for interpretation of information. If there is any obstruction or disorder in the eye or the nerves, vision is reduced, which if not corrected, could lead to blindness. While poor vision is normally associated with the elderly and the aging process, it can also affect children with several implications such as missed educational opportunities and disengaging them with their world resulting in a generally reduced quality of life (Ebeigbe et al., 2013). For these reasons, interventions are needed, either by surgery to correct the problem, or spectacles to adjust the light path that enters the eye and that is the major reason why uncorrected refractive error is a priority of the VISION 2020: The Right to Sight program (Mahjoob et al., 2016).

Refractive error is an optical defect of the eye that prevents parallel light rays (reflected from or produced by a distant object) from being brought to a clear focus on the retina (Dandona et al., 2001). It is a common cause of visual impairment and blindness worldwide across different age groups and genders. In addition, it is estimated that 2.3 billion people live with refractive errors globally (Holden et al., 2000). In 2006, 153 million people had uncorrected refractive error, as reported by the WHO, of whom 13 million were children and 45 million were adults (Dandona et al., 2001; Adeoti, 2009). Furthermore, 90% of people with uncorrected refractive error live in low-income countries, such as those in sub-Saharan Africa (Ayanniyi et al., 2010). A study among undergraduate students in Benin, Nigeria, revealed that a large proportion (68%) of the total population had not heard of refractive error, or had not gone for an eye examination, despite having had a problem with their eyes (Ebeigbe et al., 2013). According to Aguwa et al (2017), the incidence of refractive errors in Nigeria's six regions was as follows: North-West (93.6%), South-West (50.5%), South-South (32.9%), South-East (27.7%), North Central (18%) and North-East (15.8%).

The WHO defines visual impairment (VI) as visual acuity of less than 6/18 to 3/60 in the better eye, and/or visual fields of less than 10 degrees from the point of fixation (WHO, 2008). Functional visual impairment is defined as visual acuity of less than 6/18 to light perception (LP), or a visual field of less than 10 degrees from the point of fixation, but those who use, or are potentially able to use vision for planning or executing a task (WHO, 2014). The WHO estimated that of the 19 million visually impaired children globally, 12 million are visually impaired due to refractive errors, a condition that could be easily diagnosed and corrected with a pair of spectacles. Visual impairment is a public health problem and constitutes an important socioeconomic burden, not only in Nigeria as a developing country, but also in sub-Saharan Africa (Liping et al., 2010).

Refractive error is the main cause of visual impairment in the world and spectacles are the most frequently used method of correcting it. It is the simplest, cheapest and only method used in developing countries, such as Nigeria, and is recognized as one of the priorities of VISION 2020: The Right to Sight campaign (Parikshit & Gilbert, 2007). The correction of refractive errors has been reported to significantly improve visual functioning and quality of life (Esteso et al., 2007). Despite refractive errors being easily correctable with spectacles, only 1.8 billion people globally have access to eye examinations and affordable correction (Thulasiraj et al., 2003). Approximately 500 million people, mostly from developing countries (close to one-third are in Africa), have no access to eye examinations and correction, which increases their risk of visual impairment and blindness (Desalegn et al., 2016). Many children in developing countries, including Nigeria, have limited access to eye care services, which can be due to services not being available, accessible, affordable or utilized. In Nigeria, the situation is exacerbated by cultural beliefs that consider spectacle use by children or young people as unacceptable (Adeoti, 2009). Ebeigbe et al (2013) reported that young people with visual problems in Nigeria do not seek eye care as they grow up with certain stereotypes, such as the fear of wearing spectacles.This study therefore also investigated the use of spectacles among primary school children in Onitsha North and South.

1.2.1 Refractive error

Refractive error (RE) is caused by light from distant objects not being focused on the retina but focusing either in front or behind it (Barnes, 2013). An emmetropic eye focuses light from a distant object on the retina resulting in a clear image. Most of the refractive power of the cornea, and therefore the eye, is determined by the radius of curvature of its front surface (Ayanniyi et al., 2010). Compared with a flat cornea, a steep cornea has greater refractive power, which may cause light to be brought to a focus in front of the retina (myopia). The power of the crystalline lens is determined by its anterior and posterior lens curvatures, as well as the refractive indices of its component layers (Johnstone, 2008). Accommodation can be used to effect temporary changes in the refractive power of the crystalline lens by changing its curvatures (Johnstone, 2008).

1.2.2 Classification of refractive errors

The types of refractive errors include myopia, hyperopia and astigmatism. They are frequently categorized as spherical errors and cylindrical errors:

Myopia**:** In myopia (nearsightedness), the point of focus is in front of the retina because the cornea is too steeply curved, or the axial length of the eye is too long, or both, which results in distant objects being blurred, but near objects can be seen clearly (Barnes, 2013). When the axial length is excessive (axial myopia), light from a distant object will be focused in front of the retina, even though the refractive power of the eye may be 'normal'. Optically, this is equivalent to the cornea being too steep and/or the power of the crystalline lens being too great (refractive myopia). Myopia in children frequently increases until the child stops growing (Dhaliwal, 2017)**.** Exposure to near work, such as reading, has been the most consistent environmental factor linked to the development of myopia (Ayanniyi et al., 2010). Myopia can easily be corrected with a concave lens, which causes the divergence of light rays to focus onto the retina (Dhaliwal, 2017)**,** with contact lenses and refractive surgery being other methods that can be used to correct it.

Hyperopia: In hyperopia (farsightedness), the point of focus is behind the retina because the cornea is too flatly curved or the axial length is too short, or both, which results in both near and distant objects being blurred in adults (Barnes, 2013). When the axial length is too short, light from a distant object is brought to a focus behind the retina. This is axial hyperopia and is equivalent to the cornea being too flat and/or the power of the crystalline lens being too weak (refractive hyperopia) (Dhaliwal, 2017). Children and young adults with mild hyperopia may be able to see clearly because of their ability to accommodate. Contact lens, refractive surgery or a convex (plus) lenses can be used to correct hyperopia (Dhaliwal, 2017).

While axial and refractive ametropias have the same basic effect, i.e. the light fails to fall on the retina; the two categories are not the same and should not be treated interchangeably (Grosvenor, 1998). The outcome of the ametropia depends on the type (myopia or hyperopia), the category (axial or refractive) and the form of correction (spectacles, contact lenses, intraocular lenses (IOLs) or refractive surgery) (Dhaliwali, 2017).

Astigmatism: is a non-spherical refractive error that occurs when the incident light rays do not converge at a single focal point which results in the objects appearing broadened or elongated (Dhaliwal, 2017). Astigmatism literally translates to ‘not point forming’, meaning that a point of light imaged through an astigmatic optical system will not give a point image (Grosvenor et al., 1998). The image will be distorted due to the blur in at least one meridian, with astigmatism occurring when the two principal meridians of the eye have different refractive powers (Grosvenor et al., 1998). The visual result of astigmatism is that lines of certain orientations will appear clearer than lines of other disparate orientations (Barnes, 2013). In normal (regular) astigmatism, the clearest and most blurred orientations are at 90° to each other, e.g. vertical and horizontal, or 45° from the horizontal on the right and 45° from the horizontal on the left (Dhaliwal, 2017). The result of astigmatism is constant blur at both distance and near, which accommodation is unable to correct (Barnes, 2013).

Regular ocular astigmatism has two principal meridians that are perpendicular to each other (Johnstone, 2008). Each principal meridian forms a principal focal plane, the image plane of a distant object. The principal meridian with the highest refractive power will form the first principal focal plane and the meridian with the lowest refractive power will form a second focal plane. The powers of the meridians of an astigmatic system vary in a predicable manner from the highest (i.e. the meridian producing the first principal focal plane) to the lowest (the meridian producing the second principal focal plane). The power in any particular meridian can be calculated if its angular displacement from either the most or least powerful meridian is known. From a point source of light, an astigmatic surface will produce perpendicular focal lines in each of the two principal focal planes. Astigmatism can occur with or without myopia or hyperopia, and a full correction can only be achieved with a sphero-cylindrical lens oriented appropriately (Johnstone, 2008)**.**

Ocular astigmatism is classified as with-the-rule (WTR) if the power meridian is vertical (or near vertical), this form being more common (Dhaliwal, 2017). Most corneas have WTR astigmatism at birth which changes with time as the person gets older and or after the process of emmetropization. The axis meridian, which corresponds to the refractive cylinder axis, will be between 0 and 20°, or 160 and 180°, i.e. ±20° of the horizontal, while some use a more liberal definition of ±30° (Grosvenor et al., 1998). A cornea that has WTR astigmatism is steepest in the vertical meridian and flattest in the horizontal meridian (Dhaliwali, 2017). Ocular astigmatism is classified as against-the-rule (ATR) if the power meridian is horizontal (or near horizontal) and this type of astigmatism is less common in children (Barnes, 2013). In against-the-rule (ATR) astigmatism, the axis meridian, which corresponds to the refractive cylinder axis, is between 70 and 110°, i.e. within ±20° of the vertical (axis 90), with a more liberal definition again being ±30° of the vertical (Grosvenor et al., 1998). A cornea that has ATR astigmatism is flattest in the vertical meridian and steepest in the horizontal meridian (Dhaliwal, 2017).Ocular astigmatism is classified as oblique if the power meridian is neither horizontal nor vertical. The axis meridian, which corresponds to the refractive cylinder axis, will have an axis between 21 and 69°, or 111 and 159° (Dhaliwal, 2017).

1.2.3 Managing refractive errors

How refractive errors are treated or managed depends upon the amount and severity of the condition (Ayanniyi et al., 2010). Those who have a mild amount of refractive errors may decide to leave the condition uncorrected, particularly if the patient is asymptomatic. For those who are symptomatic, spectacles, contact lenses, refractive surgery or a combination of the three are used (Ayanniyi et al., 2010). However, spectacles still remain the most common form of refractive error correction.

Typically, myopia begins during childhood and progresses at a rate of 0.35 to 0.55 D per year until the mid to late teens, and may resume in the adult years (Barnes, 2013). Generally, the earlier the onset of myopia, the faster the rate of progression and the greater the final degree of myopia reached. If a small amount of myopia is present at birth, it usually decreases over the first few years of life (emmetropization) and often reappears during the middle childhood years. The cause of myopic progression in children tends to be an increase in the length of the eyeball (i.e. axial myopia). Myopic shifts that occur around or after the age of 60 (usually relatively small in magnitude) tend to be the result of crystalline lens changes, including cataractous formations. Changes in the refractive index of the crystalline lens increase its refractive power, making the eye relatively more myopic. Some believe that correcting myopia may exacerbate the condition i.e. making the patient even more near sighted (Barnes, 2013). This could be due to the very same prescription that is tailored for use at a 12-to-20 foot distance as well as for close up work, thus artificially amplifying the focusing stress that would normally be presented to the accommodation mechanism of the eye at that distance (Barnes, 2013). However, this exacerbating effect is not generally believed to exist, although in cases where the myopia is due to accommodative spasm, removing the corrective lenses for a time may lead to improvement (Barnes, 2013).

Hyperopia shows little progression before and after the process of emmetropization unlike myopia. Adult patients presenting with symptoms of hyperopia like blurring of vision at far and near do so not because their hyperopia has progressed, but rather because it has become manifest due to a natural decrease in their amplitude of accommodation (Johnstone, 2008). At this point, patients may require a distance correction that is also useful for near work. The use of a correction will once again make the accommodation previously used to ‘correct’ the hyperopia available for near tasks. Young children with moderate to high hyperopia may develop refractive amblyopia, esotropia, or strabismic amblyopia if left uncorrected. As children have large amplitude of accommodation and often undergo emmetropization, it is common to give only a partial correction to children under six years of age and when finding the prescription without a cycloplegic, the maximum plus prescription must be determined (Johnstone, 2008).

For children over six years of age, the amount of distance blur induced by the prescription must be considered, with the full plus prescription determined without cycloplegia often being prescribed. For adults between the ages of 20 and 40 years, who have not previously been corrected, a prescription is given if the patient reports asthenopia. A full non-cycloplegic distance prescription is given for use at all distances. For adults over the age of 40, the full non-cycloplegic distance prescription should be given, in addition to any near addition usually in the form of bifocals or progressive addition lenses (Grosvenor et al, 1998).

1.2.4 Consequences of refractive errors

According to the WHO, uncorrected refractive errors (UREs) are the second leading cause of visual impairment (VI) among all ages, genders and ethnic groups (WHO, 2008). Such VIs that originate from RE are correctable by refraction ("correctable visual impairment", CVI) or RE associated with ocular or neurological disease, and are thus not-correctable by refraction ("non-correctable visual impairment", NCVI). CVI (uncorrected RE) implies that visual impairment is present when there is no or inadequate refractive correction. Visual impairments have considerable direct and indirect economic costs and are considered major public health challenges (Rein, 2013). Refractive errors in children can lead to educational, psychosocial, quality of life effects as well as negative effects such as teasing, bullying and poor self-esteem (Terry et al., 1997; Dias et al., 2002; Odedra et al., 2008;).

1.2.5 Utilization of spectacles

Recent data suggests that many people are blind due to refractive error as they are not using appropriate refractive correction (Semanyenzi et al., 2015). Blindness due to refractive error in any population implies that eye care services in general are inadequate, and that sufficient personnel and adequate infrastructure are not available and affordable to the people who need those (Dandona et al., 2006). The correction of refractive errors with appropriate spectacles is among the most cost-effective interventions in eye health care (Dandona & Dandona, 2001). Studies have shown that only one third or less of children with visual impairment due to refractive error worldwide wear corrective spectacles (Wedner et al., 2008). Despite the low rates of compliance with spectacles, few studies have been undertaken to investigate the factors that influence spectacle wear in children (Saw et al., 2002). Available studies in this subject have mainly focused on amblyopic children and adults after cataract surgery (Simons, 1999), these groups not being representative of the population at large. Although teasing by peers and patient's self-esteem have been hypothesized to be important potential factors in determining spectacle wear, their impact on compliance has not been established (Castanon Holguin et al., 2006).

1.2.6 Eye care services in Nigeria

The availability of eye care services varies from country to country, and the number of eye care providers per million population in the richest countries may be nine times more than in the poorest ones (Ntosanae & Oduntan, 2010). Poor practitioner-to-patient ratios, few or limited eye-care personnel, inadequate facilities, poor state funding and lack of educational programs have been reported as the hallmarks of eye care in Africa, with preventable and treatable conditions being the leading cause of blindness (Naidoo et al., 2006).

In Nigeria, there is limited number of government eye care services, with most being privately owned (Ntosanae & Oduntan, 2010). In addition, there are few eye care practitioners working in government owned facilities and in rural areas, leaving many rural dwellers suffering blindness from avoidable and treatable eye conditions (Ntosanae & Oduntan, 2010). Furthermore, most government eye care facilities in Nigeria are not equipped with the necessary instruments, while those in big cities facilities remain underutilized (Naidoo et al., 2006). This has resulted in many rural communities relying on alternative sources of care, such as traditional healers and patent medicine sellers, who serve as frontline health workers (Fafowara, 1996). Another major barrier to accessing eye care services for rural dwellers in Nigeria is the poor conditions of the roads (Silva et al., 2002). Ashaye et al (2006) also found that beliefs and attitudes of rural populations can be major barriers to the uptake of eye care services in Nigeria. A study in Calabar revealed that 25% of those needing eye care services would rather wait at home and pray for healing or go to prayer houses to seek healing for their eye problems (Ekpeyoung & Ikpeme, 2001). The study also revealed that the majority of people in cities or urban areas preferred going to road side or market eye wear sellers instead of eye clinics or hospitals due to the cost of services, illiteracy and ignorance (Ekpeyong & Ikpeme, 2001).

In developed countries, screening for refractive errors in preschool and school-going children is done routinely and is compulsory (Tabansi et al., 2009; Misra & Baxi, 2012). Unlike the situation in some developing countries, pre-admission vision screening before starting school is not a requirement in Nigeria and no national preschool or school eye screening programs exists. Furthermore, the majority of primary school children in many parts of the country have never received a comprehensive eye examination. The lack of vision screening services results in a significant number of primary school children without appropriate refractive correction and/or referrals to other eye care services. The implication of this is that children with poor vision, who could have been identified and subsequently assisted if vision screenings were conducted, perform poorly in their school work, which further negatively impact on the quality of life.

1.3 Motivation for the study

To date, no studies have been done to establish the visual status and spectacle utilization among primary school children in Onitsha, Anambra State, Nigeria. Studies have been conducted in various parts of Nigeria: Western (Faderin & Ajaiyeoba, 2001), Northern (Balarabe et al., 2015), South Eastern (Ahuama & Atowa, 2005) and South-South (Opubiri et al., 2013) and have yielded different results. Many of these studies (Faderin & Ajaiyeoba, 2001; Ahuama & Atowa, 2004; Opubiri et al., 2013; Balarabe et al., 2015) have documented region-specific prevalence and causes of visual impairment, with most being conducted on older children and adults. There is a need for local studies to ascertain visual status (specific prevalence, causes of refractive errors, visual impairment) and use of spectacles peculiar to children in each community, as this varies from one locality to another for a variety of reasons. These factors include tribal, ethnic, geographic and socio-economic, which may have an impact on refractive error, visual impairment and utilization of spectacles. Children with refractive errors in communities, such as Onitsha, Anambra State, are less likely to go for eye examinations until they are significantly visually impaired and have difficulty performing specific visual tasks. There is therefore a need for a study to determine the visual status and spectacle utilization among primary school children in this region. This information will be useful for planning, implementing and monitoring refraction and other eye care services in this group. In addition, the information can be used as baseline data for evaluating existing refractive error and visual impairment programs in this region.

1.4 Aim of the study

To establish the visual status of a sample of primary school children in Onitsha Anambra State, Nigeria.

1.4.1 Objectives

a. To determine the prevalence and distribution of reduced vision in children (refractive error and visual impairment).
b. To determine the rate of spectacle use and reasons for spectacle wear non-compliance among the primary school children.

1.5 Research questions

- What is the visual status of primary school children in Onitsha?
- What is the prevalence and distribution of reduced vision in the children (refractive error and visual impairment)?
- What is the rate of spectacle utilization among the children?
- What are the reasons for non-compliance with spectacle wear?

1.6 Study design

This was a cross-sectional descriptive study in which the primary school children were examined at their respective schools to assess their vision in order to determine those with reduced vision, distribution, types of reduced vision, as well as the number of the children that use spectacles and reasons for non-compliance with spectacle wear.

1.7 Thesis outline

This study is presented in the following chapters:

Chapter 2. Literature review: This chapter provides a review of current trends regarding the prevalence and distribution of reduced vision and use of spectacles as well as reasons for non-compliance to spectacle wear.

Chapter 3. Methodology: this chapter presents the study area and population, and details the sample population and sampling methods. Its reviews the research tools, the pilot study, the data collection process and analysis, as well as the ethical issues.

Chapter 4. Results: This chapter presents the study findings in tables and graphs, specifically with respect to the two study objectives.

Chapter 5. Discussion: This chapter discusses the study findings and compares them with results of studies conducted elsewhere.

Chapter 6. Conclusion: This chapter addresses the extent to which the research problem was addressed and the aim achieved by reviewing the findings of each objective. It presents the limitations and the significance of the findings, and outlines a number of recommendations before concluding the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter provides a review of the literature to understand and appraise the findings of studies conducted in other countries. It reviews globally, the prevalence and distribution of reduced vision (refractive error and visual impairment), use of spectacles and reasons for non-compliance with spectacle wear among children. The literature review will also assist in making recommendations about future strategies and planning regarding refractive error (RE), visual impairment (VI) and spectacles utilization among primary schoolchildren in Onitsha, Anambra State, Nigeria.

2.2 Prevalence and distribution of reduced vision

Several studies have shown that a considerable percentage of visual impairment is related to uncorrected refractive errors (Dandona et al., 2001; Fatouhi et al., 2006; Naidoo et al., 2016), which are regarded as serious problems, even in developed countries. In Australia for example, 56% of visual impairment and 25% of blindness were attributed to uncorrected refractive errors (Hashemi et al., 2017). Refractive error is a complex and multifactorial condition, and surveys on populations with different ethnic and cultural backgrounds have shown that various factors such as genetics, environmental, demographics, ocular, socio-economic status, extrinsic and intrinsic factors contribute to the development of the condition (Naidoo et al., 2012). It is therefore not easy to compare prevalence of refractive errors across studies from different nations.

Several studies (Zhao et al., 2000; Goh et al., 2005; Aldebasi et al., 2014; Paudel et al., 2014) have shown the prevalence of refractive error to be high in Asian and Middle Eastern countries compared to African countries (Table 2.1). Moreover, the prevalence of refractive error could also be influenced by the methodology, age range, sample sizes, definitions of refractive error, geographical locations, and targeted populations used by researchers. For example, studies in Chile (Maul et al, 2000), China (Zhao et al., 2000), India (Dandona et al., 2002), South Africa (Naidoo et al., 2003) and Ghana (Kumah et al., 2013) used the refractive error study in children protocol (RESC) developed by WHO. The protocol involved the use of cycloplegia in children between the ages of 5-15 years. Prevalence of refractive error and visual impairment were determined based on uncorrected, presenting and best corrected visual acuity. Refractive error was defined as uncorrected visual acuity of 20/40 or worse, while visual impairment was defined as best corrected visual acuity of 20/40 or worse, with spherical equivalent being used to represent astigmatism (Table 2.1). Global data on reduced vision (RE and VI) in children are shown in Table 2.1.

The 2011 Nigerian National Blindness and VI Survey indicated that uncorrected RE accounts for 57.1% of moderate VI (visual acuity [VA], >6/18–6/60) (Ezelum et al., 2011). The prevalence of refractive error and visual impairment vary across different regions in Nigeria, although there is a paucity of literature on the studies conducted in the northern region. Most refractive error studies in Nigeria were done in the southern and western parts of the country. Several studies showed that refractive error is one of the common presentations among children in eye clinics (Isawumi et al., 2016). For example, URE constituted 14.3% of all pediatric cases presentation in a study carried out in South-western Nigeria (Onakpoya & Adeoye, 2009) where it was second to allergic conjunctivitis.

The global age-standardized prevalence of blindness for older adults decreased from 3% (95% CI, 2.7%-3.4%) in 1990 to 1.9% (95% CI, 1.7%-2.2%) in 2010, and the moderate to severe visual impairment (MSVI) from 14.3% in 2010 (95% CI, 12.1%-16.2%) to 10.4% (95% CI, 9.5%-12.3%) in 2012 (WHO, 2012). The MSVI prevalence was less than 5% in all four high-income regions of the world (Parikshit et al., 2007). The study by Resnikoff et al (2004) showed the prevalence of moderate visual impairment (MVI) in older adults to be highest in South Asia (29.4%), followed by Oceania (23.6%), Eastern and Western sub-Saharan Africa (18.9%), North Africa and the Middle East (15.9%). In Sao Paulo, uncorrected refractive error was found to cause visual impairment and blindness, which were reversible, in 4.8% and 1.6% Brazillians respectively (Ferraz et al., 2014). Globally, the prevalence of visual impairment is higher in women than men (WHO, 2009), while more than 80% of all visual impairment can be prevented or cured (WHO, 2012).

Table 2.1: Global data on reduced vision (RE and VI) among primary school children

Study	Year	Country	Prevalence of RE (%)	Prevalence of VI (%)	Age range (years)	Sample size (N)
Aldebasi	2014	Saudi Arabia	18.6	N/R	6-10	5176
Assefa et al	2012	Ethiopia	9.4	N/R	4-24	1852
Goh et al	2005	Malaysia	17.1	1.4	7-15	4634
Jafer & Abomesh	2009	Ethiopia	3.5	1.8	7-15	570
Kalikavayi et al	1997	India	3.1	N/R	3-18	4029
Kawuma & Mayepu	2002	Uganda	11.6	N/R	6-9	623
Kumah et al	2013	Ghana	3.7	0.4	12 -15	2435
Majoob et al	2016	India	24.6	0	7-12	400
Maul et al	2000	Chile	15.8	7.4	5-15	6998
Misiska et al	2009	Malawi	2.4	N/R	12-15	1278
Mohammed et al	2014	Egypt	66.9	N/R	6-10	142
Muma et al	2009	Kenya	5.2	N/R	12-15	1439
Naidoo et al	2003	South Africa	1.4	0.32	5-15	4890
Ovenseri &Assien	2010	Ghana	13.3	4.5	5-19	1103
Ovenseri & Omuemu	2010	Ghana	5.6	N/R	11-18	961
Paudel et al	2014	Vietnam	12.9	N/R	12-15	2238
Semenyazi et al	2015	Rwanda	26.7	N/R	11 -37	634
Wajuihian & Hansraj	2017	South Africa	15	N/R	13-18	1586
Wedner et al	2008	Tanzania	1	N/R	7 -19	1386
Zhao et al	2000	China	12.8	1.8	5-15	6134

N/R = Not reported

2.2.1 Studies on reduced vision among primary school children in Nigeria

The proportion of primary school children with refractive error was 7.3% in the northern Nigeria (Abah, 2011); while in Southern Nigeria it was 29% of the total number of patients seen in a survey of pediatric diagnosis (Adio & Alikor, 2011). The prevalence of refractive error among primary school children in Nigeria was reported to range between 2.2% to 9.5% (Faderin & Ajaiyeoba, 2001), which was shown by the results from studies by Yoloye, (1991), Nkanga (1995) and Balogun (1999) (Table 2.2). However, recent studies showed the prevalence of refractive error among primary school children in Nigeria to be highest in the South-East region.

Table 2.2: Studies on reduced vision among primary school children in Nigeria

Study	Year	Region	Prevalence of RE (%)	Prevalence of VI (%)
Abah	2011	South-West	7.3	N/R
Adioan & Alikor	2011	South-West	29	N/R
Ajeiyeoba et al	2007	South-West	N/R	1.96
Ahuama & Atowa	2004	South-East	58	N/R
Balogun	1999	South-West	8.7	N/R
Megbalayin & Asana	2013	South-South	6.9	5.2
Nkanga	1995	South-East	7.4	N/R
Onakpoye & Adoye	2009	North-West	14.3	N/R
Opubiri & Egbe	2013	South-South	2.2	N/R
Yoloye	1991	South-West	8.9	N/R

N/R = Not reported

2.3 Distribution of reduced vision in children

Various patterns and types of refractive errors have been documented across the world. Recent studies have shown a higher prevalence of myopia in Asian children, especially in Taiwan (Lin et al., 1999) and Singapore (Saw et al, 2006) than in findings in the United states (Zadnick, 1997) and Australia (Jungham et al., 2003) (Table 2.3). Several studies have revealed a greater emphasis on early education exposure, and hence near vision activities common among Asian children, to be contributory factors to high myopic prevalence among them (Ip et al., 2008; Zhang et al., 2010; He et al., 2004; Shin et al., 2010). Rudnicka et al (2016) revealed that Asian children from as young as two years actively participate in additional education classes before the formal schooling education begin. In contrast to Africa, where the literacy rates are low and formal education does not start for most children until the ages of 6–8 years, and this could be responsible for the higher prevalence of myopia in Asian children (Table 2.3).

There is mounting evidence to suggest that the prevalence of myopia is substantially higher in urban children compared to their rural counterparts (Saw et al., 2006; Lin et al., 1999). These differences have been attributed primarily to environmental difference, excessive amounts of near work, educational attainment, socioeconomic status, and more recently, the level of indoor activities (O'Donoghue, 2010). For example, studies among urban children in Ba Ria–Vung Province Vietnam (Paudel et al, 2014), Quassim Province of Saudi Arabia (Aldebasi, 2014), Ethiopia (Kassa & Daegu, 2000; Nebiyat et al., 2015), Egypt (Mohammed et al., 2014), Rwanda (Semanyezi et al., 2015) and Sudan (Atif et al., 2016) recorded high prevalence of myopia (Table 2.3).

The prevalence of astigmatism varies among different races, ethnic groups and sample populations, and ranges from 3.8% to as high as approximately 50% in children aged between two and 19 years (He et al., 2004). This large variation may be due to differences in definitions of astigmatism, sample size, testing methodology, ethnicity, response rates, and the ages of the cohorts assessed. The use of spherical equivalent in most studies makes it difficult to get the accurate distribution of astigmatism among primary school children (Dirani et al., 2010). Studies in Ghana (Ovenseri & Omuemu, 2010) and Uganda (Kawuma & Mayeku, 2009) recorded astigmatism as the most prevalent refractive error (Table 2.3).

Some studies showed that there is no significant difference in the prevalence of hyperopia among Caucasian, Hispanic, Middle East, African American, Asian and African children (Castagno et al, 2014). There is also evidence that Caucasian children are more hyperopic than African-American, Black and Asian (East and South Asia) children (Zadnick et al., 2003; Ip et al., 2008; Logan et al., 2011). Studies have shown hyperopia to be more prevalent among children in the rural than urban areas due to more time spent in outdoor activities, as farming, domestic chores. Studies in the rural areas in India (Kalikavayi, 1997), Malawi (Msiska et al., 2009), and Kenya (Muma et al., 2009) and reported hyperopia as the most prevalent refractive error among children (Table 2.3).

Table 2.3: Studies on the distribution of refractive error among primary school children

Study	Year	Country	Prevalence of myopia (%)	Prevalence of hyperopia (%)	Prevalence of astigmatism (%)	Protocol used
Aldebasi	2014	Saudi Arabia	5.8	0.7	4.4	Cycloplegic
Assefa et al	2012	Ethiopia	3	2.5	2.1	Cycloplegic
Atif et al	2016	Sudan	53	9.3	22.9	Cycloplegic
Goh et al	2005	Malaysia	32	5	15.7	Cycloplegic
Jafer & Abomesh	2009	Ethiopia	2.6	0.9	N/A	Cycloplegic
Jungham et al	2003	Australia	10.9	N/R	N/R	Cycloplegic
Kalikavali et al	1997	India	8.6	22.6	10.3	Cycloplegic
Kassa & Daegu	2000	Ethiopia	90.3	2.2	N/r	Non cycloplegic
Kawuma & Mayeku	2002	Uganda	13	35	52	Cycloplegic
Kumah et al	2013	Ghana	3.2	N/R	N/R	Cycloplegic
Lin et al	1999	Taiwan	56	N/R	N/R	Cycloplegic
Majoob et al	2016	India	6.3	5.8	12.4	Cycloplegic
Maul et al	2000	Chile	34.1	N/R	N/R	Cycloplegic
Misiska et al	2009	Malawi	0.8	1.4	0.1	Cycloplegic
Mohammed et al	2014	Egypt	62.7	3.5	0.7	Cycloplegic
Muma et al	2009	Kenya	3.2	1.7	0.3	Cycloplegic
Naidoo et al	2003	South Africa	2.9	1.8	N/R	Cycloplegic
Nebiyat et al	2015	Ethiopia	26.7	8.4	17	Cycloplegic
Ovenseri & Assien	2010	Ghana	1.7	5.0	6.6	Non cycloplegic
Ovenseri & Omuemu	2010	Ghana	6.9	4.6	14	Non cycloplegic
Paudel et al	2014	Vietnam	20.4	1.4	N/R	Cycloplegic
Saw et al	2006	Singapore	62	N/R	N/R	Cycloplegic
Semenyazi et al	2015	Rwanda	10.2	4.3	4.4	Cycloplegic
Wedner et al	2000	Tanzania	8.6	22.6	10.3	Cycloplegic
Zadnick	1997	USA	20	N/R	N/R	Cycloplegic
Zhao et al	2000	China	91.7	8.3	N/R	Cycloplegic

N/R = Not reported

2.3.1 Distribution of refractive error among primary school children in Nigeria

According to Aguwa et al (2017), the most common types of refractive error in the six geopolitical regions of Nigeria were myopia (54.2 %), followed by hyperopia (28.2%), astigmatism (15.8%) and presbyopia (1.8%). This is similar to the report by Adeoti and Egbewale, (2008) in a study carried out in Ado Ekiti, Nigeria (Table 2.4). Most studies in Nigeria also showed myopia to be the most prevalent refractive error among primary school children (Table 2.4). In Bonny Camp, Lagos, Nigeria, Faderin and Aijeyeoba, (2001) also recorded hyperopia as the most prevalent refractive error found (Table 2.4).

Table 2.4: Distribution of refractive error among primary school children in Nigeria

Study	Year	Prevalence of myopia (%)	Prevalence of hyperopia (%)	Prevalence of astigmatism (%)
Adeoti & Egbewale	2008	39.3	N/R	N/R
Ahuama & Atowa	2004	31.1	19.1	7.8
Balarabe et al	2015	60	23.3	16.7
Faderin & Ajeiyeoba	2001	9	52.2	38.8
Opubiri et al	2013	13.8	2.6	6.1

N/R = Not reported

2.3.2 Age and gender distribution of reduced vision (refractive error and visual impairment) in children

Studies on the distribution of different types of refractive error in children are reviewed with respect to age and gender.

2.3.2.1 Age distribution of reduced vision in children

Epidemiological data have shown that the prevalence of refractive error is associated with age (Atowa et al., 2017). Studies in Western populations have collectively revealed that the prevalence of myopia increases with age and was lowest (<5%) in children less than eight years old, while that of hyperopia reduces with age, and was highest among children less than eight years old (Mayer et al., 2001). In various countries, it was revealed that depending on the schooling and learning system, early significant hyperopia decreases rapidly from age five to insignificant levels by the age of 15, with a noticeable myopic shift taking place around the age of 12, when secondary school begins. The age increase in myopia prevalence corresponding with school year may be attributed to more hours of near work and indoor activities (Atowa et al., 2017).

In a study to determine the prevalence of visual impairment due to uncorrected refractive error in Hyderabad, India, Kalikavayi et al (1997) found myopia to be significantly increased and hyperopia to be reduced with age. The authors found myopia to be highest among children older than 10 years, and hyperopia to be lowest among children less than10 years old. Similar findings were found in Chile (Maul et al., 2000), Vietnam (Paudel et al., 2014), South Africa (Naidoo et al, 2003), Malaysia (Goh et al., 2005), Kenya (Muma et al., 2009), Saudi Arabia (Aldebasi, 2014), Ethiopia (Assefa et al., 2012), and Ghana (Kumah et al., 2013). In a study in China among children 5-15 years, Zhao et al (2000) reported myopia to be absent in five

year old children and was highest among children 15 years of age, while hyperopia was found to be significantly increased in children less than eight years old.
The prevalence of hyperopia has been reported to range from less than 1% to as high as 26% in children aged five to 15 years (Zhao et al., 2002; Naidoo et al., 2003; He et al., 2004; Goh et al., 2005). Studies in Lagos State (Faderin & Aijeyeoba, 2001), Abia State (Ahuama & Atowa, 2004), Bayelsa (Opubiri et al., 2013), and Kebbi State (Balarabe et al., 2015) in Nigeria found refractive error to be associated with age. They all found hyperopia to be highest in children less than eight years old and myopia highest in children more than eight years old.

In China, it has been shown that there is a moderately high occurrence of astigmatism among children aged 3–6 years (Xiao et al., 2014). Astigmatism was found to be significantly associated with age in studies in South Africa (Naidoo et al., 2003) and Nigeria (Opubiri et al., 2013). A study in Lagos (Faderin & Aijeyeoba, 2001) recorded a high prevalence of astigmatism among children six to 15 years (see Table 2.4).

2.3.2.2 Gender distribution of reduced vision

Several studies have reported refractive errors to be more prevalent among females than males. Studies in China (Zhao et al., 2000), Malaysia (Goh et al., 2005) and Saudi Arabia (Aldebasi, 2011) found refractive error to be more significantly associated with females than males (see Table 5). Most studies in Africa: South Africa (Naidoo et al, 2003), Malawi (Msiska et al., 2009) and Nigeria (Faderin & Aijeyeoba, 2001; Opubiri et al., 2013; Balareba et al., 2015) also recorded higher prevalences of refractive error among females than males. Contrary to the high prevalence of refractive error in females, Maul et al (2000), Majoob et al (2016) and Adegbehinde et al (2005) reported higher prevalence of refractive error in males than females in Chile, India and Nigeria (Table 2.5). However, studies in Sudan (Atif et al, 2016), Kenya (Muma et al, 2009), Ethiopia (Jafer & Abomesh, 2009), Ghana (Kumah et al, 2013; Ovenseri & Assien, 2010) and Vietnam (Paudel et al, 2014) recorded no significant association between refractive error and gender.

Maul et al (2000), Misiska et al (2009) and Aldebasi (2014) reported a high prevalence of hyperopia among females than males in Chile, Malawi and Saudi Arabia respectively (see Table 5). In contrast, studies in Malaysia (Goh et al., 2005), Ethiopia (Assefa et al., 2012), and Nigeria (Opubiri et al., 2013) reported myopia to be more significantly associated with females than males (Table 2.5). However, Msiska et al (2009) reported myopia to be significantly associated with males in their study to determine the prevalence of refractive error among children 12-15 years in Malawi. In another study to determine the prevalence of refractive error in China, Zhao et al (2000) found females to be at higher risk of having both myopia and hyperopia, while studies in Vietnam (Paudel et al., 2014), Ethiopia (Jafer & Abomesh, 2005) and Ghana (Kumah et al., 2013) found no significant association between myopia with gender. Aldebasi (2014) recorded males to be at higher risk of developing astigmatism than females in his study in Saudi Arabia. The distribution of refractive error with gender in children is shown in Table 2.5 below.

Table 2.5: Gender distributions of refractive error in children

Study	**Year**	**Country**	**Myopia (%)**		**Hyperopia (%)**		**Astigmatism (%)**	
			Males	**Females**	**Males**	**Females**	**Males**	**Females**
Majoob et al	2016	India	6.4	6.3	7.4	2.9	12	12.7
Maul et al	2000	Chile	19.4	14.7	22.7	26.3	N/R	N/R
Mohammed et al	2014	Egypt	35.8	64.2	N/R	N/R	N/R	N/R
Msiska et al	2009	Malawi	70	30	42	58	2	0
Muma et al	2009	Kenya	29.8	35.7	63.8	60.7	6.4	3.6
Ovenseri & Assien	2010	Ghana	0.5	1.17	2.35	2.69	2.18	2.37
Zhao et al	2000	China	36.7	55.0	8.8	19.6	N/R	N/R

N/R = Not reported

2.4 Spectacle use in Nigeria

Spectacles are the most commonly used form of refractive correction and as such, are the most appropriate treatment for RE in developing countries such as Nigeria. Proving spectacles is currently a challenge in many developing countries due to issues related to availability and affordability. In Nigeria, cost, ignorance of refractive status and lack of awareness of a possible solution for reduced vision were identified as reasons for the non-acceptance of recommended corrective spectacles (Megbalayin, 2013). This is largely attributable to inadequate, in some cases, non-existent eye care services in some parts of Nigeria.

A recent study by Aguwa et al (2017) in Nigeria showed utilization of spectacles to be highest in the North-west region (Table 2.6).The study revealed that out of the 864 subjects with refractive error who were assessed, 302 (37.%) wore spectacles during the time of examination. Megbalayin (2013), in a study to determine the barriers to spectacle utilization among undergraduates in Akwa–Ibom State, Nigeria, found that only six (9.8%) out of 81 students with refractive error were wearing glasses during the time of examination. The author reported that students with headaches, tearing and with both parents wearing glasses were likely to use spectacles. Similar findings were recorded by Faderin and Aijeyeoba (2001) in Lagos Nigeria. The authors also reported that for those whose parents were not using spectacles, there was greater awareness concerning eye problems and wearing of glasses among the pupils than their parents, which might be responsible for parental disapproval of spectacle use.

The result from available studies in Nigeria showed that factors affecting the wearing of glasses are multi-factorial (Megbalayin, 2013). Nwosu (1997) reported claims of the deleterious effects of eye glasses on the eye, such as sunken sockets and ocular discomfort, with corrective lenses as reasons for not wearing prescribed spectacles in Nigeria. Aijeyeoba et al (2006) and Megbalayin (2013) reported unawareness of the present refractive errors as the major reason for non-use of spectacles, with just above half (56.4%) of the students with REs being unaware of study related problems. All the students who wore glasses in a study in Akwa-Ibom, Nigeria were males (Megbalayin, 2013), this being contrary to the findings by Alex et al (2007),who found that females had greater tendency to wear spectacles than males. Marmamula et al (2009) also reported that spectacle wearing rate was higher in females than males (35% versus 24%). Adefule-Ositelu (1995) noted that females aged 15-18 years old wore spectacles for fashion while males wore them based on the severity of the refractive error, and not because of fashion. Spectacle utilization in different regions of Nigeria is shown in Table 2.6.

Table 2.6: Spectacle utilization in the six geopolitical areas in Nigeria

Regions	**Spectacle utilization (%)**
North-West	61.3
North-East	15.8
North-Central	19.7
South-East	31.7
South-South	31.7
South-West	55.7

2.5 Spectacle utilization in children

Studies (Rocha et al., 1997; Odedra et al., 2008; Li et al., 2008) have revealed that in many settings, only a small proportion of children with significant refractive errors wear corrective spectacle. A few studies (Fylan & Grunfeld, 2005; Castanon Holguin, 2006) have examined spectacle utilization and risk factors for non-compliance in children, with most being conducted outside Africa (Mexico, China, and America). The proportion of children who could benefit from spectacle correction, but do not yet own or wear glasses, has been found to be high in many settings: 60% in rural China (He et al., 2007), 50% in suburban Chile (Maul et al., 2000) and 49% in Native Americans in the western United States (Harvey et al., 2006).

The available studies in Africa and Latin America showed spectacle utilization rate among children to be 13%, even after the provision of free glasses (Li et al., 2010). Studies revealed the problem of limited use of refractive corrections to be particularly prevalent among children in rural areas, for example, approximately 30% to 60% of rural Chinese secondary students have myopia (He et al., 2007; Congdon et al., 2008), nearly two-thirds of whom do not own or wear appropriate glasses (Congdon et al., 2008). Another study revealed that a group of nearly 700 rural Chinese children were identified by screening as needing glasses, two-thirds failed to obtain them, including half those with habitual visual acuity of 6/18 or less, despite an educational intervention promoting glasses use targeted at parents, teachers and the children themselves (Li et al., 2008). The principal reason for failure to purchase glasses in a study in China was lack of perceived need among 60% of the children, with concerns about price being cited by only 16% (Li et al., 2008). Visual impairment was reported to be significantly high among children not wearing glasses in a study in Latin America, as 50% had uncorrected visual acuity worse than 6/15 (Congdon et al., 2008).

A study by Hashemi et al (2017) to determine the prevalence of uncorrected refractive errors, need for spectacles, and the determinants of unmet need in underserved rural areas of Iran revealed that out of 3314 participants, 18.94% [95% confidence intervals (CI):13.48-24.39] needed spectacles and 11.2% (95% CI: 7.57-14.89) had an unmet need. The prevalence of need for spectacles was 46.8%, and 23.8% in myopic and hyperopic participants, respectively. The prevalence of unmet need was 27% in myopic, 15.8% in hyperopic and 25.5% in astigmatic participants. Multiple logistic regressions showed that education and type of refractive errors were associated with uncorrected refractive errors; the odds of uncorrected refractive errors being highest in illiterate participants, with the odds of unmet need being 12.13, 5.1, and 4.92

times higher in myopic, hyperopic and astigmatic participants as compared with emmetropic individuals. It was concluded that a higher prevalence of unmet need is associated with older people and those living in rural areas with less access to health services, high levels illiteracy and limited education.

Fotouhi et al (2006) carried out a study on URE and spectacle utilization rate among 4353 children older than five years in Tehran. Multivariate logistic regression showed that variables of age, education and type of RE were associated with lack of spectacle correction. Unmet need was also found to be higher among older, less educated people and those with myopia.

A study by Castanon Holguin et al **(**2006) on factors associated with compliance to spectacle wear in 493 Mexican children aged five to 18 years who were provided spectacles free of charge in Oaxaca, Mexico, revealed that 66 out of 493 (13.4%) of those wearing their spectacles at the time of examination were myopic. The authors further observed that169 out of 493 (34%) had the spectacles with them but were not wearing them. In regression models, the odds of spectacle wear were significantly higher among younger (OR 1.19 per year of age; 95% CI, 1.05–1.33) rural (OR -10.6; 95% CI, 5.3–21.0) children and those with myopia -1.25 D (OR -3.97; 95% CI, 1.98 –7.94). The oldest children and those in urban–suburban areas were found to be significantly more likely to list concerns about the appearance of the glasses, or about being teased, than were younger, rural children**.** It was concluded that compliance with spectacle wear may be very low, even when spectacles are provided free of charge, particularly among older, urban children, who have been shown in many populations to have the highest prevalence of myopia.

In Tanzania, Wedner et al (2008) reported no significant difference in the uptake of glasses among students who had free glasses and those who paid for it. Many students who had free glasses were not wearing them during the study. In a study in China, costs were also found not to contribute significantly to poor uptake of corrective lenses (Liping et al., 2008). Li et al (2010) reported that parents ranked their most common reason for not buying glasses for their children as being “too busy with work”. This shows that compliance with spectacle wear may be very low, even when the cost of spectacles is not an issue.

In a study involving five European countries, where there were viable health insurance policies and most people could afford to pay for spectacles, Lafuma et al (2010) observed that approximately 50% of the respondents were willing to pay personally, and at higher costs, to have alternatives, such as contact lenses or refractive surgeries, and be free from glasses. These suggest that customs and cultural beliefs might explain apathy to use of corrective lenses other than cost. Semenyezi et al (2015) also reported high cost of spectacle and lack of awareness of the present refractive error as major reasons given by children for not wearing spectacles in their study in Rwanda.

In a Nigerian school survey, Abubakar et al (2001) reported that at the time of screening, none of the children screened wore glasses. Similar findings were reported among 1707 secondary school students in Ile-Ife, Nigeria (Adegbehingbe et al., 2006) (Table 2.7). Megbalayin (2013) recorded poor economic status of parents as the major reason for non-utilization of spectacles in his study in Akwa-Ibom State, Nigeria. Similar findings were recorded by Faderin and Aijeyeoba (2001) in their study in Lagos State, Nigeria. Although some studies (Walline et al., 2008; Zeng et al., 2009) of spectacle use in children have attempted to examine attitudes towards use of spectacles and basic factors (such as symptoms) underlying spectacle use, much remains to be done to establish the barriers to compliance with spectacle use in children.

Table 2.7: Studies on spectacle utilization in children

Study	Year	Country	Spectacle utilization rate (%)
Abubakar et al	2001	Nigeria	0
Adegbehinde et al	2006	Nigeria	0
Ajaiyeoba et al	2006	Nigeria	3
Aldebasi et al	2014	Saudi Arabia	33.2
Fahd et al	2013	Saudi Arabia	9.4
Foutouhi et al	2006	Tehran	9.3
Golgate et al	2013	India	29.5
Hashemi et al	2017	Iran	7.7
He et al	2014	China	15.5
Khandeker et al	2002	Oman	50
Khandeker et al	2008	India	19
Kumah et al	2013	Ghana	3.37
Majoobet al	2016	India	28.3
Mohammed et al	2014	Egypt	42.3
Msiska et al	2009	Malawi	0
Muma et al	2009	Kenya	3.4
Muthu et al	2015	India	7.4
Naidoo et al	2003	South Africa	2.7
Semanyezi et al	2015	Rwanda	26.7

2.6 Conclusion

Reviewed studies showed the prevalence and distribution of refractive error to be very high in Middle East and Asian children when compared with Africa. In Nigeria, the results are inconsistent and lacking in some geo political zones as most studies were concentrated in particular zones. Spectacle utilization rate is also highest among Asian and Middle East children possibly due to high refractive error prevalence in those areas. Few studies conducted in Africa showed spectacle utilization rate to be very low. No study was specifically conducted to check for spectacle utilization among children in Nigeria considering its population and given the variations in findings among other developing countries hence the need for this study.

CHAPTER 3: METHODOLOGY

3. 1 Introduction

This chapter outlines the research design, study site, study population, sample size, sampling procedure, inclusion and exclusion criteria, test and instrument used, data collection procedure, reliability of data, validity of data, data analysis and presentation, and legal and ethical considerations. The methods are described with respect to the two study objectives, as indicated in Table 3.1.

Table 3.1 Objectives and methods

Objectives		Methods (or tools)
1	To determine the prevalence and distribution of reduced vision	a. Demographic details/case history b. logMAR acuity chart c. Pen torch d. Occluder e. Procaine eye drop f. Cyclopentolate eye drop g. Retinoscope h. Auto refractor i. Trial lens set j. Ophthalmoscope.
2	To determine the rate of spectacle use and reasons for spectacle wear non compliance	a. Demographic details b. Spectacle utilization using questionnaires

3.2 Research design

This was a quantitative, cross sectional study design, primarily involving numerical methods of investigation (Creswell, 2003). It is an approach in which the investigator primarily uses post positivist claims for developing knowledge (i.e. causes and effect thinking, reduction to specific variable and hypothesis and questions, use of measurements and observations, and testing theories), employs strategies of enquiry, such as experiments and surveys, and collects data on predetermined instruments that yield numerical data (Cresswell, 2003). Cross sectional studies are those aimed at determining the frequency (level) of a particular attribute, such as a specific exposure, disease or any other health related event, in a defined population at a particular point in time (Mann, 2003), with exposure and outcome being determined for each subject. Cross sectional studies are used to determine prevalence and infer causation (Mann, 2003).

3.4 Study site

Onitsha is an urban area located on the eastern bank of the Niger River, in Anambra State, Eastern Nigeria. It is well known for its river port, and is a hub for commerce, industry and education. Onitsha had an estimated resident population of 511 000 people of different nationalities, according to the 2011 estimated census (UN Habitat, 2009). The indigenous people of Onitsha are Igbo, with the main language spoken being English, as in many parts of Nigeria. Onitsha is divided into Onitsha North and South local government areas. Most of the indigenous Onitsha people reside in Onitsha North (*Ime-Ogbe*) while the non-indigenous inhabitants reside in Onitsha South (UN Habitat, 2009).

3.5 Study population

The study population was primary school children from all the private and public schools in Onitsha North and South, the estimated pupil school population being 13 296 in 2009 (UN Habitat, 2009). There are 79 public and 53 private primary schools in Onitsha (132 in total), with 33 public and 27 private in Onitsha North, and 46 public and 26 private schools in Onitsha South (UN Habitat, 2009), and primary school attendance rate being estimated to be 95%. Primary schools consist of grades 1–6, and usually accommodate children aged 5–15 years though recently most children found in primary schools in Onitsha are younger than 12 years. Public schooling in Onitsha is not free, as it is in other parts of Nigeria, but it is cheaper than private schools, with parents having to cover the costs of books and other learning materials. Children who attend public schools are usually from low-income backgrounds and tend to access health services through government facilities, including eye care services, with few optometrists being employed in government establishments. Pupils attending private schools often come from middle- and high-income families and can afford private medical services, including eye care, with most optometrists being working in the private sector.

3.7. Sample size

The sample size was determined based on the prevalence of refractive error estimate in the study population, as indicated by World Health Organization Refractive Error in School Children protocol (RESC) using the following formula:

$$N = (Z)^2 (1.0 - P) (P) / [(B) (P)]^2$$

Where P is the anticipated prevalence of refractive error, B is the desired error bound, and Z = 1.96% confidence interval. The prevalence estimates from previous studies conducted in Nigeria ranged between 7.3% and 22.5% (Faderin & Ajaiyeoba, 2001; Ibenimo & Egbe, 2013; Opubiri et al., 2013). A 15% prevalence rate, which is the average of the prevalence estimates from previous studies, was used. The minimum sample size required was therefore calculated to be 968, which was increased to 1000 to adjust for anticipated absenteeism and non-participation rate, which should not exceed 10%, to ensure minimal bias in the study results.

Table 3.7 Sample size calculation

Anticipated prevalence	Sample size with B = 10%	Sample size with B = 15%	Sample size with B = 20%
10%	3,457	1537	864
20%	1536	683	384
30	896	398	224
40	576	256	144
50	384	171	96

3.8 Sampling procedure

A multi-stage sampling technique was used to select pupils in the study population. Stage 1 sampling involved the selection of 2 clusters based on the two Educational Zones in Onitsha (Onitsha North and South). The second stage sampling involved stratification of schools into public and private (total of 132 schools), and in stage 3, seven schools were selected (6 public and 1 private) from Onitsha South and nine schools (7 public and 2 private) from Onitsha North based on the ratio of schools in the clusters and the population of pupils in the schools. Onitsha North basically has a larger number of pupils than Onitsha South. The schools were randomly selected from a sampling frame of schools in each zone (public separated from private). All pupils in the selected schools were included in the study population.Cross sectional samples of the school children aged 5 to 15 were obtained through random cluster sampling. Clusters were defined on the basis of different grades (1-6) in the 132 schools in Onitsha since there are 6 grades (1-6) in primary schools in Onitsha and this consisted of six clusters in each school; therefore given a total of 792 clusters (6 x 132). All children in the 17 selected schools (6 x 17) that is within the 102 clusters were included in the study population. Ten children were selected from each of the six grades in the 17 selected primary schools, which results in 60 children being selected randomly from each school. The total number of students enumerated was therefore 60 x 17 = 1020, although the total number examined was 998.Convenient sampling was used to select subjects who were both easily accessible and willing to participate in the study from all the 17 schools (102 clusters) selected in Onitsha.

3.6 Inclusion and exclusion criteria

The following inclusion criteria applied:

- Children of both genders aged 5-15 years old,
- Children for whose parent/legal guardian was present to provide informed consent,
- Children who provided verbal assent and/or signed assent,
- Children who were Nigeria citizens, as indicated by the class register and class mistress.

The following exclusion criteria applied:

- Children less than 5 years old and older than 15 years,
- Children who were not Nigerian citizens,
- Children whose parent/legal guardian could not provide informed consent.

3.9 Data collection instruments

A number of instruments were used to meet the two study objectives.

To address objective 1, this being to determine the prevalence and distribution of reduced vision, the following instruments were used, as outlined in the Refractive Error Study in Children (RESC) eye examination form:

a. The logMAR acuity chart: to assess vision or visual acuity to determine those with reduced vision.
b. A pen torch: to perform external and anterior segment examination to detect ocular abnormalities.
c. An occluder: to assess binocular motor function.
d. Procaine local anaesthetic eye drops applied before instilling cyclopentolate drops.
e. Cyclopentolate for cycloplegic

f. Retinoscope: to objectively determine their refractive status through the process of retinoscopy.
g. Auto refractor: to objectively determine their refractive status
h. Trial lens sets: to perform subjective refraction after autorefraction to determine best corrected visual acuity.
i. Ophthalmoscope: to evaluate the lens, vitreous and fundus of the children for posterior segment ocular abnormalities.

To address objective 2, this being to determine the rate of spectacle use and reasons for non-compliance with spectacle wear the following instruments were used:

a. Demographic details: to obtain their names, ages, gender and use of spectacles
b. Spectacle use questionnaire: to assess use of spectacles and reasons for non-compliance with spectacle wear.

3.10 Data collection procedure

Once the required permission had been obtained to conduct the study from the University of KwaZulu-Natal Biomedical Research and Ethics Committee (BREC), and Onitsha Zone Education boards, the heads of the identified schools were contacted to invite them to participate in the study and obtain their permission to engage with the children in their schools. Each school provided a room in which the equipment could be set up for testing, and the teachers were informed that the children would be called out of class to have their eyes tested in the assigned rooms.

The examination procedures followed the modified version of Refractive Error Study in Children (RESC) protocol (Appendix 1). Only children with signed consent forms by their parents/guardians were examined, while those with signed consent forms who refused cycloplegic dilations were allowed to go and return later only if they consented to be examined. The children were examined in their classes or in designated rooms during lunch time and over the weekends to avoid disrupting or interfering with their normal school activities. The children were called for the tests, starting from grade 1 and according to their class register, with the help of their classroom teachers. The procedures and how to respond to the various tests were explained to the children. The researcher assisted the younger children with filling the demographic details and the questionnaires.

3.10.1 Clinical examinations and measurements

The following clinical tests were performed to meet objective 1:

a. **Demographic details:** This was taken to obtain information about the child's name, age, gender and grade using RESC form. The information was verified prior to examination with the help of the classroom teachers.

b. **LogMAR acuity chart:** Distance visual acuity was measured with a retro-illuminated logMAR chart with five optotypes on each line (Precision Vision, Villa Park, Illinois). Visual acuity measurements began at a distance of 4 meters with the top line (20/200), with the children being asked to read the letters one by one on the line. When four or more optotypes were read correctly, the child was then tested by dropping down to line 4 (20/100). When one or no optotypes were missed, the testing resumed at line 7 (20/50), continuing to line 10 (20/25) and finally line 11 (20/20). When at any level the child failed to recognize at least four optotypes, the line immediately above the failed line was tested, until successful. When the top line at 4 meters was missed, the child advanced to 1 meter, with progression down the chart, as described above. The lowest line read successfully was assigned as the visual acuity for the eye undergoing the testing. The right eye was tested first, then the left, each time occluding the fellow eye. Care was taken to ensure that the occluded eye was not pressed, and the tested eye was observed to prevent squeezing/squinting (pinhole effect) while reading the optotypes. For children wearing spectacles, their visual acuity was measured with the spectacles on, followed by measurement without the spectacles (uncorrected visual acuity).

c. **Binocular motor function:** An occluder was used to assess binocular motor function of the eyes and ocular alignment with and without spectacles, the initially readings being determined using corneal reflections (Hirschberg). This was followed by a cover/uncover test using an occluder and performed at 0.5 and 4 metres. The left eye was covered first and the right eye observed to detect any corrective movement while the child fixated a target at the required fixation distance with both eyes open. The cover was then removed and the right eye covered to detect any movement in the left eye. Strabismus was detected by classifying as constant if it present at all times for both fixation distances. If detected at only one fixation distance or not present at all times, it was classified as intermittent. The strabismus was then further classified as esotropia (outward movement of the uncovered eye), exotropia (inward movement), or vertical tropia (upward or downward movement). In all he children without tropia, an alternate cover test was performed to fully dissociate the eyes and reveal any phoria. To detect phoria, one eye was covered, and after a few seconds, the occluder was moved directly to the other eye, again after 1-2 seconds, the occluder was moved back to the original eye. The sequence was repeated a number of times (minimum 2-3) to ensure that at least one eye was covered for the duration of the alternate cover test. If a corrective re-fixation movement of the eye was detected consistently, as the cover was removed from the eye then, a phoria was noted. The phoria was classified as an esophoria (outward movement of both eyes as they are uncovered), exophoria (inward movement) and vertical phoria (upward or downward movement). If a <2 prism dioptres was detected, the condition was classified as orthophoria. Measuring the amount of tropia and phoria was performed using the objective prism cover test, with the prism strength being increased until no movement of the eyes on cover was observed (neutralization). The prism strength was then further increased until there was reversal in the direction of the tropia/phoria, and then decreased until neutralization was seen for the second time. The measure of the total strabismus or phoria size was recorded as the amount of prism power required to neutralize the deviation for the second time. This measurement was taken for both distance and near fixation where relevant and presence of nystagmus (involuntary rhythmic oscillations of the eyes) noted.

d. **External and anterior segment abnormalities:** the eyelids, conjunctiva, cornea, iris and pupil were examined with a pen torch to identify external and anterior segment ocular abnormalities.

e. **Cycloplegic refraction**: In children with unaided visual acuity of 20/40 or worse in either eye, pupillary dilation and cycloplegia (in both eyes) was attained using the following procedures: a drop of procaine was instilled in both eyes, and after waiting 2 minutes to achieve ocular surface anaesthesia, 2 drops of 1% cyclopentolate were administered 5 minutes apart to each eye. After an additional 15 minutes, when a pupillary light reflex was still present when observed with a bright torch light without magnification, a third drop was administered as required. After a further 15-20 minute interval, pupils were considered fully dilated if 6 mm or greater, and cycloplegia was considered if pupillary light reflex was absent. In some children, both dilation and cycloplegia were not achieved: dilation was less than 6 mm but cycloplegia complete, or dilation > 6 mm with incomplete cycloplegia.

f. Objective refraction: Retinoscopy was carried out using a streak retinoscope (Welch-Allyn, Skaneateles, NY, USA) in a semi dark room, with the examiner fixating at a distance of 0.75 meters and a +1.50 diopter lens in the trial frame as a working distance. The additional spherical, cylindrical power and axis necessary to neutralize the shadow movement were noted.

g. Autorefraction: In eyes with successful cycloplegia, refraction was performed with an autorefractor (Retinomax K-Plus; Nikon, Tokyo, Japan) according to the manufacturer instruction manual. The autorefractor was calibrated daily and a minimum of five readings with valid confidence rankings were obtained for each eye.

h. Subjective refraction: Using the objective refraction measurement as the starting point (when available), best corrected visual acuity with subjective refraction were determined using the trial frame. In cases where visual acuity of 20/32 or better was not achieved in both eyes, visual acuity testing was repeated with the addition of a pinhole in front of the subjective correction lenses.

i. Ophthalmoscopy: Examination of the lens, vitreous and fundus was performed with a direct ophthalmoscope (Welch-Allyn, Skaneateles, NY, USA) in children who had an unaided visual acuity of 20/40 or worse in either eye to ascertain the cause of the visual impairment. A principal cause of impairment was assigned for eyes with uncorrected (unaided) visual acuity 20/40 or worse. Refractive error was assigned as the cause if acuity improves to 20/32 or better with subjective refractive correction with or without pinhole. The cause of impairment was assigned by the optometrist (the researcher). Children with presenting visual acuity 20/40 or worse in the better eye and ophthalmic problems were referred to hospital/clinic nearest to their homes.

To address objective 2, a brief questionnaire was administered to determine the rate of spectacles use, the case history component of the RESC form was used to identify children who used spectacles. The questionnaires were administered to children with refractive error who had spectacles but were not using them to establish the reasons for their non-use by ticking reasons indicated in the forms.

3.11 Reliability of data

Reliability is the degree of consistency or dependability with which an instrument yields a certain result when an entity being measured has not changed (Robert & Priest, 2006).The reliability of this study was ensured by using standard equipment, standard optometric methods and standard testing distances. Prior to the main study, a pilot study was conducted among 50 primary school children outside the study area to check the appropriateness of the study procedures, the methods and logistics. All queries that arose from the pilot study were addressed and the procedures modified accordingly before the main study was carried out. In order to increase the reliability of the study, the researcher performed ophthalmoscopy, retinoscopy, auto refraction and subjective refraction, while four other optometrists assisted in the preliminary tests (visual acuity, external eye examination, binocular motor function and case history), thereby limiting the possibility of inter-examiner variability. In addition, all test distances were kept constant and environmental conditions, such as illumination, were similar in the various study sites. In order to further increase the reliability of the study, another optometrist rechecked 10% of the total participants seen every week for quality control and to ensure consistency.

3.12 Validity of data

Validity is the extent to which an instrument measures what it is supposed to measure (Twycross & Shields, 2004; Golfshani, 2003). The validity of the findings in this study was ensured by using a large sample size**.** All the instruments used for data collection are routinely used in optometry and were calibrated daily by a technician. As mentioned above, optometrists collected the data, and a qualified statistician provided expert advice and support with the use of appropriate data analysis techniques.

3.13 Data analysis and presentation

Class enumeration and clinical examination data forms were reviewed for completeness in the field before they were entered.Uncorrected visual acuity of 20/40 or less was regarded as refractive error and best corrected visual acuity of 20/40 or worse was regarded as visual impairment. Thresholds of 20/40 or less, less than 20/63, and 20/200 or less were used in defining visual categories. Myopia was defined as refractive error of at least −0.50 DS, hyperopia as +2.00 DS or more and astigmatism as −0.50DC or more using subjective refraction and the utilization of spectacle was defined as wearing spectacles at the time of the examination.

Assistance of a statistician was sought for the data analysis, which was analyzed using descriptive and inferential statistics using the statistical package for social sciences (SPSS) version 24. Ranges, means, standard deviations, frequencies and correlations were determined.

Chi–square and Pearson's correlation tests were used to investigate relationships between age and gender with visual impairment and refractive error and utilization of spectacles and questionnaires were analyzed descriptively.

3.14 Legal and ethical considerations

The following ethical considerations were addressed:

- Approval to conduct the study was obtained from the Biomedical Research Ethics Committee (BREC) of the University of KwaZulu-Natal (BE620/16).
- Permissions to carry out the study in primary schools were obtained from the Onitsha North and South Education Secretaries (Authorities in charge of primary school board in Onitsha) as well as headmasters and headmistresses of the primary schools selected.
- Information sheets were given to the participants, their parents and the various school heads explaining the purpose of the study and procedures to be followed.
- Consent to participate in the study was obtained from the various (school heads) and parents of the children.
- Written assents were obtained from each child once their parents had provided written consent.
- The children were informed about the purpose of the study, importance, benefits of the study and their right to decline from participating if they choose to do so.
- Anonymity was ensured by providing individual codes to all participants before and during the time of study.
- Research data sheets were kept in a secured locker and will be shredded after 5years. Electronic data was kept securely in a password protected computer and will be deleted after 5years.
- Participants with ocular pathologies were referred to the nearest eye clinic for further assessments and management.
- All procedures followed were within the scope of practice of optometry in Nigeria.

3.15 Conclusion

This study involved the use of Refractive Error Study in Children (RESC) protocol to determine prevalence and distribution of reduced vision in children and a brief questionnaire to determine the spectacle utilization rate and reasons for non-compliance with spectacle wear in children.

CHAPTER 4: RESULTS

4.1 Introduction

This chapter presents the results of the data analysis with respect to the two study objectives. The chapter starts with the demographic data, followed by the data from the eye examinations and the questionnaire, with the results being presented in tables.

4.2 Demographic data

Of the 1020 primary school children aged 5–15years from 17 primary schools in Onitsha North and South who were enumerated, 998 (97.8%) participated in the study.

Table 4.1: Age distribution of enumerated study population

Age (years)	Enumerated	Underwent a full examination	
		N	%
5-7	310	299	96.45
8-10	393	389	98.98
11-13	280	275	98.21
14-15	37	35	94.59
Total	1020	998	97.84

Out of the 998 children who participated in the study, 443 (44.4%) were males and 555 (55.6%) were females. Their mean age was 9.01± 2.5 years and 389 (39%) were aged 8-10 years (Table 4.2).

Table 4.2 Age and gender distribution of the study population

Age range (years)	Male (N)	Female (N)	Total (N)	(%)
5-7	126	173	299	29.96
8-10	184	205	389	38.98
11-13	114	161	275	27.56
14-15	19	16	35	3.51
Total	443	555	998	100

4.3. Objective 1. To determine the prevalence and distribution of reduced vision among the primary school children. The prevalence and distribution results are presented with respect to the tests that were conducted on the 998 children across the 17 schools in Onitsha.

4.3.1 Visual acuity

Regarding the results of the logMAR acuity chart tests, of the 998 children examined, uncorrected visual acuity of 20/32 or better in the better eye was found in 901 (90.3%) children, 97 (9.7%) had uncorrected visual acuity of 20/40 or worse in the better eye and 20 (2%) wore spectacles. Eighty four (86.6%) children improved to ≥20/32 in the better eye after refraction and 13(13.4%) had best corrected visual acuity of 20/40 or worse in the better eye, including one child (1%) with no light perception in one eye. This resulted in the prevalence of uncorrected visual acuity of 20/40 or worse in the better eye of 9.7%, of presenting VA of 7.7%, and best corrected of 1.3% (Table 4.3).

Table 4.3: Distribution of uncorrected, presented and best corrected visual acuity

VA category	Uncorrected VA N (%)	Wearing glasses N (%)	Presenting VA N (%)	Best corrected VA N (%)
≥ 20/32 in both eyes	891(89.3)	0	891(89.3)	980 (98.2)
≥ 20/32 in one eye only	10 (1)	0	30 (3)	5 (0.5)
≤ 20/40 to 20/63 or better in the better eye	58 (5.8)	7 (0.7)	51(5.1)	11(1.1)
≤ 20/80 to 20/160 or better in the better eye	35 (3.5%)	10 (1)	25 (2.5)	2 (0.2)
≤ 20/200 or worse in the better eye	4 (0.4)	3 (0.3)	1 (0.1)	0
Total	998 (100)	20 (2)	998 (100)	998 (100)

4.3.2 External and anterior segment abnormalities

The exterior and anterior segment abnormalities were observed in 61 (6%) of the 998 children examined. Eyelid abnormalities were present in 15 eyes of 10 (1%) children. Conjunctival abnormalities were present in 80 eyes of 42 (4.2%) children. Corneal abnormalities, mainly opacities were found in two eyes of two (0.2%) children, and an abnormal lens was observed in one (1%) child. Fundus abnormalities, including optic atrophy, macular and retinal degenerations, were present in eight eyes of 12 (1.2%) children, while two (0.2%) had micro-ophthalmos.

4.3.3 Binocular motor function

Exotropia accounted for the highest proportion of deviations and tropia with near fixation, being present in 19 (1.9%) of the 998 children examined and in 10 (1%) with distant fixation. Twenty one (72.4%) of the tropia detected was exotropia at near, with one quarter (23%) of the children being exophoric at near.

4.3.4 Cycloplegic refraction

Ninety seven (9.7%) children who had visual acuity of 20/40 or worse in either eye underwent cycloplegic refraction. Cycloplegia was considered complete if pupillary dilation of at least 6 mm and absence of light reflex were achieved. Complete cycloplegia was achieved in 85 (87.6%) right eyes and 79 (81.4%) left eyes. However, pupil dilation with light reflex present was found in 11 (11.3%) right eyes and nine (9.3%) left eyes, while absence of light reflex without full pupil dilation was found in 12 (12.4%) right eyes and 18 (18.6%) left eyes. Therefore, 72 (74.2%) children satisfied one or both criteria for ‘cycloplegia dilation’ in both eyes.

4.3.5 Objective refraction (retinoscopy and auto-refraction)

Hyperopia ranged from +1.00 DS to +5.00 DS with retinoscopy, and from+1.00 DS to +5.00 DS with auto-refraction. Both retinoscopy and auto-refraction values showed that hyperopia decreased with increasing age and was highest among children 5-7 years old. Myopia ranged from −1.00 DS to −11.00 DS with retinoscopy and −1.00 to −11.50 DS with auto-refraction. Myopia increased with increasing age and was highest among children 11-13 years and 14-15 years. Astigmatism of –0.50 DC to −1.75 DC was found in 24 (24.7%) right eyes and 37 (38%) left eyes, with retinoscopy in 25 (25.8%) right eyes and 38 (39.2%) left eyes with auto-refraction. Astigmatism of ≥ 2.00 DC was found in four (4.1%) right eyes and five (5.2%) left eyes with retinoscopy, and four (4.1%) right eyes and six (6.2%) left eyes with auto-refraction.These results indicate that significant astigmatism in either eye was present in 35 (36.1%) of the children. The prevalence of hyperopia ranged between 17.5% and 21.6% when measured with retinoscopy and auto-refraction respectively. With retinoscopy, the prevalence of myopia ranged from 6.2% in 5-7 year olds to 15.5% in 8-10 year olds. With auto-refraction, the prevalence of myopia was 49.5%, while auto refraction and retinoscopy results could not be obtained in 21(21.6%) eyes due to poor cooperation, fixation and claustrophobia

Table 4.4: Retinoscopy and auto-refraction

		Hyperopia		Myopia	
Age (years)	**No of children**	**Retinoscopy**	**Auto-refraction**	**Retinoscopy**	**Auto-refraction**
5-7	15	+1 D to +4 D	+1D to+5 D	-1 D to -4D	-2 D to -5 D
8-10	34	+0.5 D to +3 D	+1D to +4 D	-0.5 D to-10 D	-1 D to -10.5 D
11-13	44	+1 D to 2.5 D	+1D to +3.5 D	-1 D to -11 D	-2 D to -11.5 D
14-15	4	+0.5D to +2 D	+1D to +2.5 D	-0.5 D to-11 D	-1 D to -11.5 D
Total	97				

4.3.6 Subjective refraction

Of the 97 children who had refractive error, 45 (46.4%) had myopia, 35 (36.1%) had astigmatism and 17 (17.5%) had hyperopia. Forty two (43.3%) children who had refractive error were males, while refractive error was highest (45.4%) among the11-13year olds and least common (4.1%) among children 14-15 years (Table 4.5). Refractive error was found to be significantly associated with age (Pearson $\chi 2$ = 13.13, P = 0.004) and gender (Pearson $\chi 2$ = 4.17, P = 0.04). Myopia was significantly associated with males (P = 0.032) but not with age. Astigmatism and hyperopia were not significantly associated with age and gender (all P-values > 0.05).

Table 4.5: Age and gender distribution of refractive error

Variables	Myopia N (%)	Astigmatism N (%)	Hyperopia N (%)	Total N (%)
Gender				
Male	28 (62.2)	14 (40)	5 (29.4)	42 (43.3)
Females	17 (37.8)	21 (60)	12 (70.6)	55 (56.7)
Age				
5-7	6 (13.3)	1 (2.9)	8 (47.1)	15 (15.5)
8-10	15 (33.3)	14 (40)	5 (29.4)	34 (35.1)
11-13	22 (48.9)	19 (54)	3 (17.6)	44 (45.4)
14-15	2(4.4)	1 (2.9)	1 (5.9)	4 (4.1)
Total	45 (46.4)	35 (36.1)	17 (17.5)	97 (100)

Out of 70 eyes of 35 children with astigmatism, 41(58.6%) eyes had with the rule astigmatism (WTR) (Table 4.6).

Table 4.6 Distribution of types of astigmatism

Eye	With the rule (%)	Against the rule (%)	Oblique (%)	Total (%)
Right eyes (28)	16 (57.1)	5 (17.9)	7 (25)	28 (100)
Left eyes (42)	25 (59.5)	12 (35.7)	5 (4.8)	42 (100)
Total (70)	41 (58.6)	17 (24.3)	12 (17.1)	70 (100)

4.3.7 Causes of visual impairment

Of the 97 children with uncorrected visual acuity of 20/40 or worse in the better eye, 84 (86.6%) were due to uncorrected refractive error and thus improved to ≥20/32 after refraction, while13 (13.4%) could not be improved to ≥20/32 in the better eye. The prevalence of visual impairment (best corrected visual acuity of 20/40 or worse in the better eye) was therefore 13 (1.3%). Table 4.7 shows the different causes of visual impairment.

Table 4.7: Causes of visual impairment (VI)

Cause of VI	N	Percentage (%)
Refractive error	84	86.6
Retinal disorder	4	4.1
Cornea opacity	2	2.1
Amblyopia	4	4.1
Albinism	3	3.1
Total	97	100

Nine (69.2%) children who had visual impairment were females and four (30.8%) and 11 (84.6%) were between 5-7 years of age, two (15.4%) were between 8-10 years and no visual impairment was found in children older than 11 years. Visual impairment was found to be significantly associated with age (Pearson $\chi2$ =19.36, P = 0.000) but not with gender (Pearson $\chi2$ = 1.004, P = 0.316).

4.4 Objective 2. To determine the rate of spectacle use and reasons for non-compliance with spectacle wear

Of the 97 children who had refractive error, 41(42.3%) had their eyes tested and were prescribed spectacle corrections before while 20 (48.8%) of the 41 children wore them at the time of examination (Table 4.8); the spectacle utilization rate was therefore 20 out of 97 (20.6%). Eleven (55%) of those wearing spectacles were females, 13 (65%) were myopic, and children aged 8-10 years had the highest number (50%) of spectacle wearers. No significant association was found between age, gender and use of spectacles (all P-values > 0.05).

Table 4.8: Spectacles utilization by age, gender and type of refractive error

Variables	Use of glasses (N)	Percentage (%)
Age		
5-7	3	15
8-10	10	50
11-13	6	30
14-15	1	5
Gender		
Male	9	45
Female	11	55
Type of RE		
Myopia	13	65
Astigmatism	5	25
Hyperopia	2	10
Total	20	100

Six (28.6%) children of those not wearing their spectacles reported that their parents disapproved of their use. Other reasons for non-compliance are shown in Table 4.9.

Table 4.9: Self-reported reasons for non-compliance with spectacle wear

Reasons for non-compliance	N	Percentage (%)
Parents disapprove of use of spectacles	6	28.6
Concerned or teased about appearance	3	14.3
Forgot spectacles at home	3	14.3
Spectacles cause headaches	2	9.5
Do not feel spectacles are needed	2	9.5
Children should not wear spectacles	2	9.5
Use spectacles at special time or occasion	2	9.5
Spectacles will sink in the eyes	1	4.8
Total	21	100

4.5 Conclusion

The prevalence of refractive error and visual impairment found in this study were 9.7% and 1.3% respectively. Myopia was the most prevalent refractive error followed by astigmatism and hyperopia. Refractive error was more prevalent among females than males and children between 11-13 years. The spectacle utilization rate found was 20.6% and parents' disapproval of spectacle wear was the major reason for non-compliance with their use among children.

CHAPTER 5: DISCUSSION

5.1 Introduction

Reduced vision secondary to uncorrected refractive error and other ocular conditions, such as pathology, is a major public health challenge that requires urgent attention in many developing countries, such as Nigeria, many of which do not have reliable data to inform interventions. Among school children, reduced vision has a considerable impact on learning and academic achievement. To address this problem effectively, data on the visual status of children is needed across all countries. This school based cross sectional study was carried out in Onitsha, Anambra state in Eastern Nigeria, a region with one of the highest school attendance rates in Nigeria.This chapter discusses the test results presented in Chapter 4 with respect to the prevalence and distribution of reduced vision (objective 1), rate of spectacle use and reasons for non-compliance with spectacle wear (objective 2).

5.2 Demographic details

One thousand and twenty children were enumerated for this study in Onitsha but 998 completed the examination. Except for a relatively large number of 8-10 year olds and a small number of 15-year-olds, the age distribution of the enumerated population was reasonably uniform. The number of 14-15 years old was relatively low possibly because most of this age group was already in high/secondary school. Therefore, this low number of children could represent those who perform poorly academically and are still in primary school. The high response rate in this study was expected because school eye screening programs are non-existent, so the children and the parents felt it was an opportunity to get their children' eyes tested. The endorsements by the education board secretaries, co-operation of the class teachers and Parents Teachers Association (P.T.A) also contributed to the high response rate in this study.

5.3 Objective 1. Prevalence and distribution of reduced vision

The results from the prevalence of refractive error and visual impairment as well as the distribution of different types of refractive error according to age and gender are discussed and compared to the findings of other studies in Nigeria and elsewhere in this age group of 5 to 15 year olds. The prevalence and distribution were calculated based on the total number of children examined who had visual acuity of less than 20/40. Those with best corrected visual acuity less than 20/40 were considered to have visual impairment.

5.3.1 Prevalence of refractive error

In children, uncorrected refractive error can impact on academic performance, career choice, or job opportunities. Refractive error, especially myopia, can have a negative impact on learning capability and educational potential. Despite the importance of correcting refractive problems in children, there is very limited information on the type and prevalence in Nigeria. Data on refractive error prevalence and the utilization of corrective spectacles among school-aged children is necessary for eye health planning. The study was motivated by the paucity of refractive error data to guide the efficient mobilization of refractive and eye care services in Nigeria especially in the Eastern part of Nigeria and many other parts of Africa. Although the availability of eye care personnel in Nigeria is much better than the rest of the continent, particularly with regard to optometrists, their poor distribution particularly in rural areas leave many Nigerians having poor accessible to refractive eye services. Most optometrists practice almost exclusively in the private sector, whereas ophthalmologists focus mainly on the management of ocular disease and surgery and provide little with regard to refractive services.

The prevalence of refractive error (uncorrected visual acuity of 20/40 or worse in the better eye) among the primary school children aged 5-15 years tested in Onitsha, Anambra State was 9.7%. This falls within the WHO prevalence of 2-10% reported among children aged 5-15 years worldwide (Ibenmo & Egbe, 2013), and warrants regular vision screening. Vision screening is important for the early detection of children requiring glasses or referrals for further management in cases of ocular pathology. This is important to prevent amblyopia that can result in visual impairment and blindness. Table 5.1 below provides an overview of selected studies on the prevalence of different types of refractive errors among children of various ages in a range of African countries compared.

Table 5.1 Prevalence of refractive error studies in children in Africa

Author	Country	Year	Age (years)	Sample size	Prevalence of RE (%)	Myopia (%)	Hyperopia (%)	Astigmatism (%)
This study	**Nigeria**	**2017**	**5-15**	**998**	**9.7**	**4.5**	**1.7**	**3.5**
Mohammed et al	Egypt	2014	6-10	142	66.9	62.7	3.5	0.7
Nebiyat et al	Ethiopia	2015	6-19	1800	4.0	1.1	0.3	0.7
Assefa et al	Ethiopia	2012	4-24	1852	9.4	3.0	2.5	2.1
Kassa & Degu	Ethiopia	2000	5-15	1134	7.6	6.9	2.2	NR
Jafer & Abomesh	Ethiopia	2009	7-15	570	3.5	2.6	0.9	NR
Kumah et al	Ghana	2013	12 -15	2435	3.7	3.2	0.4	NR
Ovenseri & Omuemu	Ghana	2010	5-19	1103	25.6	6.9	4.6	14.1
Ovenseri & Assien	Ghana	2010	11-18	961	4.5	1.7	5.0	6.6
Muma et al	Kenya	2009	12-15	1439	5.2	1.7	3.2	0.3
Msiska et al	Malawi	2009	12-15	1278	2.4	1.4	0.8	0.1
Faderin & Ajaiyeoba	Nigeria	2001	5-15	919	7.3.	9.0	3.8	2.8
Opubiri et al	Nigeria	2013	4-15	506	22.5	13.8	2.6	6.1
Opubiri & Egbe	Nigeria	2013	5-15	1242	2.2	NR	NR	NR
Balarabe et al	Nigeria	2015	11- 20	614	4.8	2.9	1.1	0.8
Megbalayin & Asana	Nigeria	2013	9-21	1175	6.9	NR	NR	NR
Ahuam & Atowa	Nigeria	2004	7-17	2525	58	31.05	19.13	7.8
Semanyezi et al	Rwanda	2015	11 -37	634	18.9	10.2	4.3	4.4
Naidoo et al	South Africa	2003	5-15	4890	1.4	2.9	1.8	NR
Atif et al	Sudan	2016	5-15	183	2.2	1.2	0.2	0.5
Wedner et al	Tanzania	2000	7 -19	1386	0.7	0.1	0.5	0.1
Kawuma & Mayeku	Uganda	2002	6-9	623	11.6	1.3	4.3	6.0

RE= Refractive error; NR = Not reported

The prevalence of 9.7% is higher than the 2.2% reported among children aged 5-15 years in Bayelsa Nigeria (Opubiri & Egbe, 2013), but is comparable to that reported elsewhere in Nigeria, specifically in Lagos of 7.3% (Faderin & Ajeiyeoba, 2001) and 8.7% (Balogun, 1999), as well as in Enugu of 7.4% (Nkanga, 1997) and 8.9% (Yoloye, 1990) in Ibadan. However, the prevalence is lower than 22.5% and 58% reported in South-South Nigeria and Abia State, Nigeria respectively. The low prevalence recorded in Bayelsa study (Opubiri & Egbe, 2013) could be due to the fact that the study was a vision screening program, and some children with low magnitude of refractive error and normal visual acuity could have been missed. In addition, the current study was a school based among children aged 5-15 years while Opubiri et al (2013) was hospital based among 4-15 year olds, which could have accounted for this difference. It is well known that most hospital based studies would generally record higher rates of conditions than in the general population. In addition, the sample size and different definitions used for refractive error could have accounted for the differences between them. For example, the current study used a sample size of 998 and visual acuity of 20/40 or worse in the better eye for the definition of refractive error, while a sample size of 4225 and visual acuity of 20/32 or worse were used in the study in Abia State (Ahuama & Atowa, 2004).

When comparing with studies outside Nigeria**,** the prevalence of 9.7% found in the current study is higher than1.4% (Naidoo et al., 2003), 2.4% (Msiska et al., 2009), 5.2% (Muma et al., 2009) and 1% (Wedner et al., 2000) reported in South Africa, Malawi, Kenya, and Tanzania respectively. However, it is lower than11.6% (Kawuma & Mayepu, 2002), 15.8% (Maul et al., 2000), 12.8% (Zhao et al., 2000) and 18.9% (Semanyezi et al., 2015) recorded in Uganda, Rwanda, Chile and China respectively. The prevalence is more comparable to 9.4% (Assefa et al., 2012) and 7.6% (Kassa & Degu, 2000) reported in Ethiopia. These varying results could be due to the different operational definitions, methodologies and demographic factors (age group, study sites, racial differences and geographical locations). Moreover, life style/environmental factors and genetics have been reported to contribute greatly to variations in the prevalence of refractive error. Recently, increased outdoor activities and exposure to high light intensity, this being common among rural dwellers, have been proposed as factors influencing the prevalence of refractive errors in rural areas while life style factors, such as increased near work and indoor activities common among urban dwellers have also been known to increase the prevalence of refractive errors in urban areas (Hashemi et al., 2014). However, studies have shown prevalence of refractive error to be higher in urban and highly developed areas than in rural and less developed areas (Resnikoff et al., 2008). Although racial and ethnic differences are the most important reasons for differences in the prevalence of refractive errors, studies have also shown that genetically determined factors (such as eye pigmentation) may theoretically interact with environmental influences (such as outdoor light exposure) to impact refractive error development in black people (Wen et al., 2013).

5.3.2 Distribution of refractive error

Results from the distribution of different types of refractive error as a cause of reduced vision are discussed here according to gender and age, this being determined by number of children that had uncorrected visual acuity of less than 20/40 during the time of examination.

5.3.2.1 Gender distribution of reduced vision

Various studies have shown that gender differences at the age of onset of puberty affects development of refractive error and with differences between biometric ocular parameters of males and females being reported, which suggests a possible correlation between gender and refractive error (O'Donoghue et al., 2010). Refractive error was found to be significantly higher in females (56.7%) than males (43.3%) ($P = 0.04$) in the present study. Similar findings were observed in Lagos (Faderin & Ajaiyeoba, 2001), South-South Nigeria (Opubiri et al., 2013), Kebbi State, Nigeria (Balarabe et al., 2015), and Ethiopia (Assefa et al., 2012).

5.3.2.2 Age distribution of reduced vision

Studies have shown that the human eye grows by 5mm from birth to 6 years, and by an additional 1mm after 6 years until age 12 (Faderin & Ajaiyeoba, 2001). The prevalence of refractive error has been reported to increase to 2% by 6 years of age and to 15% by the age 15 years in the general population (Balarabe et al., 2015), indicating the possibility of a relationship between increase in age and refractive error. The current study found refractive error to increase with age, and was highest (48.9%) among children (11-13 years). Similar findings were reported by Assefa et al (2012) in Ethiopia and by Opubiri et al (2013) in South-South Nigeria. However, a study in Enugu State, Nigeria, by Chuka-Okosa, (2005) showed no significant association of refractive error with age. The age range of 12-21 years used in the Enugu study could be responsible for the different results.

5.3.2.3 Distribution of myopia

Myopia of −0.50 DS or worse was the most prevalent (46.4%) refractive error found in this study. This could be due to the fact that Onitsha is mainly an urban area and children in urban environment engage more in indoor and near work activities, such as higher usage of computers, smart phones and video games. These activities are believed to increase myopia in urban children as opposed to rural children, who have less access to social media gadgets and may therefore be more hyperopic. It is also possible that children in Onitsha schools enrolled before the age of 6 years and started near work from an early age, thus predisposing them to the development of myopia. Studies in Abia State (Ahuama & Atowa, 2004) and Bayelsa State, Nigeria (Opubiri et al., 2013), also found myopia to be the most prevalent refractive condition among school children aged 7-17 years and 5-21 years, respectively. Although both studies were conducted in urban environments, variations in the prevalence rates could be attributed to the differences in age range, sample size and methodologies employed. For instance, the current study used a sample size of 998 and age range of 5-15 years, while the study by Ahuama and Atowa (2004) used a sample size of 4225 and age range of 7-17 years. In addition, the present study was school based while Opubiri et al's study was hospital based.

Studies in Tanzania and South Africa by Wedner et al (2000) and Naidoo et al (2003), respectively, also showed myopia as the most prevalent refractive condition among children aged 5-15 years (Table 5.2). Higher prevalence findings of myopia were also reported in Singapore (Saw et al., 1996), China (Zhao et al, 2000), Vietnam (Paudel et al., 2014), Egypt (Mohammed et al., 2014) and Sudan (Atif et al., 2016) (Table 5.2). The higher prevalence of myopia recorded in those studies was attributed to the high prevalence of myopia in Asians and Arab children. Myopia is a common visual problem in schoolchildren globally, with early detection and management being highly indicated for educational, behavioral and quality of life benefits.

In the current study, myopia was found to increase with age, starting from 8-10 years, which could possibly be due to this age group are mostly in grade 5 and 6 which is the grade for preparing and writing entrance examination to high primary school leading to increased academic demand thus increasing the onset of myopia. Another possible reason could be the onset of juvenile myopia, defined as myopia, with an onset between 7-16 years of age, primarily due to axial elongation that is usually caused by intensive near work (Faderin & Ajaiyeoba, 2001). Ahuama and Atowa (2004) also reported myopic progression starting from 12-17 years in Abia State, Nigeria, with similar findings being recorded in the Refractive Error Study in Children (RESC) surveys in China (Zhao et al., 2000), Chile (Maul et al., 2000) and South Africa (Naidoo et al., 2003), with the upward trend in myopia starting from 13 and 14 years in the latter.

Myopia was found to be significantly associated with males (P = 0.03), which could be due to the fact that the male children engage more in indoor activities, such as computer video games, chatting on phones, reading and writing, unlike the females who do more of outdoor activities, such as domestic chores. Msiska et al (2009) also found myopia to be significantly associated with males, while Wedner et al., (2000) and Kawuma and Mayeku, (2002) reported contrary results in Tanzanian and Ugandan children respectively. Muma et al., (2009) and Kumah et al (2013) did not find any significant association between gender and myopia in Kenya and Ghanaian children respectively, which could be due to the diverse age groups in the study samples (Table 5.1).

5.3.2.4 Distribution of astigmatism

The prevalence of astigmatism varies in studies across populations, with racial factors being reported to be among the reasons for the differences observed in the prevalence of astigmatism worldwide (Mahjoob et al., 2016). Astigmatism is also an important cause of visual morbidity that could lead to amblyopia if uncorrected. Early detection and correction of astigmatism are very important, as most asthenopic symptoms that could lead to poor school performance are usually due to astigmatism. The prevalence of astigmatism of −0.50 DC or worse found in this study was high (Table 5.1). School children in urban areas engage more in near work and astigmatism is associated with increased near work. The prevalence of astigmatism found in this study is higher than 6.1% and 7.8% recorded in South-South Nigeria and Abia State, Nigeria, respectively (Table 5.1). However, it is more comparable to 38.8% reported in Lagos Nigeria by Faderin and Ajaiyeoba (2001). The reasons for the discrepancies could be the inclusion of diverse age and ethnic groups in their study samples.

With-the-rule (WTR) astigmatism was the most common type found in this study and this could due to it being commonly found in children. Similar findings were reported by Atif et al (2016) among Sudanese children aged 5-15 years (Table 5.1). Opubiri et al (2013) and Naidoo et al (2003) found astigmatism to increase with increase in age in South-South Nigeria and South Africa respectively (Table 5.1). The present study did not find astigmatism to increase with age, the variability in findings possibly being attributed to ethnic and racial differences. There was no gender difference in the prevalence of astigmatism in the current study, this being similar to a report by Muma et al (2009) in Kenya.

5.3.2.5 Distribution of hyperopia

The prevalence of hyperopia (≥+2.00 DS) was low (Table 5.1), which could be due to the study setting. Children in urban areas are more actively involved in near work and less outdoor activities, thus reducing their prevalence of hyperopia. The prevalence of hyperopia found in this study is higher than those reported in other Nigerian studies, but lower than and comparable to those conducted in other African countries (Table 5.1). This wide variation could also in part be due to the variations in the definitions of hyperopia, and/or age groups and ethnicities used in the various studies. For example, Ahuama and Atowa (2004) defined hyperopia as+0.50 DS and higher, while the current study defined it as +2.00 DS and higher (Table 5.1). The study by Ahuama and Atowa (2004) also involved rural and older school children (7-17 years), which could have increased the prevalence of hyperopia, as it is well reported that hyperopia is more prevalent among children in the rural areas (Muma et al., 2009; Msiska et al., 2009).

Hyperopia was found to decrease with increasing age and was highest among children 5-7 years old. This is possibly due to the fact that this younger age group is prone to be more hyperopic, as their crystalline lens is still growing and they engaged in less reading and near work compared with the older age groups. Similar findings were reported in South-South Nigeria (Opubiriet al., 2013) and Abia State, Nigeria (Ahuama & Atowa, 2004), as well as in China (Zhao et al., 2000), Chile (Maul et al., 2000) and South Africa (Naidoo et al., 2003). Females had more hyperopia than males in the present study, a result similar to that reported by Opubiri et al (2013) in South-South, Nigeria, but contrary to findings obtained by Kawuma and Mayeku (2002) in Kenya, Msiska et al (2009) in Malawi and Maul et al (2000) in Chile. The use of non-cycloplegic refraction in some of these studies could also have influenced the prevalence of hyperopia as this condition tends to produce more myopia and less hyperopia. Early detection of hyperopia is highly indicated, as children with significant hyperopia also have consistently poorer performance on a range of visuo-cognitive and motor tests compared to those without significant refractive errors, with subsequent implications for general development and educational attainment (O'Donoghue et al., 2010). In addition, hyperopia is highly associated with poor visual outcome, such as amblyopia and strabismus.

5.3.3 Prevalence of visual impairment

The prevalence of visual impairment (best corrected visual acuity of $\leq$ 20/40) was 1.3%, indicating that visual impairment is relatively uncommon among primary school children in Onitsha. The prevalence is much lower than that reported in other Nigerian studies by Megbeleyin and Asana, (2013) and comparable to that reported by Aijeyeoba et al (2007) (Table 5.1). It is however, not possible to make general overall comparisons among these results due to differences in ethnic backgrounds and methodologies used (Table 5.1).

Visual impairment due to refractive errors is one of the most common problems among school-age children, and is the second leading cause of preventable blindness (Atif et al., 2016). Most (84%) uncorrected visual acuity of $\leq$20/40 found in the present study was caused by refractive error. This result is consistent with studies by Maul et al (2000), Zhao et al (2000), Naidoo et al (2003), Ajaiyeoba et al (2007), Muma et al (2009) and Opubiri et al (2013). Other causes of visual impairment (best corrected visual acuity of $\leq$ 20/40) found in this study were amblyopia, retinal disorders, corneal opacity and albinism, which is similar to those reported in South Africa by Naidoo et al (2003) and Ghana by Kumah et al (2013). This study also recorded no significant association between visual impairment and gender, possibly because of the low prevalence of visual impairment. Further studies are needed to adequately understand the association of visual impairment and gender.

5.3.3.1 Ocular abnormalities

Vision in preschool children is important because their visual system is still developing, and they are at risk of developing amblyopia from uncorrected high ametropia or anisometropia (Atif et al., 2016). Amblyopia causes impairment of vision, depth perception, and contrast sensitivity that could lead to loss of single binocular vision. The prevalence of amblyopia found in this study was 4.1%, which is higher than the worldwide prevalence of 2% among children less than 16 years (Akpe et al., 2015). Amblyopia in school children may be indicative of poor access to eye care services because it requires urgent management in order to prevent visual impairment (Balarabe et al., 2015). Early school screening, especially before the age of seven, is advocated for the early detection of refractive error and strabismus in order to prevent amblyopia in children as amblyopia treatment is most effective when done before this age.

The prevalence of amblyopia in the current study was higher than the 0.16% reported by Balarabe et al (2015) in Kebbi State, Northern Nigeria, but lower than 7.6% recorded in a hospital based sample of 183 children in Sudan (Atif et al., 2016). It is again difficult to make direct comparisons due to differences in sample sizes and methodologies.

Studies have shown that binocular single vision develops at the age of 2 years and that fixation reflex does not mature until the age of 9 years (Abebe, 2000), during which time visual acuity remains in a state of flux and children are vulnerable to strabismus (Yoseph & Samson, 2002). The prevalence of strabismus varies between 0.9% and 7.4% in different parts of the world (Taha & Ibrahim, 2015), and between 0.5% and 4.4% in Africa (Wedner et al., 2000), with this study reporting prevalence figures of 1.9% at near and 1% at distance. More than 70% of the tropia found in this study were exotropia at near, this being similar to Naidoo et al (2003) and Kumah et al (2013), who reported 1.3% in South Africa and 1.8% in Ghana. Although strabismus is the leading cause of monocular visual impairment in children, only a few studies have exclusively investigated this condition, with further investigations being required to better understand this observation.

5.4 Objective 2. To determine the rate of spectacle utilization and reasons for non-compliance with spectacle wear

A brief questionnaire was used to establish the reasons for non-compliance with spectacle wear and the number of children that were wearing the spectacles during the time of examination.

5.4.1 Rate of spectacle utilization

Ovenseri and Assien (2010) estimated that 500 million people (including children), particularly in developing countries, do not have access to eye examination and affordable correction. Studies have also shown that the majority of children with refractive errors do not wear spectacles, mainly due to them not being aware of the error or because they were not taken to an eye facility for examination (Balarabe et al., 2015). Early assessment of vision in school children can facilitate timely correction of refractive error if present, which can help improve the children's participation and learning in school.

The present study showed that spectacle utilization rate among children was 20.6% out of 97 that had uncorrected visual acuity of $\leq$ 20/40. This indicates that more than half of the children with refractive errors were not using spectacles. This could be due to poor awareness about the use of corrective spectacles for refractive error and low uptake of refractive error services in Onitsha. It is worth noting that 95.7% of children with refractive error in this study had their vision improved after refraction and the provision of glasses. Interestingly, none of the 1707 children examined in a study in Ile-Ife in South West of Nigeria had previously had an eye examination (Adegbehinde et al., 2005). This could be due to the fact that Ile-Ife is a rural area with few eye care service providers and people are of low socioeconomic status. Muma et al (2009) found only one child wearing spectacles in their study in the rural area of Kenya. This result could be explained by the inaccessibility and high cost of eye care services, as well as the social stigma associated with wearing spectacle.

However, the spectacle utilization rate of 20.6% found in the current study is higher than 9.3% and 7.7% reported in Tehran (Fatouhi et al., 2006) and Iran (Hashemi et al.,2017) respectively. It is also considerably higher than the 2.7% reported in South Africa by Naidoo et al (2003) and the 3.4% reported in Kenya by Muma et al (2009), but it is lower than 42.3% reported by Mohammed et al (2014) in Egypt. Variations in spectacle utilization rates in these studies could be attributed to the racial/ethnical differences, targeted population, access to eye care services, type of refractive error prevalent in that area, cultural beliefs regarding use of spectacles and cost of spectacles. For example, the low utilization rates recorded in Tehran and Iran could be due to high cost of spectacles, while poor access to eye care services and cultural beliefs could be responsible for the low utilization rate in Kenya.

No significant association was found between use of spectacle, age and gender in this study (all P-values > 0.05). Fatouhi et al (2006) and Hashemi et al (2017) reported utilization of spectacle to be associated with age and gender in Tehran and Iran respectively. Variations in the findings reported could be due to differences in culture, geographical locations, race and socio-economic factors. Furthermore, the current study was a school based study and had a sample size of 998, while those in Tehran (Fatouhi et al., 2006) and Iran (Hashemi et al., 2017) were population based and had sample sizes of 4353 and 3314 respectively

5.4.2 Reasons for non-compliance with spectacle wear

In this study, 20 (20.6%) children wore spectacle during the time of examination, although 21 (21.6%) others reported being prescribed spectacles but were not wearing them. The current study found that parents disapproved of spectacle wear among their children, this being reported as the major reason for non-compliance with spectacle wear. This observation could be due to the stigma attached to spectacle wear and the belief that their use will eventually lead to blindness (Nebiyat et al., 2015). Fatouhi et al (2006) and Hashemi et al (2017) found that age, gender, and type of refractive error were contributory factors to non-compliance with spectacle wear. Castanon Holguin et al (2006) in Mexico also found that non-compliance was higher among older children and those in urban areas. The authors reported that older urban based children were more likely to list concerns about the appearance of the glasses and being teased than younger and rural children. These findings could be related to the current study, as only one child (5%) in the 14-15 year age range was wearing spectacles. Thirteen (65%) children who wore spectacles in this study were myopic, indicating that myopic children were more likely to comply with spectacle wear than those with astigmatism or hyperopia. This could be due to the fact that myopes wear spectacles to correct their distance vision, unlike hyperopes, who can still manage to see at distance without corrective spectacles. Hashemi et al (2017) in Tehran reported that 74.5% of those wearing spectacle were myopes. Although children with hyperopia are less likely to comply with spectacles wear; they are more at risk of developing strabismus and amblyopia. Strategic measures should be devised to reduce non-compliance with spectacle wear in school children.

5.5 Conclusion

Onitsha, like many other parts of Eastern Nigeria, has only two public (government owned) hospitals that provide eye care services and very few optometrists in the public sector. Most optometrists are in the private sector which results in eye care services being inaccessible and unaffordable to the majority of its inhabitants. Refractive errors affected 9.7% of school children in Onitsha, which is of public health concern, as this condition can easily be corrected with spectacles. Preschool vision screening, as well as eye health education and promotion, should be incorporated into primary school health programs in Onitsha, Anambra State in order to detect children with refractive error so as to prevent visual impairment and other associated consequences. The prevalence of retinal disorders, albinism and anterior segment abnormalities in the present study is a further reflection of poor primary eye care services in Onitsha State and possibly Nigeria as a whole.

CHAPTER 6: CONCLUSION

6.1 Introduction

This research was undertaken in order to determine the prevalence and distribution of refractive error and visual impairment as well as utilization of corrective spectacles and reasons for non-compliance with spectacle wear among primary school children in Onitsha, Anambra State, Nigeria.This chapter summarises the key findings of the study and draw conclusions on the results of the research. The limitations and recommendations of the study are also discussed.

6.2 Concluding remarks based on the study objectives

This is the first Refractive Error Study in Children (RESC) undertaken in Onitsha, Anambra state, Nigeria and showed that the prevalence of refractive error and visual impairment among primary school children in Onitsha were 9.7% and 1.3% respectively. Females and older children were more at risk of developing refractive error. Myopia was the most prevalent (46.4%) refractive error followed by astigmatism (36.1%) and hyperopia (17.5%). Male children and those older than 8 years were more at risk of developing myopia. Although the prevalence of refractive error and visual impairment was high; spectacle utilization rate was relatively low (21.6%). These highlight the need for services and strategies to address refractive error, visual impairment and compliance with spectacle wear.

6.3 Limitations of the study

Due to practical considerations and time factor, some private primary schools opted out of the study as they did not want anything that would disrupt their normal school activities and that made it impossible to compare findings from public schools and private schools. Measuring visual acuity and performing retinoscopy and autorefraction on 5 year-olds and 6-year-olds was a challenge, because of poor attention span, lack of understanding and restlessness. Some school heads did not allow the use of cycloplegia on children 5-7 years old. However, this did not affect the participation rate in that age group. In some children, it was difficult to get full cycloplegia and in some, reversing the cycloplegic effects took longer than anticipated. The small sample size relative to other population based Refractive Error Study in Children (RESC) surveys and the fact that the sample for this study was drawn from an urban area (urban areas have better service coverage than rural areas) limits generalization of the results. In addition, the study used convenience sampling and is therefore subjected to all the shortcomings of a convenience sampling method, such as limited generalization of the results.

6.4 Recommendations

Department of education

- It is recommended that school vision screening programs be conducted routinely in this area.
- There should also be awareness programs about the use of corrective spectacles that can be incorporated into the school health and education programs of Onitsha. These will help to prevent the negative impact of refractive error and visual impairment on children's education and development. Such a screening program would also provide an opportunity for interventions such as referrals for spectacles and other related services.
- Future studies should include all children (and not only those in schools) in Onitsha to completely understand refractive errors in this group.
- Further research into the etiology and pathogenesis of myopia is required to determine the exact cause and provide conclusive evidence about the association of near work and development of myopia.
- Training and information programs on basic eye screening techniques should be designed for teachers and school health care.

Participants and parents

- Parents should be educated about the importance of spectacle wear for their children.
- The use of frames with better aesthetic appeal instead of the usual Harry Porter (round) kind of frame may help improve compliance with spectacle wear in children.
- Low vision and other related services are required for those children who were still visually impaired after best correction.

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APPENDIX 1

RESC EYE EXAMINATION

Examination Station

School Name: ______________________________

Exam Date _____/_____/_____

SECTION A: CHILD IDENTIFICATION

Child Name: ____________________________________

Child ID: [| |] [ ] [ ] [|]

School Grade Class Child

Age [|] Sex (1: Male; 2: Female) [ ]

SECTION B: VISION ASSESSMENT

VA Examiner ID [ ]

B1. Child is wearing corrective lenses? [ ]

0: NO; Go to B3 1: YES

B2. Visual Acuity with corrective lenses:

	VA
OD	/
OS	/

Visual Acuity cannot be determined (reason):

____

B3. Uncorrected Visual Acuity (UCVA):

	UCVA
OD	/
OS	/

Visual Acuity cannot be determined (reason):

____

SECTION C: BINOCULAR MOTOR FUNCTION

Examiner ID

C1. Tropia at 0.5 meter fixation:

0: None 1: Esotropia 2: Exotropia

3: Vertical 9: Undetermined

If tropia, degrees?

1: 1 to 15; 2: 16 to 30; 3: 30+

C2. Tropia at 4 meter fixation:

0: None 1: Esotropia 2: Exotropia

3: Vertical 9: Undetermined

If tropia, degrees?

1: 1 to 15; 2: 16 to 30; 3: 30+

SECTION D: EXTERNAL/ANTERIOR SEGMENT EXAMINATION

Examiner ID

0: Normal 1: Abnormal 9: Undetermined

D1. Eyelids?

OD If abnormal: ____________________

OS If abnormal: ____________________

D2. Conjunctiva?

OD If abnormal: ____________________

OS If abnormal: ____________________

D3. Cornea?

OD If abnormal: ____________________

OS If abnormal: ____________________

D4. Pupil?

OD ☐ If abnormal: ____________________

OS ☐ If abnormal: ____________________

D5. Other anterior segment?

OD ☐ If abnormal: ____________________

OS ☐ If abnormal: ____________________

SECTION E: REFRACTION WITH CYCLOPEGIA

E0. Is **UncorrectedVA≥ 20/32** in **both** eyes? ☐

0: NO; continue 1: YES; Go to G

9: Undetermined; continue

E1.Pupil dilated ≥ 6mm **AND** light reflex absent?

0: NO; Go to E5 1:YES; continue

2: Light reflex absent, but < 6 mm; continue

8: ≥ 6mm, but light reflex present; Go to E5

9: Undetermined; Go to E5

OD ☐ If 0 or 9, comment: ____________________

OS ☐ If 0 or 9, comment: ____________________

E3. Autorefraction (staple printout & record results)

or Retinoscopy

Examiner ID ☐

	Sphere	Cyl.	Axis
OD			
OS			

Cannot be examined (reason)______________________

E5. Subjective refraction (with BCVA)

Examiner ID ☐

	Sphere	Cyl.	Axis	BCVA
OD				/
OS				/

Cannot be examined (reason) ______________________

E6. Is **BCVA ≥ 20/32** in **both** eyes? ☐

0: NO; continue   1:YES; Go to F

9: Undetermined; continue

E7 Pinhole BCVA (optional)

	Pinhole BCVA
OD	/
OS	/

Cannot be examined (reason) ______________________

SECTION F: LENS, VITREOUS AND FUNDUS

Examiner ID ☐

0: Normal 1: Abnormal 9: Undetermined

F1: Lens?

OD ☐ If abnormal ______________

OS ☐ If abnormal ______________

F2: Vitreous?

OD ☐ If abnormal ______________

OS ☐ If abnormal ______________

F3: Fundus?

OD ☐ If abnormal ______________

OS ☐ If abnormal ______________

SECTION G: IMPAIRMENT CAUSE

Examiner ID ☐

0: No impairment (UCVA ≥ 20/32)

1: Refractive Error (UCVA ≤ 20/40 and
BCVA/Pinhole BCVA ≥ 20/32)

2: Amblyopia (only if BCVA & Pinhole ≤ 20/40)
3: Corneal opacity/scar
5: Cataract
6: Retinal disorder
7: Other cause
9: Undetermined cause
10: Missing UCVA, or UCVA ≤ 20/40
& missing BCVA

OD [ ][ ] If other, specify: ______________

OS [ ][ ] If other, specify: ______________

SECTION H: ACTION TAKEN

0: None indicated
1: Glasses prescribed & to be provided
2: Glasses prescribed only
3: On-site medical treatment given
4: Prescribed medical treatment
5: Referred to Eye Center
6: Other/Multiple actions

[ ] If other/multiple actions, specify: ______________

SECTION I: REASONS FOR NOT WEARING SPECTACLES (SPECTACLE WEAR NON COMPLIANCE). Please tick reasons why you do not like wearing your spectacles

1. Spectacles will sink in the eyes
2. Use spectacles at special occasion or time
3. Children should not wear spectacles
4. Do not feel spectacles are needed
5. Parents disapprove of use of spectacles
6. Forgot spectacles at home
7. Concerned or teased about appearance
8. Spectacles cause headaches

If other, specify----------------------------------

APPENDIX 2: UKZN BREC Approval letter for the study

APPENDIX 3: Letter to the Research and Ethics Committee Faculty of Health Sciences, Madonna University Nigeria for Permission to conduct a Research Study

Department of Optometry,
Faculty of Health Sciences,
Madonna University Nigeria,
31st March, 2016.

The Chairman,
Research and Ethics Committee,
Faculty of Health Sciences,
Madonna University Nigeria.

Dear Sir,

PERMISSION TO CONDUCT A RESEARCH

I, Dr Ezinne Ngozika from Department of Optometry do hereby write to request for your permission to conduct a research study titled: Refractive errors, visual impairment and utilization of spectacles among primary school children in Onitsha, Anambra State. This is part of the requirements for the approval of my proposal for a Master degree in Optometry at the University of KwaZulu-Natal, Durban, South Africa.

Thank you.

Yours Sincerely,

Dr Ezinne Ngozika E.

APPENDIX 4: **Permission Letter to the Education Secretary Onitsha (North and South) Primary school board**

Department of Optometry,

Faculty of Health Sciences,

Madonna University

Nigeria

The Director,

Anambra State Primary school board,

Dear Sir,

Permission to conduct a research in primary schools in Onitsha North and South Local Government area

I am Dr Ezinne Ngozi E., a lecturer from Madonna University, Nigeria, currently studying for a masters' degree in Optometry at University of KwaZulu-Natal, South Africa. I intend conducting research on the topic entitled: Refractive error, visual impairment and utilization of spectacles among primary school children in Onitsha North and South Local Government area, Anambra State.

The purpose of this letter is to seek for your permission to collect data from primary schools in Onitsha. The procedure involved will not cause any discomfort or injury for the children.

I will be grateful if my request is granted.

Yours Sincerely,

Dr Ezinne Ngozi E.

APPENDIX 5: Letter to the Headmasters/Headmistresses

Department of Optometry,

Faculty of Health Sciences,

Madonna University,

Nigeria

The Headmaster/Headmistress,

……………………………………..

……………………………………..

Dear Sir/Madam,

Permission to conduct a research in your school

I am Dr Ezinne Ngozi E., a Lecturer from Madonna University Nigeria, currently studying for a masters' degree in Optometry at University of KwaZulu-Natal, South Africa. I intend to conduct research on the topic entitled: Refractive error, visual impairment and utilization of spectacles among primary school children in North and South Local Government area, Anambra State.

The purpose of this letter is to seek for your permission to collect data on children from your school.

I will be grateful if my request is granted.

Yours sincerely,

Dr Ezinne Ngozi E.

APPENDIX 6: INFORMED CONSENT FORM

Child name: **School:** **Grade:** **class**

Principal investigator: Dr Ezinne N.E

I am Dr Ezinne Ngozika Esther a master degree program in Optometry student at University of KwaZulu-Natal Durban, South Africa. I am studying how well children in primary schools in Onitsha see.

An ability to see clearly on the chalk board and read is very important for a child to do well at school. Therefore, a child who does not see well may not perform well.

Some eye problems may exist without a child knowing or children may not know how to describe their eye problems properly, hence the need to perform some eye testing in schools. These eye testing will enable the research team to identify the children that will need help with spectacles or other treatments.

Again, in Anambra state, Nigeria, the government does not know the number of children with eye problems that could affect school performance therefore, it is difficult for the government or any organization to know the extent of the problem and plan intervention.

Purpose: This is to know how many school children that may be having such eye problems. This will help the government or school authorities in planning good eye care services for school children. To obtain such important information I invite your child/ward to participate in this study.

Confidentiality: The results from the study will be kept secret and will not be given to anyone outside the study. Your name and your child or ward's name will never be used in any report.

Right to refuse or withdraw: Your child's participation is by free will and he/she can withdraw from the study after having agreed to participate. Your child/ward is free to refuse any part of the examination. I assure you that the study will not involve putting any harmful thing in their eyes and no form of the test will cause discomfort to them. You are welcomed to ask questions any time and be assured that all your questions will be answered to your satisfaction. You may contact the following too: The Biomedical Research Ethics Committee (BREC) of University

of Kwa-Zulu Natal, South Africa. This committee's task is to make sure that your child/ward as a research participant is protected from harm. If you wish to find more about BREC contact: Ezinne Ngozi, +234 70 62982372, Madonna University, Nigeria, ezinne.ngozi@gmail.com
This study has been approved by Biomedical Research Ethics Committee (BREC) of University of Kwa Zulu-Natal, Durban, South Africa.

APPENDIX 7: Consent Letter

My child has been invited to take part in the research entitled: Refractive error, visual impairment and utilization of spectacles among primary school children in Onitsha area, Anambra State. I have read the information provided to me or it has being read to me and I understand it very well. I have had opportunity to ask questions about it and all my questions have been answered to my satisfaction. I consent voluntarily to my child/ward's participation as a subject in this study. I understand that my child/wards has the right to withdraw from the study at any time without it in any way affecting his/her medical care

Name of Parents/Guardian: --

Signature------------------------------------- Date:----------------------

If illiterate

Name of independent literate witness:----------------------Signature-----------------------

Date: -------------------------------

Name of Researcher: ---------------------Signature------------ Date-------

Statement by the Researcher

I will provide verbal and/ or written information regarding this study/project

I agree to answer any future questions concerning this study/project to the best of my knowledge.

I will adhere to the approved procedure for this study.

Name of researcher: --

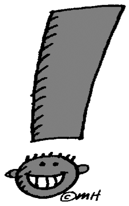
Signature: -- Date:-----------------------------

APPENDIX 8: Assent Form for children less than 12 years.

What is a research study?

Research studies help us learn new things. We can test new ideas. First, we ask a question. Then we try to find the answer.

This paper talks about our research and the choice that you have to take part in it. We want you to ask us any questions that you have. You can ask questions any time.



Important things to know…

- You get to decide if you want to take part.
- You can say ‘No’ or you can say ‘Yes’.
- No one will be upset if you say ‘No’.
- If you say ‘Yes’, you can always say ‘No’ later.
- You can say ‘No’ at any time.
- We would still take good care of you no matter what you decide.

Why are we doing this research?

We are doing this research to find out more about your eyes, if you have problems and how we can treat or manage it.

What would happen if I join this research?

If you decide to be in the research, we would ask you to do the following:

- We would give you some alphabets or numbers to read/identify for us at far and near.

- We would shine light that are not harmful in your eyes to see the inside part of your eyes.
- We would shine light in your eyes to know the movements of your eyes in different directions.
- We would ask you to read questions on a piece of paper. Then you would mark your answers on the paper.
- Talking: A person on the research team would ask you questions. Then you would say your answers out loud.

Could bad things happen if I join this research?

Some of the tests might make you uncomfortable or the questions might be hard to answer. We will try to make sure that no bad things happen.

We would put some drugs in your eye that will make you not able to read for some time up to a day.

You can say ‘no’ to what we ask you to do for the research at any time and we will stop.

Could the research help me?

We think being in this research may help you because we will be able to know if your eyes are normal or if you have problems with your eyes.

We do hope to learn something from this research though. And someday we hope it will help the government and your school authority to make plans on how to provide eye care services to other kids who have eye problems.

 **What else should I know about this research?**

If you don’t want to be in the study, you don’t have to be.

It is also OK to say yes and change your mind later. You can stop being in the research at any time. If you want to stop, please tell the research doctors.

To thank you for being in the study, we would give you a pencil

You can ask questions any time. You can talk to Dr Ezinne N.E any time. Ask us any questions you have. Take the time you need to make your choice.

 **Is there anything else?**

If you want to be in the research after we talk, please write your name below. We will write our name too. This shows we talked about the research and that you want to take part.

Name of Participant ____

(To be written by child/adolescent)

Printed Name of Researcher ____________________________________

Signature of Researcher ____

________________   ______________

Date   ***Time***

Interpreter Information ***(applicable if LEP participant)***

____

Printed Name of Interpreter during initial presentation of study

Date

____

Printed Name of Interpreter when translated form is presented

Date

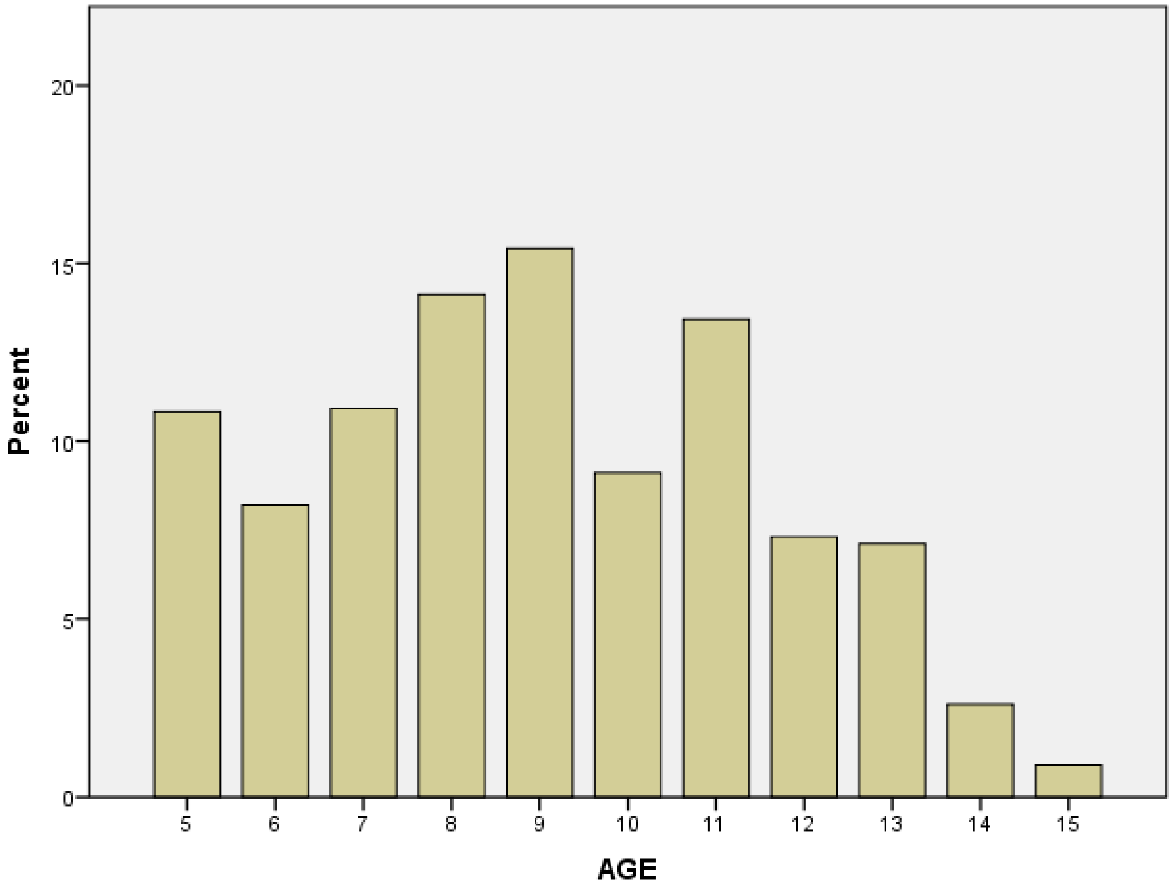
Original form to:

Research Team File

Copies to:

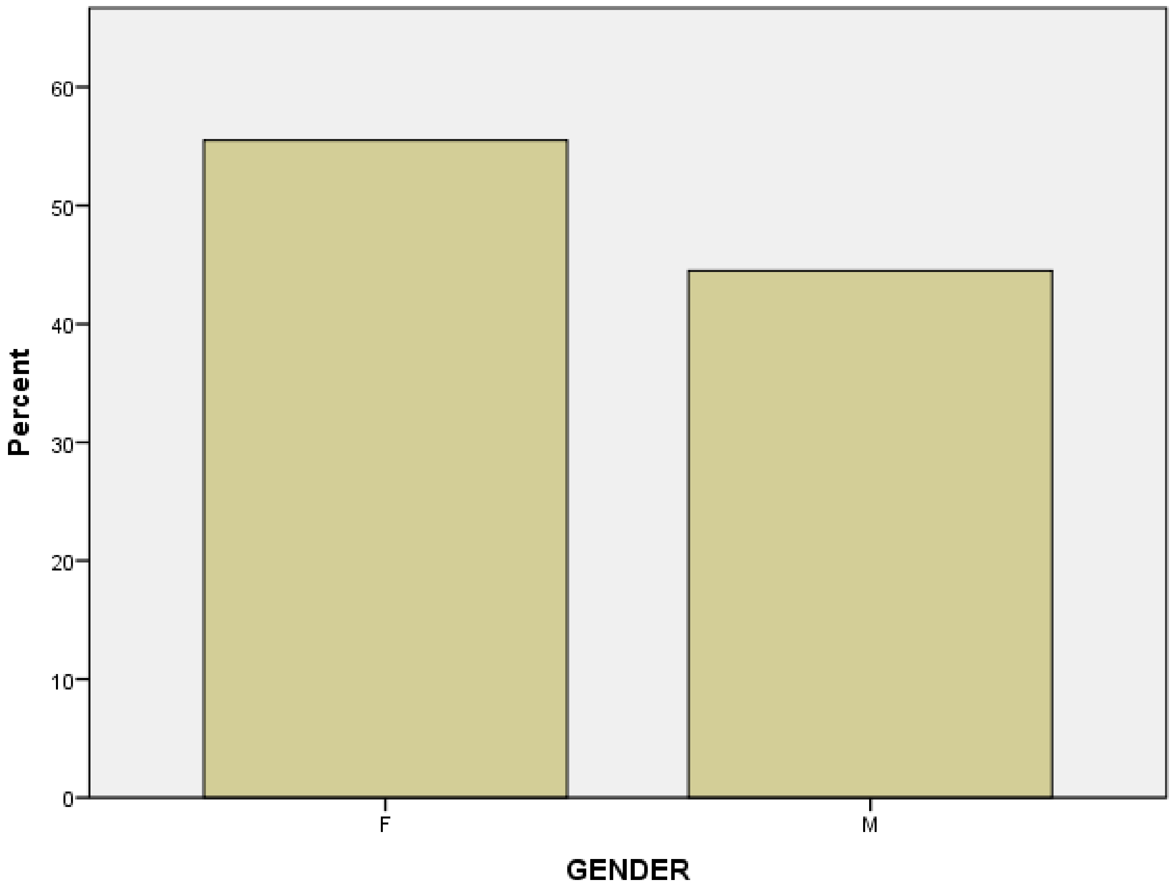
Parents/Guardians

FIGURE 1



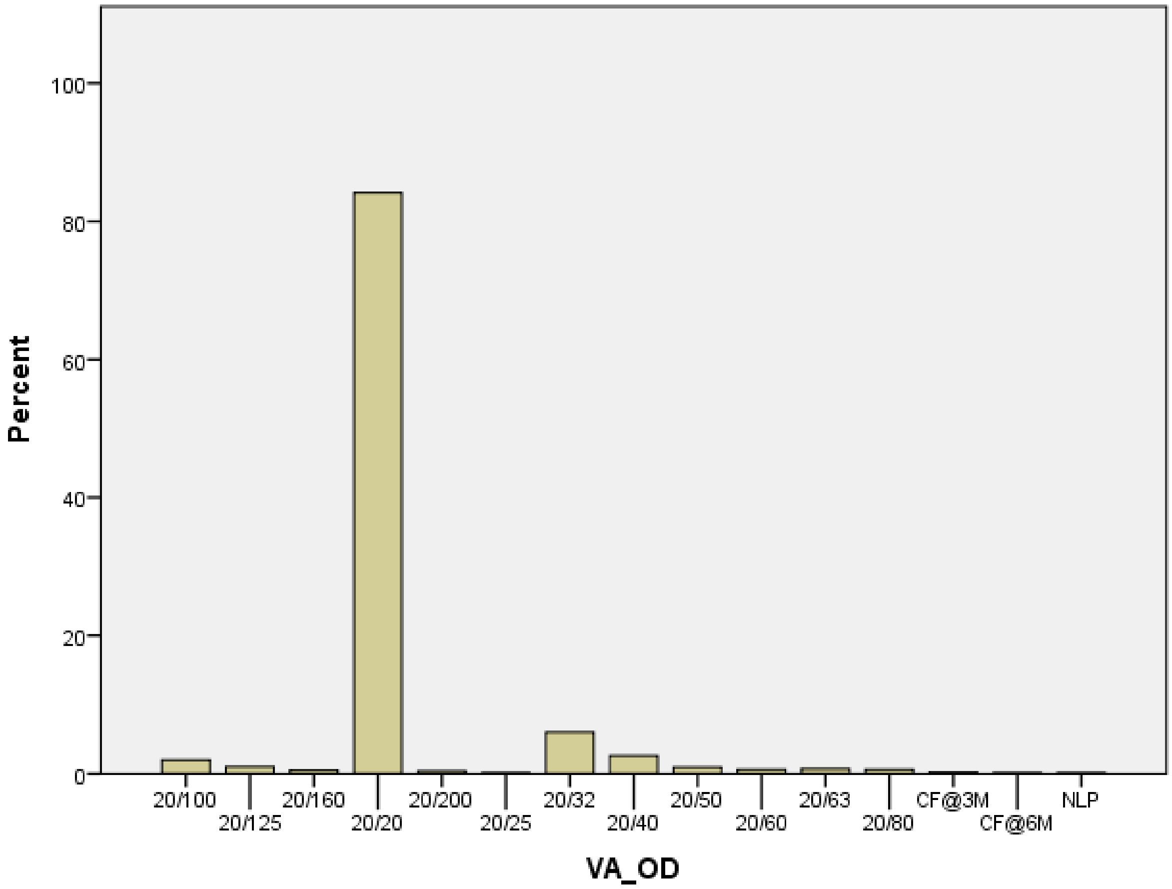
AGE DISTRIBUTION OF THE STUDY POPULATION

FIGURE 2



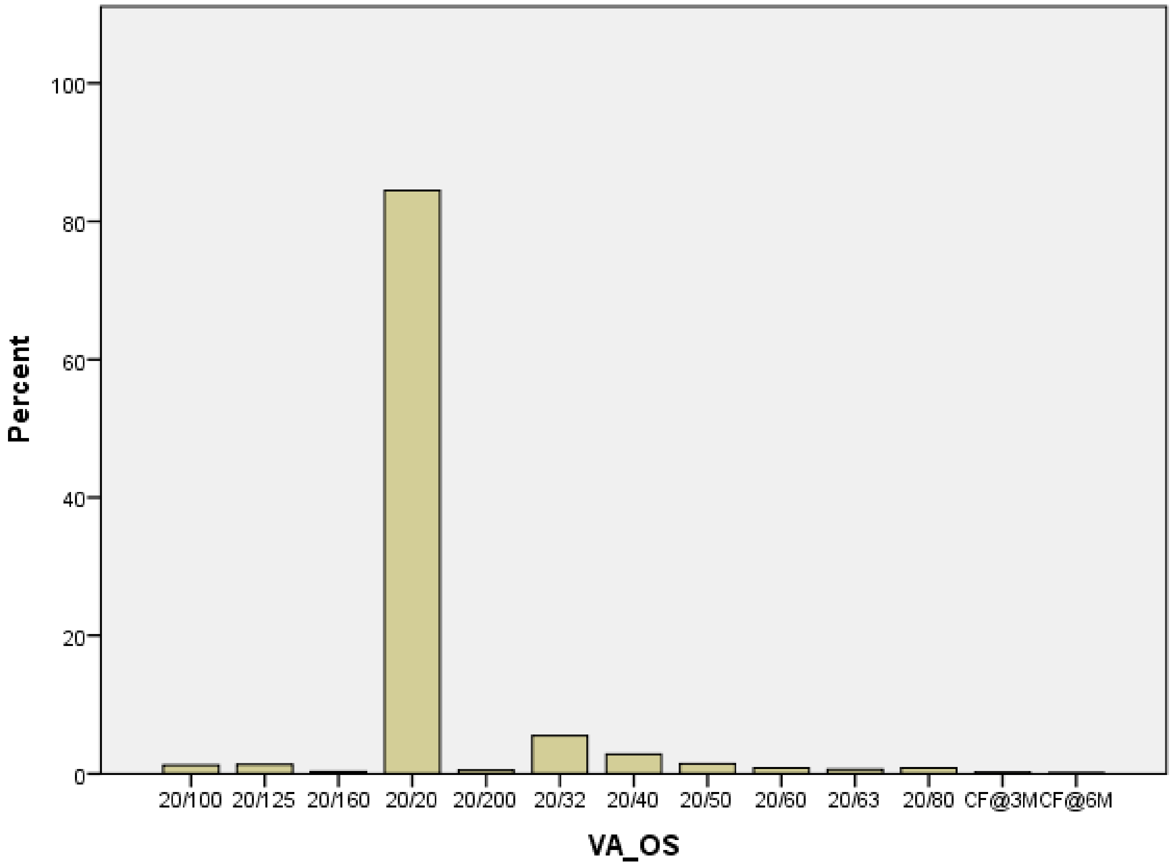
GENDER DISTRIBUTION OF THE STUDY POPULATION

FIGURE 3



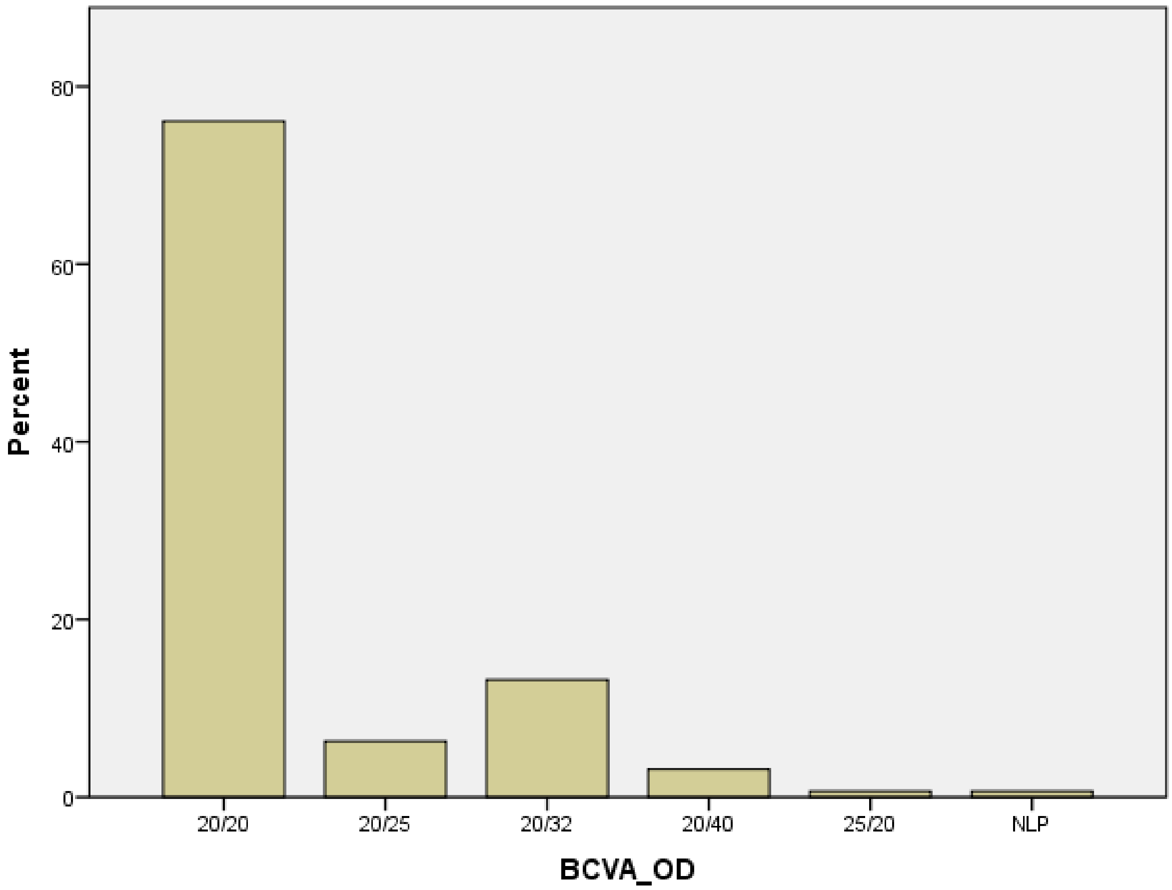
VISUAL ACUITY OF THE RIGHT EYES

FIGURE 4



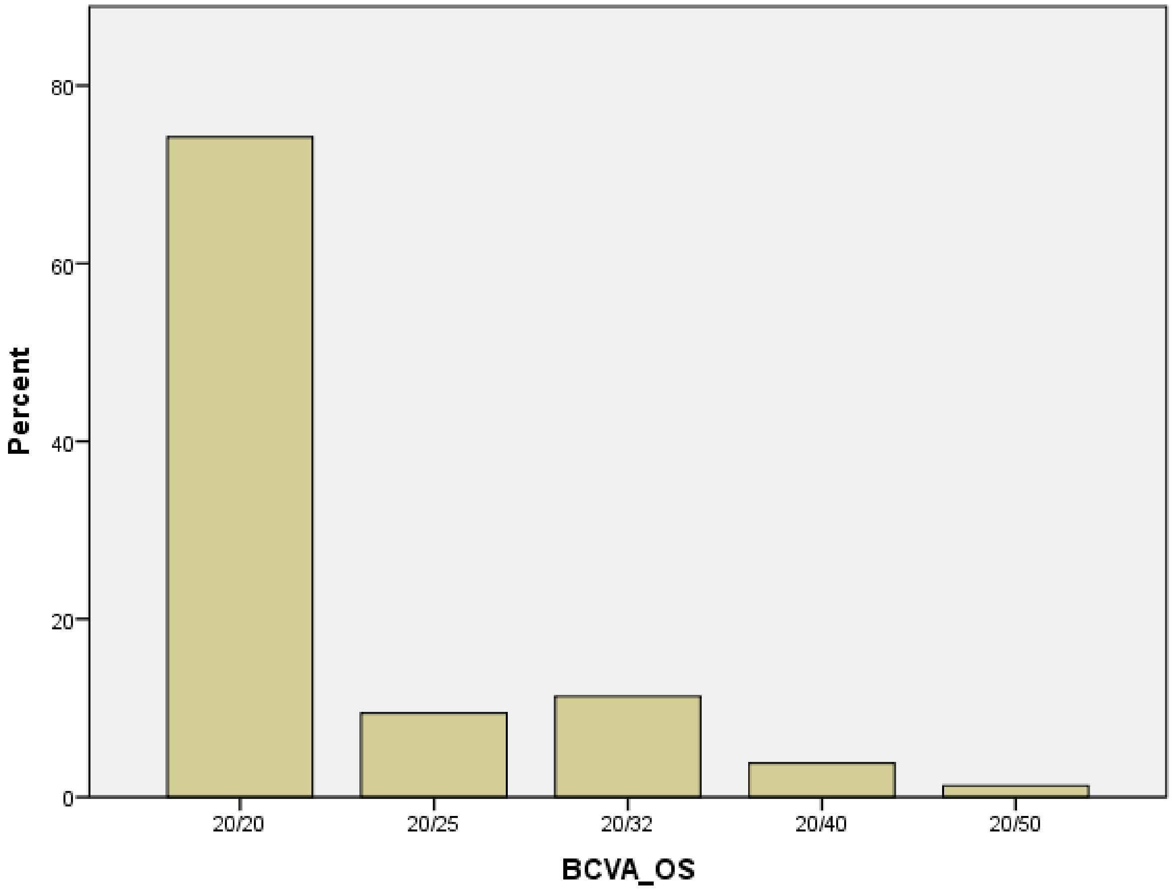
VISUAL ACUITY OF THE LEFT EYES

FIGURE 5



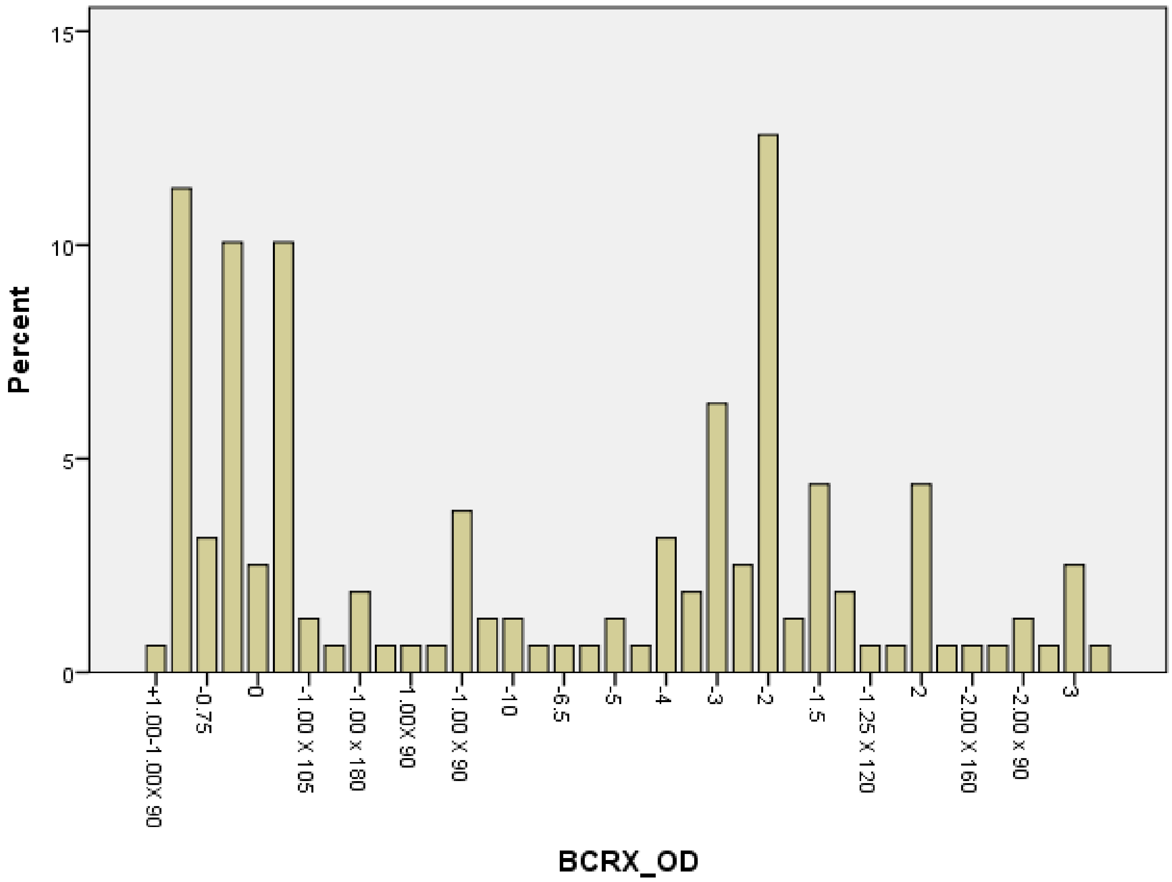
BEST CORRECTED VA OF THE RIGHT EYES

FIGURE 6



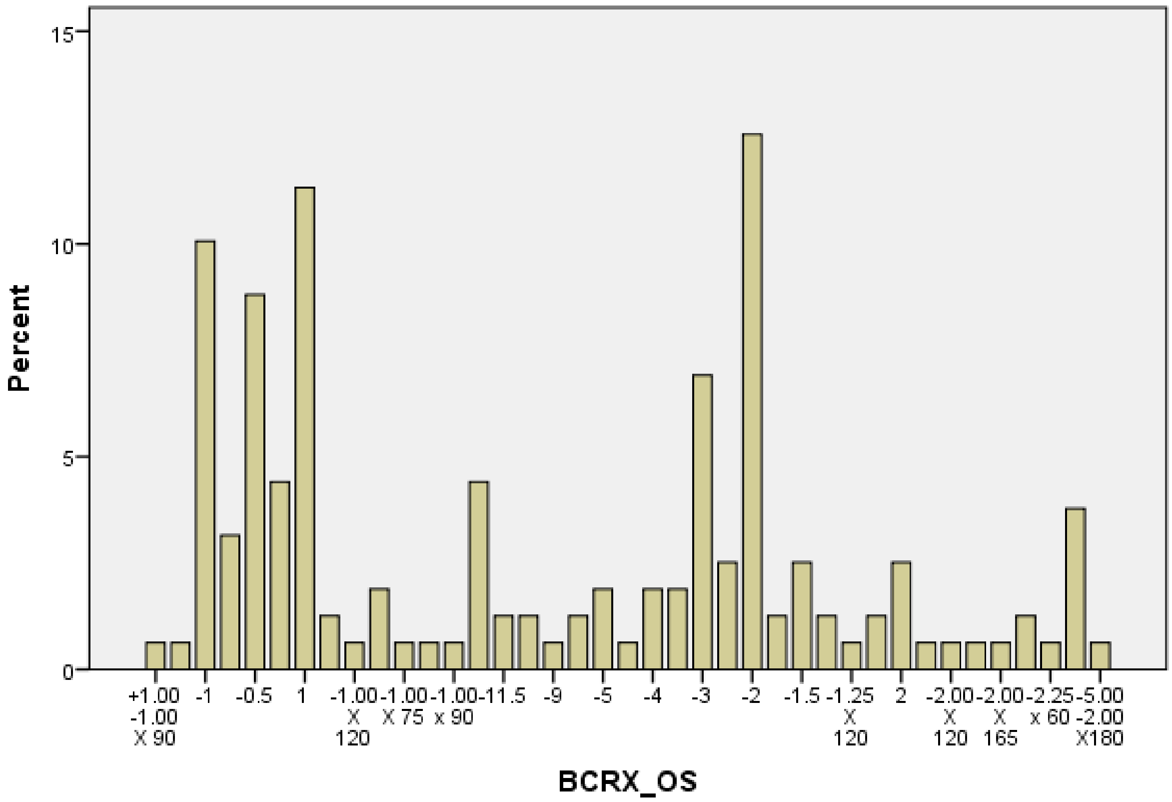
BEST CORRECTED VA OF THE LEFT EYES

FIGURE 7



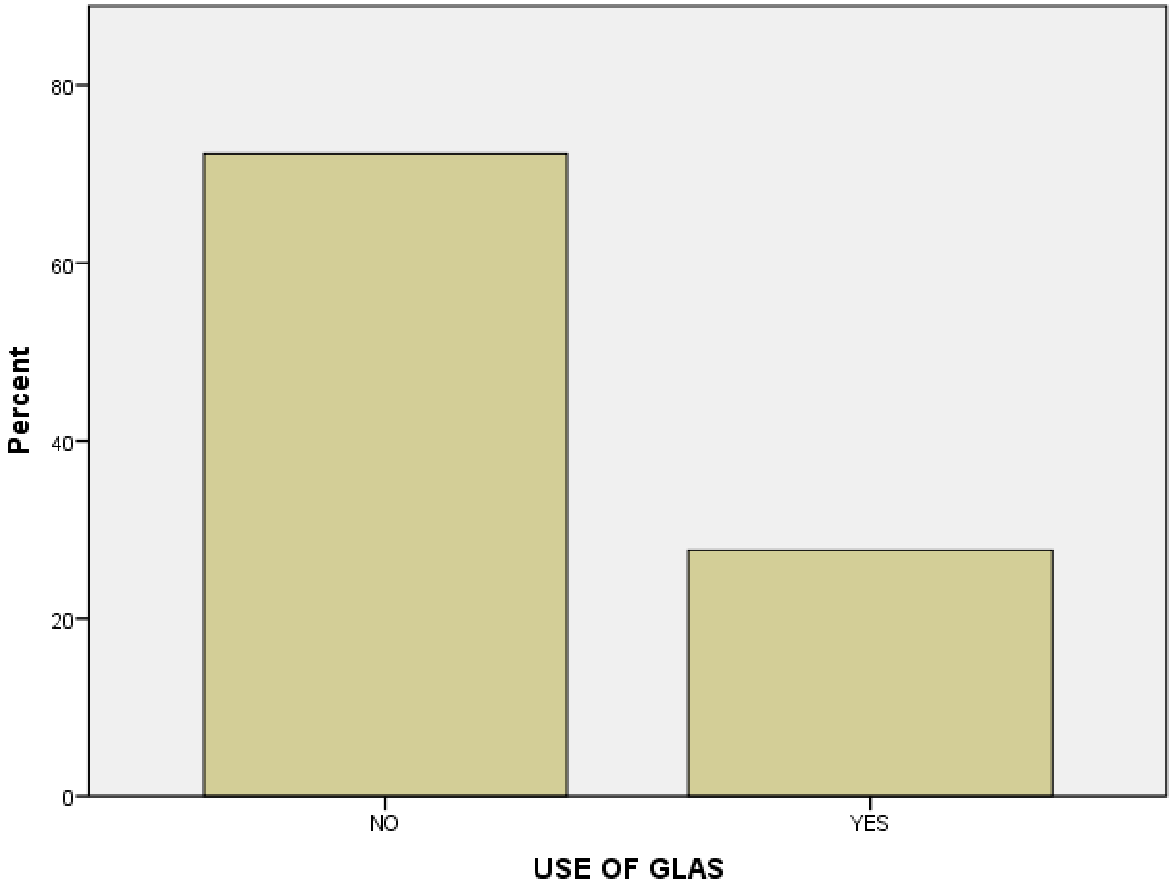
BEST CORRECTIONS ON THE RIGHT EYES

FIGURE 8



BEST CORRECTIONS ON THE LEFT EYES

FIGURE 9



USE OF SPECTACLES