PREVALENCE AND RISK FACTORS FOR MYOPIA AMONG SCHOOL CHILDREN IN ABA, NIGERIA

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DECLARATION

I, Uchenna Chigozirim Atowa, declare as follows:

1. That the work described in this thesis has not been submitted to UKZN or other tertiary institution for purposes of obtaining an academic qualification, whether by me or any other party.

2. That my contribution to the project was as follows:

- conception of the idea,
- study design and proposal writing,
- data collection and analysis,
- report writing.

3. That the contributions of others to the project were as follows:

a) Mr Alvin Munsamy and Dr Samuel Wajuihian,

- reviews and supervision,
- approval for submission.

4. Signed _____ Date_____

DEDICATION

In memory of my father, Sir Gideon E.N. Atowa

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ABSTRACT

During development, the growth of the eye is regulated by a visual guided process to maintain a balance between the axial length of the eye and its optical components, so that light rays from a distance should focus clearly on the retina. Myopia occurs when these structural changes are no longer proportional. Hence light rays from a distance are focused rather in front of the retina, resulting in a blurred distant image. There is no clear understanding of the exact mechanism for the development of myopia. However, both genetic and environmental factors have continually been associated with it. The aim of this study was to determine the prevalence and risk factors for myopia among school children in Aba, Nigeria.

This was a cross-sectional study conducted with children between the ages of 8 and 15 years attending primary and secondary schools in Aba. A total of 1261 children were recruited by a multi-stage random sampling method. Aba was divided into three cluster areas. One public primary and secondary school and one private primary and secondary school were each selected from each cluster area, making a total of 12 schools. Children aged between 8 and 15 years were recruited from each class of the participating schools by systematic random sampling. The number of participants selected from each class was proportional to the total number of students in each class. The selected children underwent a comprehensive eye examination and, together with their parents, completed a structured questionnaire. Data analysis was done using a statistical software package (SPSS for Windows, version 20.0, IBM-SPSS, Chicago, USA). Myopia was defined as spherical equivalent refraction (SER) ≥ -0.50 D in the worse eye.

Out of 1197 participants with complete relevant data, 55% were female and 45% were male; 51.5% attended private schools, and 48.5% attended public schools; 45.9% of the participants were in primary school, and 54.1% in secondary school. The overall mean age of the participants was 11.50 $\pm$ 2.3 (range 8 – 15). Participants were divided into two age groups: group 1 (8 – 11years) and group 2 (12 – 15 years).

The prevalence of myopia in the study sample was estimated to be 2.7%. Of the 96 children with refractive error, 78% were uncorrected. In multivariate logistic regression models, children in age group 2 (12 – 15 years) were more prevalently myopic than those in age group 1 (8 – 11 years) (Odds ratio (OR): 1.20; 95% confidence interval (CI), 0.16 - 9.11; $p < 0.010$); children in secondary school were more prevalently myopic than those in primary school (OR: 1.73; 95%CI,

1.05 – 2.86; p < 0.030). Children with a parental history of myopia were more likely to have myopia than those with no parental history of myopia (OR: 6.80; 95% CI, 2.76 – 16.74; $p < 0.001$) for one myopic parent and (OR: 9.47; 95% CI, 3.88 – 23.13; $p < 0.001$) for two myopic parents; children who spend more time reading (OR: 1.21; 95% CI, 1.03 – 1.42; $p < 0.020$) and children who spend less time outdoors (OR: 0.8; 95% CI, 0.74 – 0.87; $p < 0.001$) also have greater odds of developing myopia. There was no significant difference in the prevalence of myopia between male and female participants (p=0.899). The odds ratio of 9.47 (95% CI 3.88 – 23.13) for children with two myopic parents, compared with children with no parents with myopia, was three times higher than the odds ratio for any other risk factor associated with myopia in the present study. Risk for myopia was most significant associated with parental myopia in the study sample. Other factors associated with myopia included older age, more time spent on reading, less time spent outdoors, and an increased level of educational attainment.

With the high prevalence of uncorrected refractive error in the study sample, it is recommended that regular vision screening exercises be integrated into the school health programme to improve access to eye care among the school children.

Key words: Myopia, visual impairment, blindness, cross-section, prevalence of myopia, risk factors for myopia, school children, uncorrected refractive error, comprehensive eye examination, vision screening.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

In a normal (emmetropic) eye, parallel rays of light from optical infinity should be brought to a point focus on the retina; but in a myopic eye, the parallel rays of light from optical infinity focus in front of the retina. The posterior principal focus thus formed, lies in front of the retina, resulting in blurred distance vision. Conversely, the point conjugate with the retina (that is, the far point of the eye) with accommodation relaxed is located at some finite point in front of the eye, making near vision clearer. Myopia or nearsightedness is therefore a vision condition in which close objects are seen clearly, but far objects appear blurred.[1,2,3]

A

B
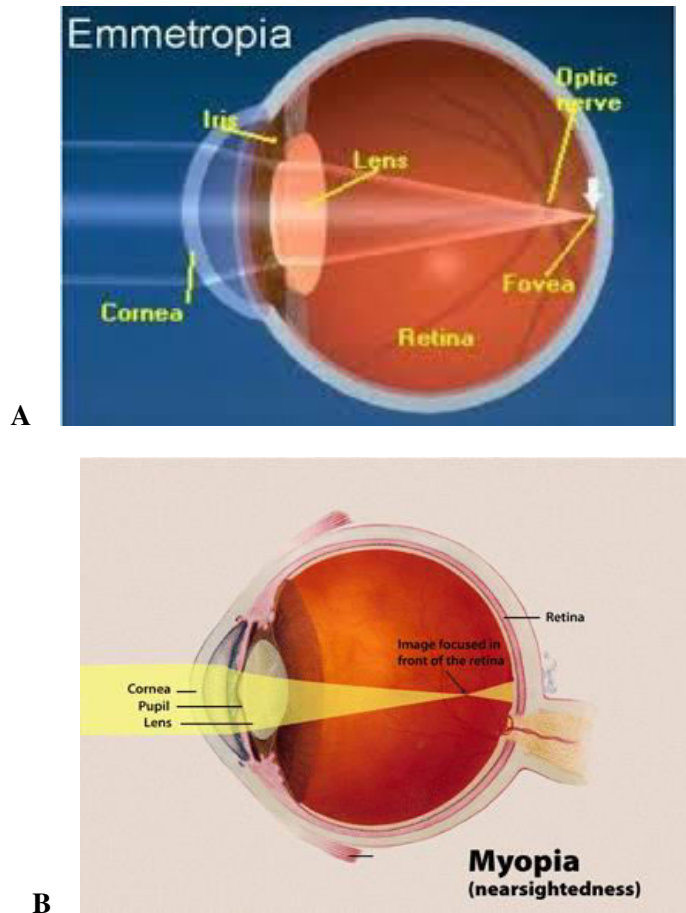
Figure 1.1. Emmetropic (A) and myopic (B) eyes.[5]

The most common symptom of myopia is blurred distant vision, often associated with straining and excessive blinking of the eye.[2,4] However, a higher degree myopia is associated with pathological signs such as: tilting of the optic disc, vitreous liquefaction and posterior vitreous detachment, peripapillary atrophy appearing as temporal choroidal or sclera crescent known as myopic crescent, sub-retinal haemorrhages, retinal hole and lattice degeneration. Other signs include: thinning of the retinal pigment epithelium with resulting atrophic appearance of the fundus, ectasia of the sclera posteriorly (posterior staphyloma), Fuch's spots (pigments, circular lesions secondary to sub-retinal neovascularization and haemorrhage) and retinal detachment.[2,5]

Generally, myopia is classified as pathological and non-pathological myopia. Non-pathological myopia (also known as physiological, simple or school myopia) is more common than other types of myopia.[6] In physiological myopia, the refractive structures of the eye develop within normal limits. However, as the eye grows, an inadequate correlation occurs among the refractive components[7] (which include the cornea, crystalline lens and the axial length). The degree of physiological myopia is generally less than –6 D in many patients.[2,6]

Pathological myopia (also referred to as degenerative, malignant or progressive myopia) was defined by Duke-Elder and Adams[3] as 'those refractive anomalies determined by the presence in the optical system of the eye of an element which lies outside the limits of the normal biological variations'. It usually presents early in childhood and is generally progressive. The degree of pathological myopia is usually higher (greater than –6 D) with axial length greater than 26.5mm.[6] These types of myopia have been reported as one of the main causes of visual impairment.[8]

Myopia is measured by the spherical power in diopters (D) of the diverging lens needed to focus light onto the retina, which can be expressed as a spherical equivalent or refraction in the least myopic meridian.[7,9,10]

1.2 BACKGROUND INFORMATION

Myopia is a common eye disorder affecting 85% – 90% of young adults in some Asian countries such as Singapore and Taiwan[11,12] and between 25% and 50% of older adults in the USA and Europe.[13,14] Myopia prevalence has increased over the past several decades, leading to a growing concern among the public and scientific community;[15,16] it is now estimated to affect around 1.6 billion people worldwide, with numbers expected to climb to 2.5 billion by 2020, according to the Institute of Eye Research.[17] In the USA, the prevalence of myopia between 1999 and 2004 was

two-thirds higher than it was between 1971 and 1972.[18] The prevalence of myopia in Taiwanese schoolchildren was 6% in 7-year olds in 1980, with the prevalence increasing to more than 70% by age 15 years.[19] In South Africa, children showed a lower rate of myopia prevalence of 4.0% that, however, started from age 14 to increase to 9.6% by age 15.[20]

Myopia is often found in children between the ages of 8 and 12 years old; it typically progresses until about age 20.[21,22] During the teenage years, when the body grows rapidly, myopia may become worse.[23] The mean rate of progression in children of 8 – 12 years of age is −0.5 D/year for Caucassian[24], −0.6 D/year for Hong Kong Chinese[25] and −0.8 D/year for Asian children, according to meta-analysis.[26] It follows that the earlier the onset, the longer the period of progression and the faster the progression.[21] Between the ages of 20 and 40 years, there is usually minimal change.[27]

Myopia is often taken as a seemingly benign disorder, a minor inconvenience that poses little or no risk to the health of the eye, for which spectacles, contact lenses and surgical procedures could remedy the blurred distance vision.[28] In certain instances, myopia can be so progressive and severe that it is considered a degenerative condition.[29] High myopia (greater than −6 D may be associated with glaucoma, cataract, retinal degeneration, myopic macular degeneration and retinal detachment.[1,2] These risks increase steeply with each diopter (D) of myopia.[30,31]

The yearly incidence of retinal detachment has been estimated as 0.015% in patients with < −4.74 D myopia and increases to 0.07% in patients with myopia ≥ −5 D and 3.2% in patients with myopia ≥ −6 D[32,33] The risk of developing macular neovascularization ranges from twice for patients with −1 D to −2 D of myopia, and 4 times with −3 D to −4 D of myopia, to nine times for those with −5 D to −6 D.[34,35] The Blue Mountains Eye Study showed that glaucoma was present in 4.2% of eyes with low myopia and 4.4% of eyes with moderate to high myopia, compared with non-myopic eyes.[36]

There is an enormous public health and economic impact from myopia.[13] Direct cost related to the correction of myopia, including refractive surgery, is estimated to be in excess US$150 million in Singapore[37] and about US$12.8 billion annually in the USA.[38] There are also indirect costs associated with the treatment of myopia complications such as retinal detachment and related corneal ulcers.[39] The armed forces spend huge amounts of money on pilot training, but pilots may not be able to continue flying if they develop myopia.[13] Spectacles are the primary choice of

correction, especially for children. For some individuals, contact lens may offer better vision than spectacles by offering a wider field of view and clearer vision.[21]

1.3 STATEMENT OF PROBLEM

The Nigerian National Blindness and Visual Impairment Survey identified uncorrected refractive error as the most common cause of mild and moderate visual impairment (77.9% and 57.1% respectively).[40] However, many children in underserved and under-resourced-communities are not aware of it until their vision has greatly deteriorated.

A child with myopia may need to sit in front of the classroom to be able to see clearly, hold books very close, seems to be unaware of distant objects, blinks excessively, rubs his or her eyes frequently, and experiences persistent straining.[23] Furthermore, children with higher degrees of myopia have a greater risk of developing sight-threatening complications that could lead to permanent visual impairment, with a considerable impact on learning, achievement and quality of life.[21,31]

As mentioned above in earlier sections, several myopia risk factors have been identified as probable causes of myopia.[10,21,41] At the same time, several authors have found the prevalence of myopia to vary from one geographical location to another.[21] Therefore, understanding how these risk factors influence the development and progression of myopia in these locations should be central to preventing the progression of myopia and thus reducing the morbidity associated with it.[10,13,15]

In spite of the consequences of uncorrected myopia, data on prevalence and risk factors for myopia in sub-Saharan Africa are limited.[40,42,43] To the best of my knowledge, no Refractive Error Study in Children (RESC) studies have reported on the prevalence and risk for myopia in school children in Aba. The present study is intended to provide information on refractive errors and associated risk factors that is necessary for effective and efficient eye health planning and education.

1.4 RESEARCH QUESTIONS

The research questions in this study are:

1. What is the prevalence of myopia among school children between the ages of 8 and 15 years in Aba, Nigeria?

2. Does an association exist between myopia and age and gender

3. Does an association exist between environmental factors (near work, level of education, outdoor time and socioeconomic factors) and the development of myopia in school children in Aba?

4. Is there a relationship between family history of myopia and the development of myopia in school children in Aba?

1.5 AIM AND OBJECTIVES

1.5.1 Aim

The aim of the study was to determine the prevalence and risk factors for myopia in school children in Aba, Nigeria as at June 2015.

1.5.2 Objectives

1. To estimate the prevalence of myopia among school children in Aba between the ages of 8 and 15 years.

2. To study the association between myopia and age and gender

3. To investigate the association between myopia and environmental factors (near work, level of education, outdoor time and socioeconomic factors) in school children in Aba, Nigeria using a questionnaire.

4. To examine the relationship between family history of myopia and the development of myopia in schoolchildren in Aba, Nigeria using a questionnaire.

1.6 SIGNIFICANCE OF THE STUDY

1. Parents, teachers, students and the larger community will have a better understanding of the effects of environmental and hereditary factors on the development and progression of myopia.

2. Data from the study will be useful to both the Departments of Health and Education in drawing up plans for schools' vision screening programmes.

3. The study will highlight the importance of regular vision screenings and ocular heath education in schools.

4. The results will benchmark data for future research in this area.

1.7 TYPE OF STUDY AND STUDY METHODS

This was a population based observational study (descriptive and analytical), using cross-sectional sampling methodology to provide quantitative data by employing the use of probability sampling method in selecting participants. The study population included schoolchildren aged 8 – 15 years attending primary and secondary schools in Aba. A total of 1261 school children were recruited from 12 schools (public and private) through a systematic random sampling method.

The research instruments used were cycloplegic refraction and questionnaire. The vision assessment was based on the children RESC protocol with specific modifications to serve the purpose of this study as well as the availability and affordability of instruments. The questionnaire included questions on spectacle use and family history of myopia; questions on parents' education and occupation; questions on near vision work and physical activity during and after school such as number of hours spent reading, writing, watching television, playing video games; and number of hours spent indoors and outdoors. The questionnaire was used to gather data for the time spent on these activities for weekdays and weekends. The study methods will be discussed in detail in Chapter Three (Methodology).

1.8 STUDY OUTCOMES

The study outcomes are the prevalence of myopia and the association between myopia and genetic and environmental factors

1.9 DEFINITION OF TERMS

1.9.1 Prevalence: This concept refers to the total number of cases of a disease condition that are present in a specific population at a specific time and is usually expressed as a fraction or as a percentage.

1.9.2 Risk factor: A risk factor is any variable, attribute, characteristics or exposure of an individual that increases his/her chances of developing a disease. In the present study, the risk factors included genetic factors such as family history of myopia, and environmental factors such as near work activities, time spent outdoors and indoors, and socioeconomic status of parents.

1.9.3 School children: These are children attending primary and secondary schools in Aba. Mostly between the ages of 6 and 18 years

1.9.4 Myopia: For the present study, myopia was defined as spherical equivalent refraction (SER) refraction ≥ -0.50 D.[41,44,45]

1.10 STUDY OUTLINE

The study focused on the variables associated with the prevalence of myopia among school children.

Chapter 1 (Introduction): The background information as well as, the rationale for the study are discussed here. The research questions, objectives of the study including its significance are also presented.

Chapter 2 (Review of previous studies): Recent studies on prevalence and risk factors for myopia are discussed here with emphasis on the methodology, findings and limitations of the studies as well as their recommendations for future research areas.

Chapter 3 (Methodology): The sample population and the sampling method for the study design are stated in this chapter. The measuring instruments and the data collection processes are clearly described including the statistical methods that were applied in analyzing the findings. Problems that were encountered in the course of data collection and how they were resolved are also mentioned.

Chapter 4 (Results): The research findings are presented in a table form. The relationships between genetic, environmental and prevalence of myopia were analyzed. The odds of developing myopia for each of the variables were calculated.

Chapter 5 (Discussion): An in-depth analysis of the findings was done by comparing the results with those of previous studies in this area, and deductions were made from facts and figures presented.

Chapter 6 (Summary and conclusion): This chapter summarizes the entire research study. A valid conclusion is drawn, based on the findings and comparison with previous studies. Limitations which may affect the generalization of the findings are equally stated. Finally, recommendations are made on how society can benefit from the study and on future research areas.

1.11   SUMMARY

Chapter One presents a general introduction to the study. It begins with the definition of myopia, the symptoms and a broad classification into pathological and non-pathological myopia. Following this, is background information to the study, a statement of problems, research questions, aims and

objectives, significance of the study, study design and outcomes including an outline of the other chapters.

The next chapter concerns the review of some studies on myopia's development, prevalence and risk factors, with emphasis on studies done with children as participants. The review focuses largely on the study design, the sampling method, the use and non-use of cycloplegia and cut-off points applied to define myopia. The chapter also reviews the association between myopia and associated risk factors such as age and education, near work, outdoor and indoor sports and physical activity, gender and urban distribution, family history of myopia and dietary factors.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The focus of the present chapter is on the review of previous studies on prevalence and risk factors for myopia. The chapter commences with discussion on various theories of the development of myopia. This is followed by a review of prevalence of myopia across countries and regions with focus on studies conducted using children as participants. Similarly, studies on myopia risk factors such as age, education, near work, indoor sports and outdoor activities, gender, rural-urban distribution, socioeconomic factors, family history and dietary factors were also reviewed. Lastly, an overview of myopia control strategies is presented.

2.2 AETIOLOGY OF MYOPIA

2.2.1 Emmetropization

Children are usually born with some amount of hyperopia, but this hyperopia decreases towards emmetropia as they grow.[46,47] Ingram and Barr[12] state that if a child is born with less than +2.50 D of hyperopia, the tendency is for the child to become emmetropic. The change is caused by the appropriate proportional interactive changes of the dioptric components and axial length. Myopia develops in children when these changes are no longer proportional.[48] For this reason, some researchers believe that myopia is acquired rather than inherited.[50] Mutti et al[48] found that myopia develops in children when the lens stops compensating for the continued growth of the eye. They found that, in children without myopia, the lens grew thinner and flatter to maintain normal vision as the eye grew. However, in children who developed myopia, the lens stopped changing in response to eye growth. The authors stated that 'the onset of myopia is really the sudden occurrence of an imbalance between the growth of the eye and the development of the crystalline lens'.[48]

The active process mechanism theory proposes that emmetropization is regulated by the retinal image[50] which involves the defocus detection and a coordinated growth of the refractive components of the visual system towards emmetropia with active structural changes.[51]

As the eye grows, more lens fibres are added, and the lens becomes thinner and flatter by stretching in the equatorial plane. The lens thins and loses power to compensate for the increasing axial length, and maintains emmetropia.[52,53] When the lens fails to stretch and thin, the eye becomes myopic while the eyeball shape becomes more prolate (egg-shaped). The cause of the interruption of the equatorial expansion is still unknown.[48,54]

The development of myopia causes a greater increase in the anteroposterior length over the transverse dimension, resulting in relatively hyperopic defocus in the peripheral vision, along the lateral dimensions further from the macula as shown in Figure 2.1. The peripheral vision in the myopic eye becomes hyperopic and could potentially trigger the active process of emmetropization.[55] Local retinal regions can control local eye growth and could lead to the progression of corrected myopia.[56] The peripheral refractive status of the eye can affect eye development, and especially the progression of myopia.[57] A study found that 90% of textile factory workers involved in controlling product texture who were emmetropic with peripheral hyperopic defocus before starting work become myopic over time at their work.[58] Hyperopic eyes are usually myopic in the periphery, raising the possibility that the peripheral focus could lead to potential eye growth.[59]
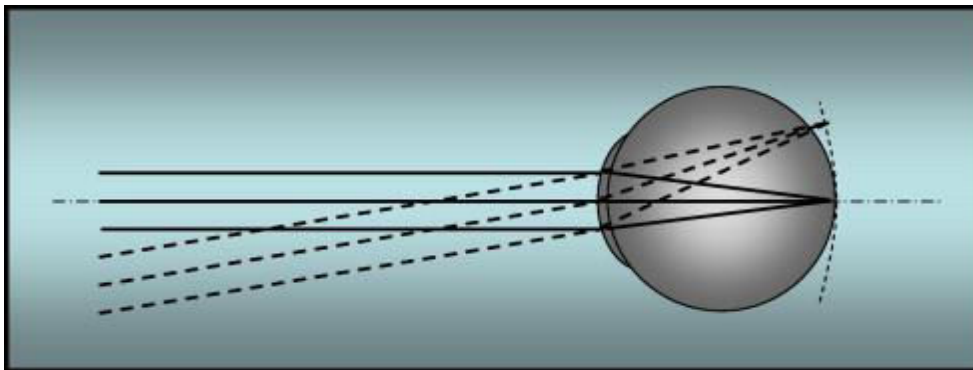
Figure 2.1. Emmetropic eye with relative hyperopic defocus on the periphery.[60]

2.2.2 Accommodation

The use-and-abuse theory proposed that myopia onset was an adaptation to use and abuse of the eyes during sustained near vision.[46] The theory was first described by Cohn in 1886 and has been traced back to Kepler.[61] The assumption is that sustained near vision focusing is somehow indirectly responsible for the increase in axial length of the eye.[46,61] This argument may be

indirectly supported by the evidence that myopes exhibit a greater lag of accommodation.[61] This lag of accommodation results in hyperopic defocus on the retina and is assumed by some to be a link between near vision work and myopia progression. Sustained periods of near vision work compound the exposure to this defocus, which pushes the focal plane behind the retina, thereby causing myopia. The eye becomes more prolate by growing axially, with the posterior pole protruding; this extends the area of peripheral retina that receives hyperopic defocus elongation, furthering the growth cycle.[62,63] A study by Gwiazda et al.[64] demonstrated that children with higher degrees of myopia also had greater accommodative lag, but those children were already myopic before being enrolled in the study.

Conversely, a more recent study by Mutti et al.[65] showed no changes in accommodative lag prior to the onset of myopia; moreover, accommodative lag was only documented in children after the onset of myopia. The authors concluded that 'accommodative lag may be a consequence rather than a cause of myopia and is unlikely to be a predictive factor'.[65]

2.2.3 Genetic predisposition

It has been suggested that the development of ametropia is the result of genetic inheritance of an abnormality in one of the variables of the dioptric components.[66] Twin studies, segregation analysis, familial aggregation studies and, more recently, genome-wide association studies (GWAS) have seemingly added weight to the genetic basis of myopia.[13,41]

Twin studies have shown a high heritability index varying from 75% to 94%.[60] Heritability can be defined as the proportion of variance of a disease or trait owing to an addictive genetic factor.[13] A recent large sample of monozygotic and dizygotic twins provided an estimate of a heritability index of 77%. Some studies have also reported an increase of refractive error proportional to the refractive components in monozygotic twins compared with dizygotic twins.[67] He at al[68] also estimated a high contribution to axial length (AL) and anterior chamber depth (ACD) and angle opening distance in twins from Guangzhou Registry. While twin studies might have provided evidence that myopia is inherited,[67] it will be too quick to draw conclusions solely on higher heritability values, based on the potential differences in the degree to which environments are shared between monozygotic and dizygotic twins.[69] Mutti et al.[70] suggested that monozygotic twins may share a more similar environment, and that this may erroneously increase heritability estimates.

Several genetic reports have noted that children with myopic parents are more likely to have myopia than those with non-myopic parents.[67,70] Those who have two myopic parents are mostly at a higher risk than those who have only one.[13,67] In Taiwan, Liang and colleagues found in individuals aged between 17 years and 45 years that AL was greater than 20% in those with myopic parents (both parents had myopia) compared with only 8% in individuals with no myopic parents.[71] Mutti et al. also cited rates of 40%, 20% ─ 25% and 10% for children who had two myopic parents, one myopic parent and no myopic parents respectively.[70]

Multiple myopic loci have been identified, establishing myopia as a common complex disorder;[72] however, the exact mode of inheritance has not been identified.[13,67] The role of heredity is postulated to be more significant in persons with a higher degree of myopia.[13] The findings of Liang et al.,[69] which show that parental high myopia was predictive of earlier onset and a higher degree of myopia, appear to support the hypothesis that early-onset of high myopia has a strong genetic component, whereas later onset and often lower degree of myopia is more probably influenced by environmental exposures.

The increase in prevalence of myopia as observed in some countries such as Taiwan, Singapore and Hong Kong may not be entirely of genetic origin. There may be an interaction between genetic and environmental factors such that certain people who are genetically predisposed to myopia are more prone to environmental risk factors of myopia.[13,60,67] However, Morgan and Rose, in a comprehensive review of literature, argue that the supposed genetic and environmental interaction in the development of refractive error may be the result of shared environmental factors, with only a minimal contribution from shared genes.[73]

2.2.4 Environmental influences

The environmental risk determinants implicated in myopia development are near vision work, lack of physical activity, light exposure, diet, a higher level of education, socioeconomic status and urbanization.[61,70,74] Among these variables, near work is most frequently associated with the development of school-age myopia.[10,13, 41] Near vision work involves tasks of high accommodative demand, such as reading, writing, computer work and close television viewing.[41,75] The strongest correlation with near work is education.[76] Studies of the effect of reading have attempted to show a more direct relationship between myopia and near work activity. Children with myopia spent more

time studying and reading, and less time playing sports, than children without myopia.[69] However, the results of these studies have not been conclusive.[69,77]

There has been an increase in educational attainment, especially in developed nations, with an accompanying increase in the prevalence and progression of myopia.[78] An increase in myopia incidence was recorded in Arctic regions of Alaska and Canada that coincided with the establishment of compulsory schooling after World War II and with an increase in exposure to near vision work.[13,79] A higher prevalence of myopia has also been reported among college graduates as compared with other people in the same age group.[80] Results from studies on similar and comparable protocols have shown that 5-year-old children from various countries have very few refractive errors and that, depending on the schooling and learning system, those children developed myopia, with a low percentage (0.3%) in Nepal and 70% in China.[81,82,83]

Rapid technological inventions have increased the complexity of the near work question; many children nowadays use display terminals for computer-aided instruction, cellular and smart phones and video games, as well as increased television viewing.[69] The rise in myopia prevalence in East Asia reported in some studies may be attributed to an increase in the use of modern electronic devices over the past 20 years.[13,84] Nevertheless, a strong relationship has not been fully established between the use of electronic devices and the development of myopia, and more work needs to be done in this area.[84]

Understanding that geographical location influences the distribution of refractive errors, many studies have been conducted to determine whether environmental or hereditary factors have any contribution in refractive error distribution. Most studies have shown a variation in rural-urban distribution, with many of them reporting greater prevalence in urban areas.[85,86,87] For example, Garner et al.[87] measured refractive error in two groups of students coming from a similar genetic background, but residing in distinct urban and rural setting. The researchers found that students in urban Kathmandu had a 21.7% prevalence of myopia than the rural Solu Khumbu region (2.9%). While both groups attended compulsory schooling, the researchers postulated that the students in Kathmandu were exposed to a near work association with myopia, insofar as differences in the intensity and duration of study are experienced by students in rural and urban education settings. However, there are other factors in addition to study intensity and duration that differentiate between children living in rural and urban environments. These include exposure to television and computers, time spent outdoors, exposure to light and dietary intake.[69]

The role of light in the development of myopia has been more evident in animal studies. In animals, photoperiodicity is known to affect eye growth.[88] Evidence in mice (a primarily nocturnal animal) has shown that prolonged exposure to light leads to myopic eye growth;[89] and in chickens, steady exposure to bright light results in corneal flattening and hyperopia.[90] In another study, constant sunlight or artificial light resulted in shorter eyes and retardation in the process of emmetropization in chicks.[91] In monkeys, ambient light of high intensity slowed down form deprivation myopia.[92] Animal studies have also shown that lower light intensities reduced the relative speed of responses to negative lenses (hyperopic blur) compared with positive lenses (myopic blur) without changing the set-point of emmetropization, an effect blocked by a dopamine antagonist.[93] In humans, a number of epidemiological studies have showed that more time spent outdoors and participation in physical activity during childhood is associated with a decreased risk of myopia.[41,44,74,77] Furthermore, preliminary data from current trials in China have reported that the inclusion of an extra 40 minutes of time outdoors significantly reduced myopia progression in grade 1 children.[94]

Although most myopia developed during the school years and stabilizes before adult years, there is evidence that a number of individuals developed myopia after entering university.[21,39] This type of myopia is classified as adult onset and has been associated with occupation and level of education.[39,61] A study observed that 77% pilots, who were emmetropic before, developed myopia during their training.[60,62] High incidence and progression rates of myopia have also been reported in individuals who spend long hours on near work activity, such as carpet weavers, visual display terminal workers and microscopists.[39]

2.2.5 Diet and myopia

Another environmental risk factor that has been proposed to influence the development of myopia is diet.[83] Myopia prevalence is on the rise in countries that have adopted western dietary patterns and has led to the hypothesis that hyperglycaemia and hyperinsulinaemia induce myopia.[95] The western lifestyle involves a larger intake of food with high glycaemic load,[95] and less developed societies adopting the western dietary pattern experience increasing incidences of hyperglycaemia, insulin resistance, hyperinsulinaemia, and type 2 diabetes.[96,97] A large sucrose intake reduces insulin sensitivity[98] and blocks the binding of insulin to the receptor, and a high glycaemic load imposes acute and chronic hyperinsulinaemia.[94] Cordain and colleagues argue that high glycaemic

load and the resulting hyperinsulinaemia affect different growth factors, resulting in scleral growth that leads to myopia.[99]

2.3 PREVALENCE OF MYOPIA

It is difficult to compare prevalence studies across countries and regions due to inconsistency in definition and methods applied. In spite of these constraints, several studies were reviewed with a view to understanding the study design and findings, as well as factors which may limit the generalization of findings.

As shown in Table 2.1, the prevalence of myopia often varies with age, country, ethnicity, and geographic regions. The Sydney Myopia Study (SMS) was a 6-year follow-up population-based longitudinal cohort study by Rose et al.[44] to assess the association between near and mid-working distance and outdoor activities with myopia prevalence in school-aged children in Sydney. A total of 1765 6-year-olds (year 1) and 2367 12-year-olds (year 7) participated in the study. The children had a cycloplegic refraction and their parents completed questionnaires. Myopia was defined as spherical equivalent refraction (SER) ≥ −0.50 D based on the result of cycloplegic auto refraction. For the 6-year-olds (year 1), the prevalence of myopia was 1.5%, whilst it was 12.8% for the 12-year-olds (year 7).

In a population-based study in Al Hassa, Saudi Arabia,[100] the prevalence of visual impairment and refractive errors among primary school children between the ages of 5 and 15 years was estimated. Probability sampling was used in the recruitment of 2246 participants from 12 schools randomly selected in the region. A comprehensive eye examination was carried out on each participant, and those who were found to have a refractive error (RE) underwent cycloplegic refraction. Myopia was defined as ≥ −0.50D based on subjective refraction. The prevalence of myopia was found to be 9.0% in the study population.

In South Africa,[101] a cross-sectional study was carried out to determine the causes, prevalence and distribution of ocular disorders among rural primary schoolchildren in the Mopani District of Limpopo Province. A total of 388 black South African children aged 8 − 15 years were identified by random selection from 5 primary schools randomly selected from the district. Myopia was defined as SER ≥ −0.50 D. A prevalence of myopia of 2.5% was reported, based on the results of non-cycloplegic auto refraction and retinoscopy. Regression models for myopia showed that a unit increase in age had 1.94 fold increase risk of developing myopia.

Balarabe et al[102] conducted a cross-sectional study to determine the prevalence of uncorrected refractive error among secondary schools children in Birnin Kebbi, Nigeria. Using stratified random sampling methods, 614 school children aged 11 – 20 years were recruited from three schools in Binin Kebbi metropolis. Any child with a visual acuity (VA) ≤ 6/9 was examined using pinhole, and subsequently referred for detailed eye examination and retinoscopic refraction. Overall, RE and uncorrected RE was found in 30 (4.8%) and 27 (4.4%) children respectively. Prevalence of myopia ≥ ー0.50 D was 2.9%, hyperopia ≥ +1.00 D was 1.1% and astigmatism of cylinder ≥ ± 1.00 D was 0.8%. They authors reported that lack of awareness and access to eye care services was major barriers to the uptake of eyecare services in the area and therefore recommended for the establishment of regular and effective school vision screening program.

Ovenseri-Ogbomo and Assien[103] conducted a cross-sectional descriptive study to assess refractive errors among school children aged 11 – 19 in Agona Swedru, Ghana. Two public and two private schools were selected for the study and all 637 students in the selected schools participated in the study. Non-cycloplegic retinoscopy was carried out, followed by subjective refraction. To ensure that accommodation was relaxed, a + 1.50 D lens was used to fog the eye monocularly during refraction. Myopia was defined as ≥ ー0.50 D based on subjective analysis. The authors found the prevalence of myopia to be 1.7%.

A cross-sectional study to estimate the prevalence of refractive errors among primary school pupils between the ages of 12 and 17 in Kilungu Division, Kenya, was conducted by Muma, et al.[104] Eight primary schools were selected for the study by computer-generated random numbers and a total of 1439 pupils from the selected schools participated in the study. Any participant with a visual acuity of 6/18 or worse in either eye was assumed to have a RE and was asked to undergo cycloplegic retinoscopy. The prevalence of myopia was 1.7%; however, the authors did not state the criteria for myopia.

In contrast, the prevalence of myopia was higher in some South-east Asian countries. The Beijing Childhood Eye Study by You et al.[105] was aimed at determining the factors associated with myopia in school children in China. A total of 15 066 participants aged 7 – 18 years were recruited for the study by a random selection stratified cluster sampling technique. Myopia was defined as SER ≥ −1.00 D and all the children underwent non-cycloplegic autorefraction. The authors reported a myopia prevalence of 57% that highlights the extreme prevalence of myopia in South-east Asian population.[82,83]

In South Korea, a study was conducted by Lee et al.[80] to assess the prevalence and risk factors for myopia in consecutive military conscripts. A total of 2805 male college students aged 19 years were recruited by convenience sampling. They completed questionnaires and underwent cycloplegic refraction. The prevalence of myopia was found to be 83.3%. In Taiwan, a cross-sectional study aimed at identifying the prevalence and risk factors of myopia among elementary school children was conducted by Wu et al.[106] One hundred and forty-five children aged 7 – 12 years were recruited from two schools by random sampling. Data were obtained by means of parental questionnaires and ocular evaluation that included cycloplegic auto refraction. The authors observed that about 31% of the children were myopic.

In a study conducted to estimate the prevalence of refractive errors among children, adolescents and adults in Germany,[107] the parents (aged 24–65 years) and their children (516 subjects aged 2–35 years) completed a questionnaire about their RE and spectacle use, and the children were grouped into four age groups of 2 – 6, 7 – 11, 12 – 17 and 18 – 35 years. The results of their REs were controlled with reports from the children's opticians. Myopia was defined as ≥ -0.50 D. The authors found that the prevalence of myopia differed significantly between age groups: the prevalence was 0% in children aged 2–6 years, 5.5% in children aged 7–11 years, 21.0% in adolescents aged 12–17 years, and 41.3% in adults aged 18–35 years. The prevalence of myopia in female subjects (23.6%) was significantly higher than in male subjects (14.6%, $p = 0.018$). The difference between self-reported and REs reported by opticians was not significant ($p = 0.850$).

Table 2.1. Prevalence of Myopia in school children across various countries and cultural origins

Author/year Country	Sample size (*N*)	Age group (years)	Study design	Criterion (D)	Cycloplegic	Prevalence (%)
Rose et al. (2008)[44] Australia	1765 2367	6 12	Population-based longitudinal study	− 0.50	Yes	1.5 12.8
Wu et al. (2010)[106] Taiwan	145	7 – 12	Cross-sectional	− 0.50	Yes	31
Al Wadaani et al. (2013)[100] Saudi Arabia	2246	6 – 14	Population-based cross-sectional	− 0.50	Yes	9.0
You et al. (2013)[105] China	15066	7 – 18	Population-based cross-sectional	−1.00	No	57.0
Mabaso et al. (2003)[101] South Africa	388	8 – 15	cross-sectional	− 0.50	No	2.5
Ovenseri and Assien (2010)[103] Ghana	637	11 – 18	Cross-sectional	− 0.50	No	1.7
Balarabe et al (2015)[102] Birnin Kebbi, Nigeria	614	11 − 20	Cross-sectional	−0.50	Yes	2.9

2.4. MYOPIA AND ASSOCIATED RISK FACTORS

2.4.1 Age and gender

Several populations based cross-sectional studies conducted on the basis of common protocol – the Refractive Error Study in Children (RESC) in various countries and regions, such as Nepal,[82] Chile,[108] South Africa[20] and India,[109] reported an increase of myopia with age. The RESC protocol utilised a geographically defined cluster sampling design and a door-to-door enumeration of children between 5 and 15 years. The examination involved visual acuity measurement, ocular assessment, retinoscopy and autorefraction under cycloplegia. Overall, there was no significant

difference between the results of the cycloplegic retinoscopy and auto refraction. Myopia was defined as SE $\geq -0.50D$. There was an increase of myopia with age among school-aged children in all the studies. In a rural district in Nepal,[82] myopia increased from 1% in 5-year-olds to 3% in 15-year-olds; it increased from 3.4% in 5-year-olds to 19.4% in 15-year-olds in a city in Santiago, Chile;[108] in urban and semi-rural areas of KwaZulu-Natal, South Africa,[20] myopia prevalence was 4.0% in 14-year-olds and 9.6% in 15-year–olds; while in a rural district in India,[109] the 5-year-olds were hyperopic which decreased to a myopia prevalence of 10.5% in the 15-year-old children. In a logistic regression model, myopia was significantly associated with older age in all the studies. Gender was only significantly associated in the RESC study in rural India[109] by multiple logistic regression analysis.

2.4.2 Education

The age increase in the prevalence of myopia has been reported to be linked to higher levels of educational attainment, which are mediated by near vision work.[50] In a study involving participants of the same age (19 years) from consecutive male conscripts in Jeju, South Korea, to assess the prevalence and risk factors for myopia, Lee et al[80] found that myopia was significantly higher in university students than in students at high school or lower. In Taiwan,[106] myopia progression showed a significant association with the school year in elementary school children. A review of prevalence of myopia in Finland during the 20th century by Parssainen[78] found a lower prevalence of myopia in those who were born during the first three decades of the 20th century whereas, among those born during the second half of the 20th century, the prevalence increased to 21% – 30%. The author postulated that education might be the main reason behind the increase. Accordingly, a review of the literature suggests that the increase in the prevalence rate of myopia concomitant with higher levels of schooling might have resulted from greater demands for near work, and was not necessarily because of age.

2.4.3 Outdoor time and physical activity

Several researchers have found an apparent protective effect of time spent outdoors on myopia development.[12,61,110] In a study by Rose et al.[44] to assess the association between near, mid-working distance and outdoor activities with prevalence of myopia in school-aged children in Sydney, a total of 1765 6-year-olds (year 1) and 2367 12-year-olds (year 7) participated. For the 6-year-olds (year 1), the prevalence of myopia was 1.5%, and 12.8% for the 12-year-olds (year 7). It was found

that children who combined high levels of near work with low levels of outdoor activity had the highest odds ratio (OR) of myopia; while those who combined low levels of near work with more time spent outside had the lowest odds ratio of myopia after adjusting for other factors. They concluded that the increased time spent outdoors and not necessarily sports activities were associated with less myopia.

Jones-Jordan et al.[110] investigated visual activities before and after the onset of juvenile myopia using 731 incident myopes and 587 emmetropes aged between 6 years and 15 years. Parents supplied visual acuity data annually. Data from myopic children from 5 years before to 5 years after myopic onset were compared with data from age, sex and ethnicity-matched models of children who remained emmetropic. The result of the association between visual acuity variables before and after onset of myopia showed that children who spent less time outdoors and on sports activities have a higher risk of developing myopia. There was no evidence of a relationship between near visual activities and the development of myopia.

The Sydney Adolescent Vascular and Eye Study (SAVES)[45] was a 5 to 6-year follow-up of the Sydney myopia study. At follow-up, 2013 children were re-examined: 892 (50.5%) from the younger cohort and 1211 (51.5%) from the older cohort; and 1196 in the older cohort had complete refraction data. Cycloplegic refraction was carried out on all participants, and myopia was defined as spherical equivalent refraction ≥ -0.50 D. It was found that children who became myopic spent less time outdoors than children who remained non-myopic. Children who became myopic performed significantly more near work.

A more recent study hospital-based study in Beijing by Lin et al.[19] also found outdoor activity and leisure to be inversely associated with myopia in primary school children. The study by Lin et al.[19] assessed the relationship between near work, outdoor activity and RE using 386 students from primary (6 – 12 years) and secondary (13 – 17 years) schools. The students underwent comprehensive eye examination including cycloplegic refraction and completed a detailed questionnaire about their visual and leisure activities. Lin et al.[19] found a significant association between outdoor activity time (in hours per day) and SE in the primary school children but not in the secondary school students after adjusting for similar confounders. They concluded that higher levels of outdoor activity were associated with less myopic refraction in primary school students in Beijing. Nearwork activity was not found to be associated with refraction at either level.

One common feature of these studies is that they used parent questionnaires, which have the potential of memory, guessing and misclassification bias. In particular, the study by Jordan-Jones[110] relied on data supplied annually by parents on the visual acuity of their children as a measure of myopia among the children. To support the claim of bias from the use of parent questionnaires, findings from a more recent study by Dirani et al.,[77] using baseline data from Singapore Cohort study Of Risk factors for Myopia (SCORM), found a protective effect on time spent outdoors, which differed with their own initial cohort analysis of the same SCORM[111] data which found no association with outdoor activity and the incidence of myopia. They noted that the difference was because the previous cohort analyses in SCORM were completed via parent questionnaires at baseline whereas the more recent study used a comprehensive outdoor activity questionnaire that was completed by participants who were older at the time of examination. In the present study, we adopted an all-inclusive approach that involved interviewing children together with their parents and teachers.

2.4.4 Near work

As was evident in most of the studies reviewed above, the findings of many researchers on near vision work and myopia development have been inconsistent. The result of the study by Jones-Jordan et al.[110] on an association between visual acuity variables, before and after onset of myopia, failed to show evidence of a relationship between near visual activities and development of myopia. In Beijing, You et al.[105] found an association of myopia with longer daily studying duration (odds ratio (OR):1.10; 95% confidence interval (CI) 1.06 – 1.15) and a shorter duration of watching television or computer (OR: 0.93; 95% CI 0.89 – 0.97). French et al.[45] found a variation in the effect of near work between younger and older children. They found that younger children who became myopic performed significantly more near work (19.4 hours v. 17.6 hours) than those who were non-myopic, while there was no difference among the older children in the number of hours of near work between the myopes and the non-myopes. Rose et al.[44] also reported that greater amounts of time spent on near work combined with less time outdoor was associated with myopia.

In another study, Ip et al.[112] examined the association of time spent on near work and reading, with SER in a population-based sample of 12-year-old Australian school children. All students in year 7 aged 12 years in the schools selected by cluster design were invited to participate. Data was collected by means of questionnaires and eye examinations that included cycloplegic refraction. It was found that myopia was not significantly associated with time spent on near work after

adjusting for other factors. Rather, close reading distance and continuous reading of more than 30 minutes (OR 2.5; 95% CI 1.74 – 4.0 and OR 1.5; 95% CI 1.05 – 2.10, respectively) were independently associated with myopia. They concluded that intensity rather than the total duration of near work was an important factor in the development of myopia.

A recent study by Parssaine et al.[113] did not show any association of near vision work with myopia. The study was a randomized 3-year clinical trial with bifocal treatment and a subsequent 20-year follow-up conducted to examine myopic progression and factors connected with myopic progression in school children with no history of spectacle wear. The mean age of participants at baseline was 10.9 years. A comprehensive eye examination was carried out annually for 3 years and thereafter at 10-year intervals; additional refractive values were received from the participants' optometrists and ophthalmologists. Data on the parents' myopia and the children's near vision activities and time spent outdoors were gathered by means of a structured questionnaire. Although they found a greater myopic prevalence and progression among those reading more than 3 hours versus less than 3 hours, the difference between the two groups was not statistically significant. They concluded that myopic progression was mainly associated with parents' myopia and less time spent on sports and outdoor activities in childhood.

2.4.5 Rural-urban distribution and socioeconomic factors

As reviewed in the previous sections, a population-based study by Al Wadaani et al.[100] to evaluate the prevalence and pattern of RE among primary school children aged 5 – 15 years in Al Hassa, Saudi Arabia, found that 40.1% girls were myopic as against 25.5% boys. They did not find any significant difference between urban and rural distribution of myopia. You et al.[105] also found that girls are at greater risk of developing myopia (OR: 1.35; 95% CI 1.25 – 1.47). Their findings also showed that higher socioeconomic background and school type were associated with myopia.

In Egypt,[114] a cross-sectional study was performed to evaluate the environmental risk factors for REs in 1292 school children aged 7 – 15 years. The children were recruited from 12 different schools by a multistage random sampling method. The authors found that the prevalence of RE was significantly higher among female (21.4%) than among male (13.6%) students, and higher among students of high socioeconomic status than those of middle status. The prevalence of RE was significantly higher among students with a positive family history of RE (80%) than those with no family history. The prevalence of RE was significantly higher among preparatory (college) school students (20.6 %) than among primary school children (11.3%). The prevalence of RE was

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significantly higher among students who did more than 5 hours of nearwork per day (23.4%) than those who did less than 5 hours/day (17.1%). Data on the risk factors were obtained by a structured questionnaire.

2.4.6 Genetic factors

Numerous studies have also been done to determine the genetic influence on the development of myopia.[106,113,115,116] Most of these studies have been conducted through the use of a questionnaire to measure the association between parental myopia and the development of myopia in children. The results of these studies have supported the general understanding that children with myopic parents are at greater risk of developing myopia; with children with two myopic parents at a higher risk than those with one.

A cross-sectional study by Low et al.[115] with disproportionate random sampling of 6-month-old groups of 3009 Singapore Chinese children aged 6 − 72 months was performed to assess the risk factors for myopia including family history of myopia. Data on family history, near work and outdoor activity were obtained by a structured questionnaire. Myopia (SER) $\geq$ −0.50D was assessed by cycloplegic refraction. Their findings showed that children with two myopic parents were more likely to be myopic (adjusted OR: 1.91; 95% CI 1.38 − 2.63), while near work and outdoor activity were not associated with myopia. They concluded that family history of myopia is the strongest factor associated with pre-school myopia.

As mentioned above, a study to access the influence of heredity on myopia from onset to adulthood by Parssinen et al.[113] reported that higher myopia prevalence in adulthood is strongly associated with parental myopia. Also, a study conducted in Taiwan[106] on elementary school children showed that prevalence of myopia was associated with myopic parents. A study in Egypt[114] found that RE (myopia included) showed a positive correlation with family history, with children of two myopic parents having a lower incidence of 10% compared with 38.9% for only a myopic father, and 32% for only a myopic mother.

Kiefer et al.,[116] in a genetic association study on myopia with 45 771 participants of European descent, reported 22 genetic regions significantly associated with the age of onset of myopia. Of these 22 genetic regions, two were replications of previously identified associations while 20 were novel associations. These 22 associations altogether accounted for 2.9% of the variation in the myopia age of onset and point towards a number of different mechanisms behind the development

of myopia. Ten of the new associations replicate in a different cohort. Sixteen of the novel associations are in or near genes implicated in eye development and signaling, the visual cycle of the retina and general morphology. The authors stated that their findings point to the numerous biological pathways involved in the development of myopia and, in particular, the eventual development of myopia may be the result of early eye and neuronal development.

A study to determine the relationship between puberty and growth spurts, with peak spherical equivalent (SE) or axial length (AL) velocity in Singaporean school children, was conducted by Yip et al.,[117] comprising 1779 (892 boys and 887 girls) schoolchildren, aged 6 – 14 years. The schoolchildren included 1329 Chinese, 316 Malays, 114 Indians and 20 children of other races. Data on puberty parameters, age of peak height velocity, age of menarche, and break of voice (BOV) was recorded. Peak velocity was defined as the greatest change in measurements over a period of 1 year. Tanner stage 1 for pubic hair or breast development, in boys and girls, respectively, at age 12 was categorized as 'later puberty',' whereas stages 2 to 5 corresponded with 'earlier puberty'. The participants underwent cycloplegic auto-refraction and ocular biometry to determine their axial length. They found that age of peak height velocity occurred earlier in girls than in boys ($p < 0.001$) and that both boys and girls with earlier peak height velocity experienced peak AL velocity and peak SE velocity earlier than those who experienced later peak height velocity. Again, both boys and girls who had early peak height velocity had earlier age of onset of myopia than those with later peak height velocity. Progression of myopia with respect to AL velocity also occurred earlier in boys and girls with earlier peak height velocity (for boys, $p < 0.001$; and for girls, $p < 0.004$, respectively). However, there were no significant associations between myopia and other puberty parameters such as Tanner staging, age of menarche, or break of voice (BOV). The authors[142] hypothesized that the variation in the onset and progression of myopia might have been influenced by growth spurts. More so, both boys and girls with earlier peak height velocity had correspondingly earlier onset and progression of myopia.

2.4.7 Dietary factors

Evaluating the influence of diet on myopia has been challenging to researchers in terms of finding a standardized method of quantifying food nutrients. Some studies have used a food frequency questionnaire while others have been conducted using a self-reported food intake. Many of these studies have found no significant association between diet and myopia.[105,118,119]

A cross-sectional study by Lim et al.[118] to evaluate the possible association between dietary factors and myopia among 851 Chinese school children using a semi-quantified food frequency questionnaire for diet, an auto-refractometer for measuring myopia defined as SER ≥ −0.50 D, and contact ultrasound A-scan biometry for axial length (AL) found no association between myopia and any of the food nutrients. Although higher quartile groups of calcium and vitamin A intake were associated with myopia in age- and gender-adjusted models, these associations did not persist with multivariate adjustment. No significant associations were found with other nutrients analyzed. The same analyses were repeated with nutrients as quantitative measures in units, and no associations were found.

In a study to examine the correlation between the RE of elementary school children with parents' vision status, dietary history, and outdoor and indoor activities in Taiwan, 731 children from one school participated in the study. A comprehensive eye examination, including cycloplegic refractive procedure, was carried out on the children who also completed a multi-item questionnaire. It was found that myopia > −1.00 D increased from grade 1 to grade 6 but there was no difference between boys and girls. RE was associated with mothers' vision status, but did not have any relationship with that of the fathers' visual status. After adjusting for gender, grade and age, no correlation was found between spherical equivalent refraction (SER) and the intake of meat, vegetables, grains, poultry and fish, or frequency of beverage intake and sugar content of the beverages. However, from 29 categories of food items, the frequency of ingesting grapes more than twice a week showed a strong positive correlation with SER (Cheng et al.)[119]. You and colleagues[105] also found an association of myopia with self-reported higher protein intake (OR: 0.94; 95%CI 0.9 – 0.99).

2.5 AN OVERVIEW OF MYOPIA CONTROL STRATEGIES

2.5.1 Optical interventions

2.5.1.1 *Single vision under-correction*

Under-correction of myopia reduces the accommodative demand for near work and the accommodative lag associated with development of myopia. Evidence from animal studies has indicated that under-correction can arrest progression of myopia. However, the results on humans are unclear.[68] In some studies on children, under-correction was associated with either an increase in progression of myopia or no change as compared with full correction controls.[61,120] One

assumption is that the under-corrected children might have been discouraged from spending as much time in outdoor activities (such as sports) as the full correction control group, as a result of the blurred distance vision caused by under-correction,[121] since time outdoors has been found to be protective of myopia.[41,44,74] Findings from monocular under-correction of myopia have yielded promising results with under-corrected eyes showing an average of 0.36 D/year in myopia compared with the fellow fully corrected eye.[122] However, this method induces anisometropia when the same eye remains under-corrected, and therefore would be unsuitable as a clinical treatment.[121] At present, there is no consensus on effectiveness of under-correction as a myopia control therapy, and further investigation is required.[67]

2.5.1.2 *Bifocal and progressive spectacle correction*

Bifocal lenses were first used by optometrists in the 1940s in an attempt to slow myopia progression.[123] Bifocal lenses have been postulated to slow the progression of myopia by reducing near accommodative demand and, unlike under-correction, clear vision for distance objects is retained.[124] Different success rates have been reported for both bifocal and progressive lenses. In some studies, success has been limited to subjects with large near esophoria,[41] large accommodative lags,[64] or rapid myopia progression rates.[125]

Goss[126] conducted a retrospective study to assess the effect of bifocal lenses on the rate of myopia progression on children who were esophoric at near. There was a statistically significant decrease in myopia progression for children wearing bifocal lenses as compared with single-vision lenses, of 0.32 D/year versus 0.54 D/year, respectively. Similarly, the mean myopic progression over a 2-year study for efficacy of progressive lenses on slowing myopia progression by Leung and Brown[125] was 0.7 D for the +1.50 D add group and 0.6 D for the + 2.00 D add group. The add groups showed a statistical significant decrease in the amount of myopic progression associated with axial length changes as compared with the single-vision lens group.

To determine the effect of near phoria on reduction of myopia using bifocal lenses, a recent report highlighted the likelihood of inducing an exphoria shift with bifocals in myopic children, and therefore compared the effects of prismatic bifocal lenses with single-vision and bifocal lenses.[127] Following a 3-year trial, mean myopia progression rates were significantly slower in groups wearing prismatic bifocals and bifocals (mean change − 0.69 D/year). Contrary to reports that near-

phoria status dictates treatment success, there was no significant difference in progression rates between the two types of bifocal lenses.

2.5.1.3 Single vision Contact lenses

Although many randomized clinical trials comparing soft contact lenses with spectacle lenses to slow the progression of myopia found no significant difference in myopia progression, changing from spectacles to contact lenses, however, does change the peripheral refractive status, changing the relative defocus to myopic defocus with contact lenses.[28,128] If relative peripheral refraction is implicated in myopia development, such a change in peripheral refraction may reduce myopia progression.[28]

2.5.1.4 Multifocal contact lenses

Two types of multifocal contact lens treatment strategies have been proposed. The first involves the use of multifocal contact lenses similar to progressive lenses to slow the progression of myopia. The second is that of soft multifocal lenses with the distance centre designed to eliminate the peripheral hyperopia induced by spherical correcting contact lenses.[129,130,131] The latter is a novel dual-focus (DF) soft contact lens, with a central correction zone and concentric treatment zones that simultaneously create myopia retinal defocus. This design has been shown to reduce the progression of both the myopic refractive error and the corresponding axial elongation of the eye.[129] Antstice and Phillips[129] conducted an experimental study to determine the ability of DF soft contact lens to reduce myopic progression using a crossover paired eye control study design where one eye had a dual focus lens with +2.00 D peripheral myopic blur arranged concentrically in two treatment zones, and the other had a single vision lens. Forty children, $11 - 14$ years old, with mean spherical equivalent refraction (SER) of -2.71 ± 1.10 D wore the lenses for a period of 10 months and then switched over for another 10 months. There was a significant difference of -0.25 D myopic reduction with correlated changes in axial length between the two groups. The mean change in the DF wearing eye (-0.44 D) was less in the eye wearing the conventional lens (-0.69 D). The mean increase in axial length with DF (0.11 mm) was also less than the eye wearing the conventional lens (0.22 mm).

The fact that DF lenses provided normal visual acuity and contrast sensitivity and allowed normal accommodative responses to near targets suggest that it is the myopic defocus in the central and peripheral retina during both distance and near viewing that is responsible for reduction in

progression of axial myopia, and not changes in accommodation lag.[28] The results of other studies corroborated these claims.[131,132]

2.5.1.5 Orthokeratology

Orthokeratology (also referred to as ortho-k, corneal reshaping, corneal refractive therapy or CRT, and vision shaping treatment or VST) was first described by Jensen in the 1960s, and used special rigid gas-permeable contact lenses to reshape the cornea, resulting in a temporary elimination of refractive error.[2,61] The theory is that changes to the position and shape of the image shell relative to the peripheral retina result from steepening of the peripheral cornea in orthokeratology. This change in peripheral refraction from predominantly hyperopic to predominantly myopic peripheral retinal defocus has been reported in several studies.[57,59,61]

Cho and colleagues,[133] in the Longitudinal Orthokeratology Research In Children (LORIC) study, reported a significant slowing of eye growth as reflected in less of an increase in axial length (AL) and vitreous chamber depth (VCD) measurements with 46% myopia reduction. However, there was substantial variability in the amount of eye elongation for any subject, suggesting that there is no way to predict the effect of orthokeratology on myopia progression for any individual.

2.5.2 Pharmaceutical interventions

2.5.2.1 Atropine

Atropine is a nonselective muscarinic antagonist. It was first used for myopia treatment by Wells in the 19th century.[7] Numerous studies have recommended its use in myopia control.[134,135] The Atropine in the Treatment of myopia (ATOM) study was a randomized, double-masked, placebo-controlled trial in Singapore, where 400 children were treated monocularly with 1% atropine. After 2-years, myopia progression significantly reduced in children by 77% (0.28 D in the control group versus 1.2 D in the atropine group).[136,137] The atropine group's mean axial length remained basically unchanged, while the placebo group's mean axial length increased by 0.39 ± 0.48 mm. The ATOM subjects were followed up for a further 12 months after the treatment was stopped, and mean progression of myopia in the treatment group was reported as 1.14 D (over the 12 months), and 0.38 D in the placebo group; that is, cessation of treatment accelerated the rate of myopia progression, commonly referred to as treatment 'rebound effect'.[138]

Recently, phase two of the ATOM study was performed to evaluate a lower concentration of atropine. At the end of the 2-year treatment period, myopia progression rates were −0.30 D, −0.38 D and −0.49 D for the 0.5%, 0.1% and 0.01% concentration groups, respectively. There was a statistically significant difference in myopia progression between the 0.5%, 0.1% and 0.01% groups. However, the 0.01% group had minimal side-effects compared with the 0.1% and 0.5% atropine groups. The researchers reported allergic conjunctivitis as the most common adverse effect in the 0.5% and 0.1% groups, but no cases of allergic conjunctivitis were reported in the 0.01% group.[139]

The mechanism of action of atropine in retarding the progression of myopia is not clearly understood. There are also ocular and systemic side-effects including possible rebound effect associated with the use of atropine as a method of myopia control. These factors have formed strong impediments to the widespread adoption of atropine as a method of myopia control.[14, 68] However, atropine may be a viable option for children with rapidly progressive, high myopia and a strong family history of high myopia and its comorbidities such as retinal detachment.[67]

2.5.2.1 Pirenzepine

Pirenzepine is also an antimuscarinic drug used for the treatment of myopia progression. Unlike atropine that binds to M3 and M1 receptors, pirenzepine binds only to M1 receptors, and therefore has lesser mydriatic and cycloplegic effect than atropine does.[140] Studies have shown it to be significantly less effective in the reduction of myopia progression than atropine,[141,142] but it has fewer adverse effects than atropine.[142]

2.5.3 Lifestyle factors

Many studies have reported that time spent outdoors decreases the prevalence and progression of myopia.[41,44,74,77] The mechanisms underlying the apparent benefits of being outdoors on myopia progression are unclear.[28] However, the intensity and wavelengths of light have been identified through animal studies to play key roles in the development of myopia. One suggestion is that bright light may stimulate the release of the neurotransmitter dopamine which may in turn reduce eye elongation. The role of vitamin D should also be examined as the body produces it after exposure to UV light, and it has been found that vitamin D is lesser in myopes than in non-myopes.[143] Peripheral retina defocus is believed to be greater indoors than outdoors owing to

fixation upon close-up work and enclosed spaces. However, it has been suggested that, in bright outdoor lighting, pupillary constriction may limit the amount of defocus on the peripheral retina.[144]

2.6 SUMMARY

The present chapter reviewed literature on the prevalence and risk determinants of myopia among school-aged children. The chapter looked at the prevalence of myopia across different geographical regions and countries. It was observed that prevalence of myopia was highest in children from Southeast Asian countries and least in African children. Studies on the association of myopia with environmental and genetic factors were also reviewed, with some showing an association of myopia with some variable factors. For instance, myopia was found to increase with age from studies done in different countries but on the same RESC protocol. Outdoor activity was also found to have a protective effect on myopia. However, the findings of some studies were inconsistent owing to differences in study design such as variation in cut-off points applied to define myopia; refraction done without cycloplegia; the use of parent questionnaires; and reliance on self-reported myopia.

Heredity, visual behavior and environment, as shown in this chapter, can have a substantial effect on refractive error development. Prevalence of myopia was constantly associated with age, level of education, near work activities, parental myopia, and reduced outdoor and light exposure. The findings from those studies also supported the long-standing observation that myopia varies from one geographical location to another.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In the present chapter, the research setting and methods used in the study are discussed. Under the research methods, the study population, sampling method and eligibility criteria for participating in the study are presented. In addition, the data collection instrument which involved a questionnaire and vision assessment and a detailed procedure in each step of the data collection process, are presented. The reliability of the instruments, as well as the validity of the study, data analysis and ethical considerations are also presented in the chapter.

3.2 STUDY DESIGN

This was a population based observational study (descriptive and analytical), using cross-sectional sampling methodology to provide quantitative data. This study design was appropriate because prevalence of myopia were measured at a particular period of time (June, 2015). Cross-sectional study design is suitable for measuring prevalence of a particular disease at a given point in time. Apart from the advantage of not losing participants to follow-up, the fact that the method of data collection is relatively cost effective made it an approach of choice.

3.3 STUDY AREA

The study was conducted in Aba, a commercial city in Abia State, Nigeria, predominantly of Igbo ethnicity. Primary and secondary education is provided by public and private institutions, and all schools follow the same national educational system and curriculum. The public primary and secondary schools are separately managed by the State Primary Education Board (SPEB) and Secondary Education Management Board (SEMB) respectively. Private schools are self-governed under the supervision of the State Ministry of Education to ensure that minimum standards as outlined in the national curriculum are adhered to.

The eyecare services in the public sector are restricted to one centre at the Abia State University Teaching Hospital (ABSUTH) in Aba. Eyecare personnel include ophthalmologists, optometrists, ophthalmic nurses and dispensing opticians. Private sector eye clinics are primarily located in the commercial city centre and operate on a commercial basis

3.4 STUDY POPULATION

The study population comprised school children aged 8 – 15 years attending primary and secondary schools in Aba. Both private and public schools were included in the study, and all schools were comparable in terms of curricular and extra-curricular activities. There are 32 public primary and 20 secondary schools and about 35 government-approved private primary and secondary schools in Aba, with a total student population of 113 204 in the 2014/2015 academic year.[145]

3.5 SAMPLING AND SAMPLE SIZE

A probability sampling method was applied in selecting the participants through a multi-stage sampling approach. Aba was divided into three cluster areas for the purpose of recruiting participants. A list of public and private primary and secondary schools from each of the three areas were drawn from the education boards/authorities. Four schools (a public primary and secondary school, and a private primary and secondary school) were randomly selected from each of the three cluster areas, making a total of 12 schools in all. The next stage was the recruitment of children aged 8 – 15 years from each level of primary 3 to 6, Junior Secondary 1 to 3 and Senior Secondary 1 to 2 of the participating schools by systematic random sampling. One to three classes of each level were randomly selected from each school with a minimum cluster size of 25. All students within a class were invited to participate. If the minimum sample of 25 was not achieved from the first class, students from the second selected class were used to attain the required sample size. For this, every second or third child starting from the first child in a class register was included until the desired cluster sample size is reached. The number of participants selected from each class was proportional to the size of the students in each class.

The sample size was calculated using the formula:

$N = (Z)^2 (1.0 - p) (p) / (b)^2;$

where N is the minimum sample size, p is the anticipated prevalence (Assumed to be 50%), b is desired error bound taken as 5% and Z = 1.96 for a 95% confidence interval. A minimum sample size of 384 was calculated. A design effect of 2 was considered as an allowance for the cluster sampling, taken the sample size to 768. A 10% contingency factor to account for attrition was also considered. The final sample size for the study was 845 students.

3.6   INCLUSION AND EXCLUSION CRITERIA

Inclusion	Exclusion
All primary and secondary school students aged 8 – 15 years	All primary and secondary school students below age 8 years and/or above age 15 years
All primary and secondary school students within the age bracket with no history of eye trauma affecting vision	All primary and secondary school students within the age bracket with known history of eye trauma affecting vision
Any primary and secondary school student within the age bracket with no known anterior or posterior segment disease	Any primary and secondary school student within the age bracket with known anterior or posterior segment disease
All primary and secondary school students within the age bracket with no history of any systemic disease that may affect vision	All primary and secondary school students within the age bracket with any known history of systemic disease that may affect vision

3.7   DATA COLLECTION INSTRUMENTS

3.7.1   Patient questionnaire

A structured questionnaire containing questions on spectacle use and family history of myopia; questions on parents' education and occupation; questions on near vision work and physical activity during and after school such as number of hours spent reading, writing, watching television, playing video games; and number of hours spent indoors and outdoors, was used to gather data for the time spent on these activities for weekdays and weekends. The parents' education was classified into, no education/primary education, secondary/college level education, University level/professional qualification. Parents' profession was classified into low (farmers, traders, and artisan), medium (Teachers and civil servants) and high income (Politicians, lecturers, doctors, engineers, bankers and businessmen).[103] Additional data were also reported for record keeping only on types of food eaten in the last seven days, time of sleep, general mood and wellbeing of the students. The questionnaire was modeled from a similar study by You et al.[105] (see appendix 1 for full question list).

3.7.2. Instrumentation

Visual acuity (VA) measurements for distance and near were performed with the logMAR chart (Precision Vision, Villa Park, IL, USA). Cycloplegic autorefraction was carried out with the Topcon RM-8000B (Topcon Corporation, Tokyo, Japan) auto-refractometer. Anterior and posterior segments assessment examination including ocular motility assessment and pupil evaluation was performed with the Wellch Allyn diagnostic set. Ocular alignment was initially assessed by the corneal reflex (Hirschberg) test, and then followed by the cover test using an occluder at distance and near. Near point of convergence (NPC) was measured with the RAF (Royal Air Force) rule.

All the optometric instruments used for this study were sourced from a private optometry practice in Aba. The instruments were properly calibrated by the owner and regularly used in day-to-day practice. Their results have been found to be valid and reliable.

3.8 PILOT STUDY

The field staff underwent a 5-day training exercise before the survey fieldwork and were all familiarized with the questionnaire and standard examination procedures adopted. Thirty participants were randomly recruited at a primary and a secondary school from one of the cluster areas (but not included in the main survey), for a pilot field exercise to validate the data collection instruments. Through the pilot exercise, some questions which were not very clear to the children were identified. Those questions were modified to give a better understanding to the respondents before the survey. Logistical problems were also identified where it was found that two optometrists were not enough to perform refraction and another optometrist was added to the final survey. Of the 30 children who were randomly selected, one had myopia representing a prevalence of 3.3%. The field staff for the actual survey included three optometrists, two ophthalmic nurses and two support staff.

3.9 DATA COLLECTION PROCEDURE

3.9.1 Informed consent

Selected schools were visited individually in advance to solicit for the cooperation of the school authorities. During the visits, the head of the schools were informed about the details of the study including side effects of cycloplegia during testing. Thereafter, invitation to participate in the study was sent to parents of the participants recruited for the study together with the consent form and

information leaflet. They were also invited through the school authorities to a meeting of the Parents Teachers Association (PTA) prior to the survey. During the PTA meeting, details of the study including objectives, significance and procedures were clearly restated. Those who wished to continue with the survey were asked to sign and submit the consent form. The children whose parents signed and submitted the consent form were interviewed, together with their parents, in the presence of their class teachers by a member of the research team, and were encouraged to provide accurate answers to the questionnaire. An appointment card for vision screening exercises was given to each participant who successfully completed the questionnaire. A convenient date was fixed for the eye examination with the help of the school authorities.

3.9.2 Vision assessment

The vision screening exercise was scheduled mostly on days which generally did not have much school activity. The aim was to reduce the impact of the cycloplegic eye drops on the students' school activities for that day. Participants were pre-screened before cycloplegic refraction procedure to exclude those that did not meet the inclusion criteria. . Shadow test was also carried out with trans-illuminator to exclude those with narrow anterior chamber angle.[20,44] Standard vision assessment procedures were conducted in a room provided by the school authorities at each participating school, and a light meter was used to ensure that illumination was maintained at room illumination of 1300 lux[146] in each examination room. Validated optometric instruments were used, and an average of three readings was taken for each procedure. All procedures and techniques described in the present study followed the standard optometric examination procedures as stipulated in the modified school base RESC protocol[147]. Owing to the effect of cycloplegia on near vision, all near tests were carried out prior to cycloplegic refraction. Students who required follow-up or further examination were referred to Abia State University Teaching Hospital, Aba, or a private eye clinic designated by the research team as a referral centre for the present study.

3.9.2.1 Visual acuity

Distance visual acuity was measured with a retro-illuminated logMAR chart (Precision Vision Villa Park, IL, USA) containing five optotypes per line. Each child was seated properly at 4 meters' testing distance from the chart and was asked to occlude one eye at a time using a handheld occluder. Starting from the top line (20/200), the child was asked to read the letters one by one. If at least 4 letters were read correctly, the child was then directed to line 4 (20/100). If one or no

optotypes was missed, the testing continued at line 7 (20/50), then line 10 (20/25) and finally line 11 (20/20). If at any of the lines the child failed to identify ≥ 4 optotypes, the line immediately above the failed line was tested until successful. If at 4 meters the child could not recognize the letters on the topmost line, the child was asked to move towards the chart at 1 meter progressions until the child was able to read the letters as described above. The lowest line that was read successfully was recorded as the visual acuity of the eye being tested. For known spectacle wearers, visual acuity was measured first with their spectacles, followed by unaided visual acuity.[147]

3.9.2.2 Binocular motor function

The unilateral cover test was used to distinguish between tropia and phoria while the alternate cover test was used in the measurement. Cover and uncover tests were performed using a handheld occluder at 0.5 meters and 4 meters.[4,147] The left eye was covered first and the right eye was observed to detect any movement while the child was asked to fixate at a letter above best acuity of the worst eye for distance and near fixation targets with both eyes open. The cover was then removed and the right eye was covered to detect any movement in the left eye. The movement was noted as orthotropia (no movement), esotropia (outward movement of the uncovered eye), exotropia (inward movement), or vertical tropia (upward or downward movement). It was further classified as constant if present at all times for both fixation distances or intermittent if detected at only one fixation distance or not present at all times.

In performing the alternate cover test at 0.5 meter and 4 meters, one eye was covered and then after a few seconds the handheld occluder was moved directly to the other eye, and again after $1 - 2$ seconds, the occluder was moved back to the initially covered eye. The sequence was repeated for a few times. If the eye moved in any direction to take up fixation when the cover was removed, the direction of the movement was noted as esophoria (outward movement of both eyes as they are uncovered), exophoria (inward movement) and vertical phoria (upward or downward movement). If < 2 prism diopter was detected, then the condition was classified as orthophoria. Prism bar was used in measuring the amount of tropia and phoria. The prism strength was 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 observed for the second time. The measure of the total tropia or phoria size was

recorded as the amount of prism power required to neutralize the deviation for the second time. All ocular alignment assessments were performed without spectacles.

3.9.2.3 Ocular motility

The test was performed at room illumination and without the child wearing spectacles. The child was instructed to look at the light source (trans-illuminator) and follow it while keeping his/her head still and to report if the light appeared double at any time or if his/her eyes felt uncomfortable or painful in any of the positions. Starting at a testing distance of 40 cm, the light source was moved in an arc with the child's head at the centre in such a way that the child's eye followed the edge of the binocular field. It was then moved into the 8 diagnostic positions of gaze by moving the target in the 9 cardinal points of gaze. The result was recorded on the examination form as SAFE (smooth, accurate, and with full extent of movement) while any abnormality such as fixation losses and jerky movements were noted.[4,6]

3.9.2.4 Cycloplegic refraction

Cycloplegia was achieved by giving two drops of cyclopentolate eye drop (1%) at 5-minute intervals. Cycloplegia was considered full when the pupil was fixed and $\geq$ 6 mm in diameter. If on evaluation after 20 minutes, the pupillary light reflex was still present, a third drop was administered. Cycloplegic autorefraction was carried out with the Topcon RM-8000B (Topcon Corporation, Tokyo, Japan) auto-refractometer 60 minutes after first instillation of the drops. An average of three readings was taken for each child.[147]

3.9.2.5 Ocular health assessment

Eyelids, conjunctiva, cornea, iris, and pupil were examined with a trans-illuminator for any abnormalities in dim illumination. The lens, vitreous chamber and fundus were examined with a direct ophthalmoscope. The child was properly seated on the examination chair and was directed to focus at the biggest letter on the visual acuity chart directly opposite at 4 meters. With the eye open and pupil still dilated after cycloplegic refraction, the media and fundus were assessed for any abnormalities by an optometrist.

3.10 CLASSIFICATION OF REFRACTIVE ERROR

Refractive error (RE) was reported as myopia, hyperopia and astigmatism and was classified based on spherical equivalent refraction (SER) (sphere + 1/2 cylinder). Myopia was defined as SER $\geq$ −0.50 D[44,45] in the worst eye and was sub-classified as low (SER $\geq$ 0.50 D $\leq$ 3.00 D); medium (SER > 3.00 $\leq$ 6.00 D) and high (SER > 6.00 D). Hyperopia was defined as SER $\geq$ + 2.00 D in the worst eye and was sub-classified as low (SER $\geq$ +2.00 D < +4.00 D); medium (SER $\geq$ +4.00 D < +6.00 D) and high (SER $\geq$ +6.00 D). Astigmatism was defined as cylinder (cyl.) $\geq$ 0.75 D. Anisometropia was defined as an interocular difference $\geq$ 1.00 D SER.[148] All definitions referred to values obtained after cycloplegic autorefraction. The association of myopia with the risk factor variables was analyzed in detail.

Table 3.1. Classification of refractive errors.

Refractive error / Degree of refractive error	Myopia (SER (D) in the worst eye)	Hyperopia (SER (D) in the worst eye)	Astigmatism (cyl. in the worst eye)	Anisometropia (inter-ocular difference of SER in (D)
Low	SER $\geq$ −0.50; $\leq$ −3.00	SER $\geq$ 2.00; < 4.00	Cyl. $\geq$ 0.75	SER $\geq$ 1.00
Medium	SER> − 3.00; $\leq$ −6.00	SER $\leq$ 4.00 ;< 6.00		
High	SER> − 6.00	SER $\geq$ 6.00		

3.11 DATA MANAGEMENT AND ANALYSIS

Data entry was done on a daily basis, alongside the daily fieldwork. Additional data cleaning and consistency checks were conducted, once data collection and entry were completed for an entire school/cluster by an experienced data officer. The statistical analysis was performed using commercially available Statistical software Package for Social Science (SPSS for Windows, version 20.0, IBM-SPSS, Chicago, USA).

The prevalence was calculated as the number of children with a particular type of RE in relation to the total number of children who participated in the study expressed in percentages. The association between the prevalence of myopia and other parameters was explored using the z-test

for two population proportions for categorical variables and logistics regression analysis for continuous variables. Multivariate regression analysis was performed using presence and absence of myopia as the dependent variable, and the parameters which were significantly associated with the prevalence of myopia in univariate analysis as independent variables after adjusting for age, gender and parental myopia. ORs and 95% confidence intervals (CIs) were presented. A p value < 0.05 was used as the criterion for statistical significance.

3.12 RELIABILITY AND VALIDITY

The study was designed on the basis of the protocol that had already been used in recent studies[105,148] on this area. The questionnaire was modeled from the study by You et al.[105] The questionnaire was pilot tested and problems encountered were addressed before the survey. An appropriate sample size was calculated and probability sampling was employed to determine a suitable sample representation of the population group.

Data were collected with a questionnaire and optometric examination in a detailed and systematic approach. An audit trail of data was maintained, documenting clearly the flow and processing of the data including data collection decisions. Optometric instruments had already been calibrated before the examination and averages of three readings were recorded. The illumination was maintained at the same room illumination in each classroom in the various schools selected, using a light meter.

3.13 ETHICAL CONSIDERATION AND CONFIDENTIALITY

- Ethical clearance was obtained from the Biomedical Research and Ethics Committee (BREC) at the College of Health Sciences (UKZN).
- Ethical approval was also obtained from College of Medicine Research Ethics Committee (COMREC), University of Nigeria Enugu Campus.
- Approval was granted by the Zonal Education Management Board, Aba, and the local government education authorities in Aba South and Aba North Local Government, Abia State, Nigeria.
- Permission was obtained from the principals of the various schools that participated in the survey.

- Parents/guardians of the students gave their consent and the participants voluntarily accepted to participate in the study.
- Participants were identified by unique numbers and not by names to ensure anonymity.
- All consent forms and data have been kept in a locked cupboard and will be shredded after 5 year

The data is the property of the University of KwaZulu-Natal.

3.14 SUMMARY

In this population based descriptive study, the relationship between myopia and risk factor variables such as parental myopia, near vision work, outdoor and indoor physical activity, and socioeconomic status were assessed using a validated data collection instrument such as an eye examination with optometric instruments and interviews with a structured questionnaire. Data were collected by means of a transparent and systematic approach together with proper data management that ensured reliable and valid outcomes. The study was conducted using a protocol similar and comparable to previous studies in this area.

In the next chapter (Chapter 4), the results obtained from the vision examination and interviews conducted on the participants are presented. In addition to the narrative presentation of results, tables and figures are included. The classification of myopia is presented on the basis of the definitions stated above. The risk factors for myopia are presented in sections.

CHAPTER 4

RESULTS

4.1 INTRODUCTION

In this chapter, the results of the vision assessment together with the data from interviews conducted with the participants through a structured questionnaire are presented. The results are illustrated using tables and figures. The chapter comprises three sections; the first focuses on the characteristics of the study sample, and the second on the overall prevalence of RE in the study sample. Lastly, the association of myopia with risk factors is presented.

4.2 STUDY POPULATION

The characteristics of the study sample are summarized in Table 4.1. Of 1261 school children randomly recruited from 6 primary and 6 secondary schools, selected by a systematic sampling method, 1212 (96.1%) participated in the study. However, only 1197 (94.9%) of the participants with complete relevant data were included for analysis. Fifteen (1.2%) children had incomplete data. There was no indication of selection bias, as the children with complete data were similar to the children with missing data in all other respects. The overall mean age of the participants was 11.5 ± 2.3 (range 8 – 15). Participants were divided into two age groups: group 1 (8 – 11) years and group 2 (12 – 15) years. Six hundred and fifty-nine (55.0%) participants were female while 538 (45.0%) were male; 581 (48.5%) children were from public schools, whereas 616 (51.5%) were from private schools; 549 (45.9%) and 648 (54.1%) were from primary and secondary schools respectively.

Table 4.1. Characteristics of study population.

Characteristics	Number of participants (*N*)	Percentages
All children	1261	100
Participants	1212	96.1
Non-participants	49	3.9
Participants with complete data	1197	94.9
Age		
Group 1 (8 – 11); mean age (9.5±1.2)	595	49.7
Group 2 (12 – 15); mean age (13.5±1.1)	602	50.3
Gender		
Female	659	55
Male	538	45
School		
Public	581	48.5
Private	616	51.5
Level of education		
Primary	549	45.9
Secondary	648	54.1

4.3. ESTIMATING THE PREVALENCE OF MYOPIA AMONG SCHOOL CHILDREN

To evaluate the prevalence of REs among the study participants, data from 1197 school children with complete relevant data were analyzed. Overall, 96 (8.0%) of the study participants had a RE which comprised 0.9% hyperopia, 2.7% myopia and 4.4% astigmatism (Table 4.2). The prevalence of uncorrected RE from the study sample was 6.3%. All hyperopia recorded based on the definition criteria for the study was of low degree with a mean SER of +2.16 ± 0.13 D in the worse eye. Among the myopes (2.7%), low, medium and high accounted for 87.5%, 9.4% and 3.1% respectively, with a mean SER of −1.48 ± 2.12 D in the worse eye. In addition 62% of the myopes were exophoric at near. Anisometropia ≥ 1.00 D was found in 3.1% of the children with RE.

Table 4. 2   Prevalence of corrected and uncorrected refractive error (N=1197)

Refractive error	Corrected	Uncorrected	Total
Myopia	7 (0.6%)	25 (2.1%)	32 (2.7%)
Hyperopia	3 (0.3%)	8 (0.6%)	11 (0.9%)
Astigmatism	11 (0.9%)	42 (3.5%)	53 (4.4%)
Total	21 (1.8%)	75 (6.3%)	96 (8.0%)

4.4   RISK FACTORS FOR MYOPIA

To investigate the association between the development of myopia and associated genetic (family history of myopia) and environmental risk factors, the selected children completed an interview together with their parents using structured questions about family history of myopia and spectacle wear; parents' occupation and level of education; visual activities during and after school; and the amount of time spent on playing sports and other leisure activities. The results of the interview were compared between myopic and non-myopic participants first, in univariate analysis and then in multivariate analysis. The details of the statistical analysis are presented in paragraph 4.4.1 to 4.4.3

4.4.1   Association of myopia with environmental factors

4.4.1.1   Age and gender

Table 4.3 illustrates the data for prevalence of myopia by age and gender. There was a significant increase in myopia prevalence with older age. The prevalence of myopia increased from 8 (1.3%) in age group 1 to 26 (4.3%) in age group 2 ($p<0.001$). There was no significant difference in myopia prevalence between male and female participants. The prevalence of myopia was marginally higher in female (18 (2.7%)) than in male (14(2.6%)) participants, the difference was not statistically significant (z-test for two population proportions, $p = 0.890$).

Table 4.3. Prevalence of myopia by age and gender

	Participants	Myopia n (%)	Hyperopia n (%)	Astigmatism n (%)
Gender				
Male	538	14 (2.6)	5 (0.9%)	22 (4.0)
Female	659	18 (2.7)	6 (0.9%)	31 (4.7)
Age group				
Group 1	595	8 (1.3)	7 (1.2)	24 (4.0)
Group 2	602	26 (4.3)	4 (0.7)	29 (4.8)

4.4.1.2 Education

The distribution of myopia according to level of education and type of school are illustrated in Table 4.4. The prevalence of myopia (by level of education) was significantly higher in secondary schools than in primary schools ($p = 0.001$). The distribution of myopia according to the type of school showed that myopia was more prevalent in private than in public schools. As shown in Table 4.4, 15.6% of myopic children were from primary schools, while 84.4% were from secondary schools. The increased rate of myopia with higher levels of education was statistically significant (z-test for proportions, $p = 0.001$). The number of myopic children observed in the study comprised 9 (28.1%) public school children and 23 (71.9%) private school children. The difference was statistically significant (z-test for proportions, $p = 0.020$).

Table 4.4. Distribution of myopia by school type and level of education

	N (n=32)	Z-score	P-value
Type of school			
Public	9 (28.1%)	−2.3398	0.020
Private	23(71.9%)		
Level of education			
Primary	5(28.1%)	−3.483	0.001
Secondary	27(71.9%)		

4.4.1.3 Nearwork, indoor sports, outdoor activities

A two-sided paired *t*-test was used to compare the mean hours spent by both myopic and non-myopic children on near work, sports and leisure activities. Overall, myopic children spent more time reading and writing per day, watching television on weekends, playing video games and using computers per day on weekdays and weekends. Children who developed myopia spent less time on outdoor activities per week. There was no significant difference between the mean time spent by myopic children and non-myopic children on watching television on weekdays ($p=0.307$) and playing indoor sports per week ($p=0.403$).

Table 4.5 illustrates the mean time spent by myopic and non-myopic children on nearwork, indoor sports and outdoor activities. The average reading time spent by myopes was 5.3 hours per day as compared with 2.5 hours per day by non-myopes. Statistically, the difference was significant (*t*-test, $p < 0.001$). The average daily time spent by myopes on writing was 4.0 hours per day as against 1.8 hours per day by non-myopes. Statistically the difference was significant (*t*-test, $p < 0.001$). An average of 2.8 hours was spent daily by myopic children on computer use on weekends, whereas 1.4 hours was spent by non-myopic children; the difference was statistically significant (*t*-test, $p = 0.001$). On weekdays, myopes spent an average of 2.6 hours per day on computer use in comparison to 1.5 hours per day spent by non-myopes on computer use. The difference was statistically significant (*t*-test, $p = 0.001$). The average daily time for watching television was slightly higher in myopic participants (3.3 hours on weekends and 3.2 hours on weekdays) versus that by non-myopic participants (2.7 hours on weekends and 2.9 hours on weekdays). Statistically, the difference in duration of hours of watching television on the weekend showed a statistical significance of (*t*-test, $p = 0.040$), but on weekdays the difference was not statistically significant (*t*-test, $p = 0.300$). Additionally, the average daily time for playing video games was moderately higher in children who have myopia (2.6 hours on weekends and 2.3 hours on weekdays) versus those who had no myopia (2.1 hours on weekends and 1.9 hours on weekdays). Playing video games for a longer time on weekends showed a statistical significance of (*t*-test, $p = 0.010$) while playing video games on weekdays showed a statistical significance (*t*-test, $p = 0.030$).

The average outdoor sports and leisure time for myopes (4.9 hours per week) was significantly lower when compared with the average outdoor sports and leisure time for non-myopes (8.4 hours per week) (*t*-test, $p < 0.001$. There was no significant difference in the amount of time spent on indoor sports between myopic children and non-myopic children in a week ($p = 0.400$).

Table 4.5. Comparison of average time-based activities of children with and without myopia.

	Myopic (*n* = 32)		Non myopic (*n* = 1165)		*t*-test
Activities	Mean	SD	Mean	SD	*p* value
Daily reading hours	5.3	0.9	3.1	1.6	0.001*
Daily writing hours	4.0	0.8	2.7	1.8	0.001*
Daily computer hours/weekend	2.8	1.9	1.4	2.0	0.001*
Daily computer hours/weekdays	2.6	1.7	1.5	2.2	0.001*
Daily TV hours/weekend	3.3	1.6	2.7	2.2	0.040*
Daily TV hours/weekdays	3.2	1.6	2.9	2.0	0.307
Daily video games hours/weekend	2.6	2.0	1.6	2.1	0.013*
Daily video games hours/weekdays	2.3	2.1	1.5	1.9	0.037*
Weekly outdoor sports/leisure hours	4.1	1.9	8.4	2.6	0.001*
Weekly indoor sports hours	4.1	2.6	4.5	3.1	0.403

SD, standard deviation.

Note: p values with asterisk indicate statistical significance.

4.4.1.4 *Socioeconomic factors*

Table 4.6 shows the data for socioeconomic factors among myopic and non-myopic participants. The family socioeconomic factor for participants was measured by asking questions on the parents' level of education and profession. The parents' level of education was categorized into 3 groups (primary, secondary/college, and university/degree). Parents' professions were grouped into low-, medium- and high-income jobs. It was observed that participants with paternal university education were at greater risk of developing myopia, whereas children who had paternal and maternal low-income jobs were at lower risk of developing myopia.

There was a significant difference between myopic children (62.50%) with paternal university education and non-myopic children (35.26%) with paternal university education (z-test for two population proportions, $p = 0.002$). There was no significant difference between myopic participants (51.61%) with maternal university education and non-myopic participants (34.60%) with maternal university education (z-test for two population proportions, $p = 0.050$). The number of children with paternal secondary/college education was higher in non-myopes (55.52%) than in myopes (34.52%); the difference was significant (z-test for two population proportions, $p = 0.020$).

Paternal primary education and maternal secondary/college education was not associated with myopia. No myopic participant had maternal primary education.

The analysis regarding the participant's parents' profession, mothers and fathers with low-income jobs was inversely associated with myopia (z-test for two population proportions, $p=0.020$; and z-test for two population proportions, $p = 0.005$ respectively). Medium and high-income jobs for both parents was not associated with the prevalence of myopia in the study sample.

Table 4.6. Socioeconomic factors (indicators of family income).

		Student percentage		Z-test for proportions	
		Non-myopic (*n*=32)	Myopic (*n*=1165)	Z-score	*p* value
Maternal education	Up to primary	11.10%	0.00%	-1.9644	0.050
	Secondary/college	54.30%	48.39%	-0.6524	0.500
	University/degree	34.60%	51.61%	1.9600	0.050
Paternal education	Up to primary	9.22%	3.13%	-1.1857	0.200
	Secondary/college	55.52%	34.38%	-2.3713	0.020*
	University/degree	35.26%	62.50%	3.1672	0.002*
Mother's profession	Low-income	36.31%	15.63%	-2.4084	0.020*
	Medium	56.05%	68.75%	1.4291	0.200
	High	7.64%	15.63%	1.6567	0.100
Father's profession	Low-income	32.90%	9.38%	-2.8085	0.005*
	Medium	59.02%	75.00%	1.8162	0.070
	High	8.08%	15.63%	1.5290	0.100

Note:p values in asterisk indicate statistical significance.

4.4.2 Relationship between development of myopia and family history of myopia

Figure 4.1 illustrates data for family history of myopia. Parental myopia was significantly associated with the prevalence of myopia in the present study. The study sample revealed that children with both parents being myopic are at greater risk of developing myopia. Figure 4.1 showed that the number of myopic children with parental myopia (23 (71%)) and those with no parental myopia (9 (29%)) differed significantly (z-test for proportions, $p < 0.001$). The proportion of children with myopia varied according to the number of parents with myopia, as shown in Figure 4.3B, such that 41% of the myopic children had both parents as being myopic, 31% only one parent as being myopic and 28% with no myopic parents.

A greater number of myopic children in the study sample also had siblings with myopia. The percentage of myopic children with myopic siblings was 40.6%, 15.6%, 34.4% and 9.4% for no siblings with myopia, 1 sibling, 2 siblings, and 3 siblings with myopia, respectively (Figure 4.3C). Of the 9 myopic participants with no parental myopia, 5 (55.6%) had at least 1 sibling who was myopic.
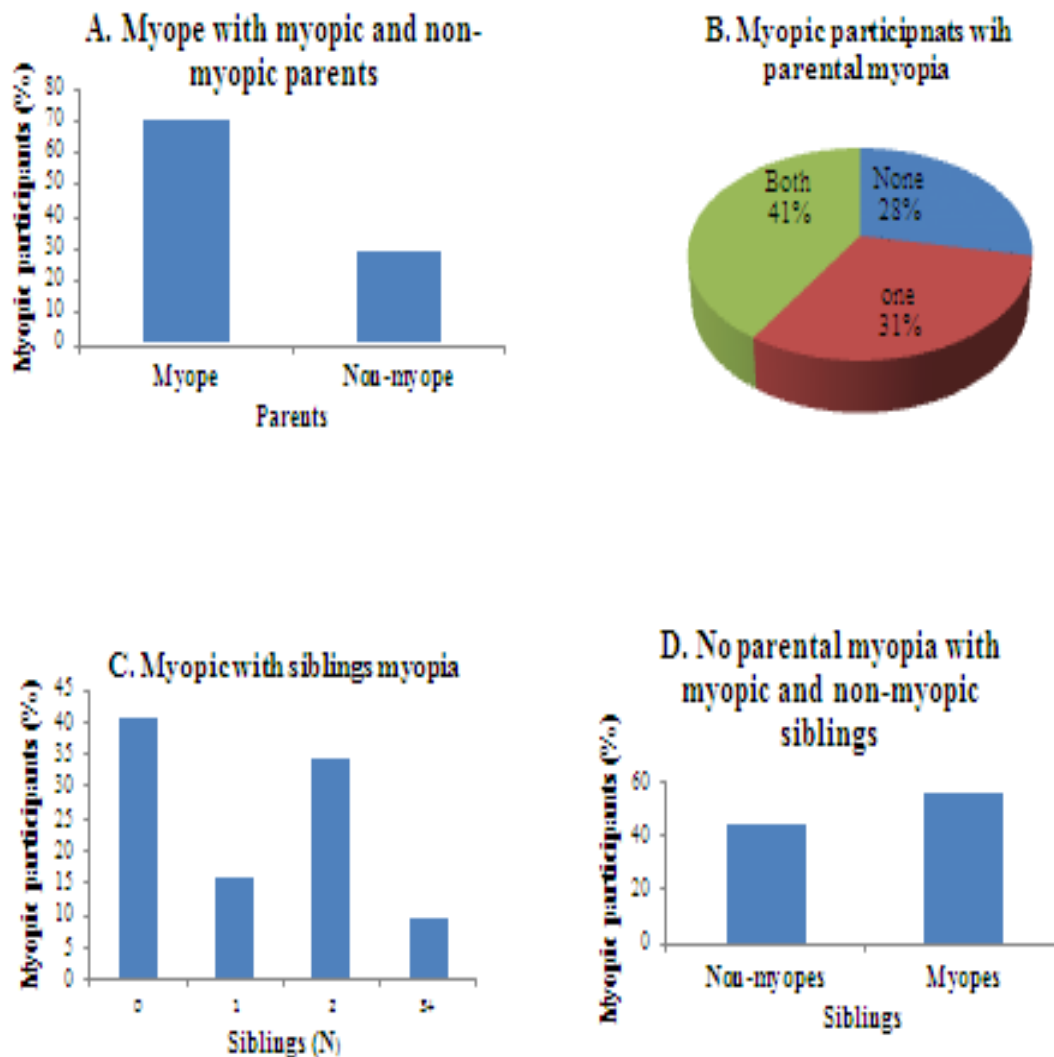
Figure 4.1. Family history of myopia among study participants: (A) Myopic participants with parental myopia. (B) The proportion of parental myopia among myopic participants. (C) Myopic participants with (*N*) siblings' myopia (D) Distribution of myopic participants with no parental myopia with myopic and non-myopic siblings.

4.4.3 Association of myopia with associated risk factors in the multivariate analysis

Table 4.7 shows the results of multivariate logistic regression analysis. After adjusting for confounders, the present study revealed that an association exists between environmental factors such as age, reading, and level of educational attainment, outdoor activities and myopia. There was also a relationship between family history of myopia and the development of myopia in schoolchildren.

In the multivariate model the presence and absence of myopia was the dependent factor while the variables that were significantly associated with myopia in univariate analysis were the independent factors. After adjusting for age, it was found that myopia remained significantly associated with, Older age (OR: 1.20; 95% CI, 0.16 - 9.11; $p < 0.010$), higher level of educational attainment (OR: 1.73; 95%CI, 1.05 – 2.86; $p < 0.030$), longer reading hours (OR: 1.21; 95% CI, 1.03 – 1.42; $p < 0.020$), less time spent outdoors (OR: 0.8; 95% CI, 0.74 – 0.87; $p < 0.001$), parents myopia (OR: 6.80; 95% CI, 2.76 – 16.74; $p < 0.001$) for one myopic parent and (OR: 9.47; 95% CI, 3.88 – 23.13; $p < 0.001$) for two myopic parents).

Table 4.7. Factors associated with myopia in multivariate analysis.

Variables	OR*(95%CI)	*p*-value
Age(years)	1.37(0.86 – 2.19)	0.010*
Parental myopia		
0 parents	Reference	
1 parent	6.80(2.76 – 16.74)	
2 parents	9.47(3.88 – 23.13)	0.001*
Type of school		
Public	Reference	
Private	1.37(0.34 – 5.45)	0.650
Father's education		
Up to primary school	Reference	
Secondary/college	1.21(0.49 – 2.98)	
University/degree	0.88(0.34 – 2.30)	0.790
Mother's profession		
Low income	Reference	
Medium income	2.14(0.72 – 2.80)	
High income	3.28(0.80 – 3.54)	0.090
Father's profession		
Low income	Reference	
Medium income	0.62(0.21 – 1.81)	
High income	0.45(0.11 – 1.89)	0.280
Level of education		
Primary school	Reference	
Secondary school	1.73(1.05 – 2.86)	0.030*
Near work		
Daily reading hours	1.21(1.03 – 1.42)	0.020*
Daily writing hour	0.89(0.76 – 1.04)	0.140
Daily computer hours (weekend)	0.93(0.82 – 1.06)	0.270
Daily computer hours (day)	1.00(0.99 – 1.01)	0.980
Daily Television hours (weekend)	0.98(0.88 – 1.11)	0.750
Daily videogames hours (weekend)	0.99(0.98 – 1.01)	0.930
Daily videogames hours (day)	0.99(0.93 – 1.05)	0.870
Weekly outdoor sports/leisure hours	0.80(0.74 – 0.87)	0.001*

p values in asterisks indicate statistical significance.
CI, confidence interval.
OR, odds ratio. Model was adjusted for age.

4.5 SUMMARY

The results obtained from vision assessments and interviews via structured questionnaire are presented in the current chapter. Of 1261 school children recruited from primary and secondary schools, only 1197 with complete relevant data were included for analysis. There were more female participants (55%) than male (45%); more secondary school children (54.1%) than primary school children (45.9%) and there were almost equal numbers of children from private (51.5%) and public (48.5%) schools. Overall, the prevalence of RE was 8%, with 78% being uncorrected.

The prevalence of myopia in the study population was 2.7%. The data obtained with the use of the activity questionnaire were compared between myopic and non-myopic participants. In the univariate analysis, prevalence of myopia was associated with a unit increase in age, higher level of education, school type (private v. public), longer hours on near work activities such as reading for longer hours, writing for longer hours and use of computer and video games, and less outdoor activities. Higher level of education of participants' parents, and parents' myopia, were also associated with myopia. However, in the multivariate logistic regression analysis, higher age, higher educational attainment, longer duration of reading, less time spent outdoors, and parents' myopia were only associated with myopia after adjusting for confounders. Gender was not associated with myopia in univariate and multivariate analysis.

In the next chapter, the results reported in the current chapter are interpreted and discussed in comparison with reports from previous studies. As in the present chapter, the discussion is organized in sections according to the objectives of the study.

CHAPTER 5

DISCUSSION

5.1 INTRODUCTION

In the current chapter, the results presented in Chapter 4 are interpreted and discussed in comparison with findings from other studies. As in the previous chapter, the discussion is organized in sections according to the objectives of the study. The discussion starts with a general account of the study population, followed by a discussion on the overall prevalence of REs with emphasis on the prevalence of myopia. The environmental risk factor variables associated with the prevalence of myopia are also discussed, followed lastly by a discussion on the relationship between the prevalence of myopia and family history of myopia.

5.2 STUDY POPULATION

This study evaluated the prevalence and risk factors for myopia among school children in Aba. Overall 1216 school children between the ages of 8 to 15 were recruited for the study, however only 1197 participants with complete data where included in the analysis. The number of female participants was greater than male participant. This may be attributed to the higher enrollment of girls in the present academic session.[145] Similarly, more participants were recruited from private schools than public schools because private schools have a greater number of school children.[145]

5.3 PREVALENCE OF MYOPIA

The overall prevalence of RE of 8.0% observed in the present study is comparable to that reported in the cosmopolitan city of Ikeja Lagos, Nigeria[146] but lower than that observed in other geographic locations.[105, 108, 148] Faderin and Ajaiyeoba[146] reported RE prevalence of 7.3% in 919 school children aged (6 – 15) years recruited from two schools in Ikeja Lagos by stratified random sampling method.

The results of the present study revealed a myopia prevalence of 2.7% in school children in Aba. This prevalence was comparable to that reported in Nigeria school children and other African countries; for instance, in Birnin Kebbi[102], Nigeria, it was 2.9%, in Mopani district of Limpopo[101] and Durban area of KwaZulu-Natal Provinces[20] of South Africa, it was 2.5% and 2.9% respectively, and in Agona Swedru, Ghana,[103] was 1.7%, but was lower than that reported in Beijing, China[105] (57%), Chimei Island, Taiwan[106] (31%), Amman, Jordan[41] (17.6%) and Sydney,

Australia (12.8%).[44] The difference in prevalence of myopia in the present study with previous studies could be partly because of the difference in geographic location, ethnicity, sample size and age of the study population and the definition of myopia, as prevalence of myopia varies with age and from one geographic location to another.[45,100,101,102,103,104] For instance, the age range (12 years – 17 years) of the study participants in Amman, Jordan[41] is different from the age range (8 years – 15 years) of the present study participants. In Beijing[105] the sample size was 15 066 children with a mean age of 13.2 ± 3.4 (range: 7 – 18 years) whereas the sample size for the present study was 1197 participants with a mean age of 11.5 ± 2.3 (range: 8 – 15years). The age of the study participants in Australia was 12 years and the sample size was 2367 school children. In addition, the high prevalence of myopia in China and Taiwan may be owing to geographic location since epidemiological studies have reported high prevalence of myopia in Southeast Asian countries.[11,12]

The lower prevalence of RE in Nigeria school children than in other geographic areas should not lead one to underestimate the contribution of RE to visual disability in Nigeria. In fact, uncorrected REs have been previously reported as the most common cause of mild and moderate visual impairment (77.9% and 57.1% respectively)[40] in the adult population of Nigeria. Furthermore, 78.1% of the children with RE in the present study were uncorrected, perhaps owing to the unfounded belief about spectacle wear, caused by lack of awareness and ocular health education: parents believe that children using spectacles at an early age will suffer worsened vision and eventually become blind [102,103]. Inadequate manpower and disproportionate distribution of refractive services in communities may also be a contributory factor.[102,103] The public eyecare service is limited to one facility in the city of Aba, and refractive services are mainly provided by private eye clinics predominately located in the commercial city centres. As a result, eyecare services are inaccessible and unaffordable to many people.

5.4 RISK FACTORS ASSOCIATED WITH MYOPIA

5.4.1 Association with environmental factors

5.4.1.1 Age and gender

The prevalence of myopia increases with age.[101,102,103,104] This risk factor is supported by the observation of an increased prevalence of myopia with age in the present study, which is consistent with previous studies.[105,106,107] The population-based RESC studies in South Africa,[20] China,[81]

India[109] and Chile[108] reported an increased rate of myopia with higher age in children between the ages of 5 and 15 years. In particular, the study in China[81] reported an apparent increase in myopia prevalence from 7 – 8 year olds which coincided with the age at which schooling begins. Another significant increase in myopia prevalence was observed between 11 and 12 years, around the age of starting high school education. In South Africa,[20] children showed myopia prevalence of 4.0% that however, started from age 14 to increase to 9.6% by age 15; the age of senior secondary education that involves more rigorous near work activities. Thus, it appears that the increase in prevalence of myopia with older age may be as a result of more demand for near work and less time spent outdoor since it has been reported in literatures that over time constant visual stress may lead to a permanent reduction in distance vision[2, 80, 148].

The present study, however, did not find any significant difference in the prevalence of myopia between male and female participants. This finding agrees with those of several studies on African children[101,102,103,104] and is comparable with the results of RESC studies in Nepal[82] and Chile.[108] However, in China,[81] Saudi Arabia[148] and Finland,[149] it was found that the prevalence of myopia was significantly higher in female than in male subjects. Taken together, the latter three studies noted that the difference was influenced by the earlier growth and maturation rate of girls than that of boys in their study samples. Parssinen and Lyyra[149] suggested that myopia was more progressive in girls than in boys because of the early maturation of girls within the age group of their study sample. Adebasi[148] noted that the age range (6 years – 13 years) of the study participants included active growth. Consequently, the difference in prevalence of myopia between boys and girls was attributed to differences in growth velocity between the sexes, as previous studies on growth and myopia[117,149] reported that the age of peak height velocity occurred earlier in girls than in boys. In contrast, a study on childhood myopia (with subjects between 6 years and 15 years) by Goss[150] observed that gender did not have much effect on the prevalence of childhood myopia.

The present study did not measure growth spurts and maturation rates of participants. However, the difference in findings from the present study between those that found significant differences between boys and girls might be owing to differences in ethnicity, age of study participants, and sample size. It could also be that the participants (male and female) in the present study might have had comparable growth spurts and maturation rates.

5.4.1.2 Near work

Near vision work has continually been implicated as an environmental risk factor for the development of myopia.[13,41,60,61] Animal studies have revealed the acquisition of form deprived myopia (FDM) when reared in a controlled environment.[88,89,90,91,92,93] In humans, evidence of the contribution of near work to the development of myopia has been inconsistent.[110,111,112]

Data from the present study show that, among the near work variables evaluated, only reading was significantly associated with myopia in the multivariate logistic regression analysis. Other near work variables such as writing, watching television, playing video games and computer use which were initially associated with myopia in the univariate analysis did not persist in the multivariate model. Recent studies also found similar associations between reading and myopia.[70,105,111] However, the studies by Jones-Jordan et al.[110] found no significant difference in near work activities between future myopes and emmetropes. Rather, they found that those who developed myopia spent less time outdoors. They argued that near work has less impact on the development of myopia. In a longitudinal study, Ip et al.[112] hypothesized that intensity rather than duration of reading is related to myopia. They found that myopia was not significantly associated with time spent on near work, but rather with close reading distances of less than 30 cm and continuous reading for more than 30 minutes per day. The difference between the findings of the present study with those of the two studies above may be owing to the use of a different activity questionnaire and activity definition. The present study adopted the same RESC questionnaire used by previous RESC study[105] and the finding of the present study corroborates their results.

Unlike in Asia,[105] where duration of computer use, playing video games and watching television were significantly associated with myopia, there was no association between computer use, playing video games, watching television and myopia in the present study. Mutti et al.[70] and Zadnik et al.[152] also found no association of myopia with duration of non-reading near work variable factors. Zadnik et al,[152] evaluated 4512 ethnically diverse, non-myopic school-aged children over a 20-year period and found no association between myopia and watching television or computer use. The study by You et al[105] examined 15 000 school children and found that children with myopia spent significant time watching television, playing video games and computer use than the non-myopic children. In the present study on 1197 school children, it was observed that the duration of time spent on computer use, playing video games and watching television were nearly uniform among

the study sample. The difference in the findings between the study conducted in Asia[105] and the ones that found no association between myopia and non-reading nearwork variables including the present study may be owing to differences in study design and sample size. For instance, the study by You et al[105] included participants form rural and urban settings while the present study comprised only school children from semi-urban and urban areas of Aba. Secondly, it may be owing to the genetic influence to the development of myopia in Asian children.[11,12]

5.4.1.3   Level of education

In the present study, myopia prevalence was found to be significantly associated with increased level of education. Similar results have been reported in the literature.[80, 106] However, there is an ongoing debate on whether educational attainment should be an independent factor or a surrogate for already established environmental risk factors. Some researchers argue that the increase in the onset and progression of myopia observed with increased levels of educational attainment might have been a result of a visual condition undergoing its normal course, considering that myopia prevalence increases with older age in children.[76,80,102,106,108]

In the present study, the study participants were children between the ages of 8 and 15 years. Data showed that the odds of developing myopia were higher in secondary school than in primary school (OR 1.73, 95% CI 1.05 – 2.86) (Table 4.7). Findings from studies on similar and comparable protocols have showed that 5-year-old children from various countries have very few REs and that, depending on the schooling and learning system, those children developed myopia, with a low percentage (1.2%) in Nepal but 70% in China.[81,82] In Taiwan,[106] myopia progression showed a significant association with the school year in elementary schoolchildren. In another study by Lee et al.[80] they found that myopia was significantly higher in university students than in students at high school or lower. The authors reported that increased prevalence of myopia with higher level of education in their study sample might have been a result of accumulated near work over the period of education. The increased myopia prevalence with increased educational attainment in the present study agrees with this hypothesis.

5.4.1.4   Outdoor time

The association between increased time spent outdoors and decreased myopia found in the present study is consistent with the reports from cross-sectional and longitudinal studies on myopia and outdoor activities.[11,44,45] Furthermore, preliminary data from current trials in China, have reported

that the inclusion of an extra 40 minutes of time outdoors significantly reduced myopia progression in grade 1 children[94]. Animal studies have also provided evidence in support of the role of light in myopia development. In chicken exposure to elevated light intensities can eliminate the development of deprivation-myopia.[153]

The present study also confirmed the report from the Sydney Myopia Study (SMS)[44] that the critical factor is not only time spent on sports or leisure activities but also the total time spent outdoors. Time spent indoors on sports did not show any association with myopia whereas total time spent on outdoor sports and leisure activities showed an association with myopia.

It is not clear how this protective effect is achieved; the mechanism may be complex. For instance, the greater viewing distance outdoors leads to greater depth of focus, and hence a sharper image owing to pupil constriction, reduced peripheral hyperopic defocus, and less accommodative demand;[28],[44,153] altogether, this would create a more uniform dioptric space, which has been hypothesized to remove the stimulus for myopic growth.[153] Another possible protective mechanism is spectral composition, as the emmetropization process has been shown to be sensitive to chromatic aberrations.[61,153] Also, bright light has been reported to stimulate the release of retinal dopamine which is known to inhibit the growth of the eye.[93,151]

5.4.1.5 Socioeconomic factors

The socioeconomic status (SES) of the present study included children from low, middle and high SES level schools. Socioeconomic status (indicator of family income) was not significantly associated with myopia. Although fathers' higher level of education and low and medium-income jobs of both parents were initially associated with myopia in the univariate analysis, such association did not continue in the multivariable model. This finding is consistent with the result of the study by Saw et al.[37] on myopia and socioeconomic factors. The study by You et al.[105] found a significant relationship between myopia and family income. The difference in the results of the present study with that of You et al.[105] might have been owing to the method used in measuring socioeconomic status of participants by the two studies. While the study by You et al.[105] measured socioeconomic status directly by asking questions on parents' annual income, the present study, measured socioeconomic status of the participants by using indicators of family income such as parents' level of education and profession.

5.4.2 Association with family history of myopia

There was a strong significant association between family history of myopia and development of myopia in the present study. The odds of developing myopia (9.4 for children with two myopic children and 6.8 for children with one myopic parent) were three times higher than any other significant risk factor associated with myopia in the present study including near work. Different age-related cohort studies have also observed a significant association between family history of myopia and development of myopia.[13,70,114,115] For instance, Low et al.[115] found that family history of myopia was the strongest factor responsible for preschool myopia, while near work was not significantly associated with myopia. Mutti et al.[70] reported that heredity (OR: 3.31; 95% CI, 1.32–8.30) for one parents being myopic, (OR: 7.29; 95% CI, 2.84–18.7) for two parents being myopic and near work (OR: 1.018; 95% CI, 1.008–1.027) were significantly associated with myopia, with heredity the strongest factor; the authors did not find any evidence that supports the hypothesis that heredity is a strong factor because parents with myopia have children who do more near work. In another study, Parssinen et al.[113] also observed that higher myopic prevalence in adulthood was strongly associated with parents' myopia but that neither near work nor outdoor activities was significantly associated with early myopia. In the present study on schoolchildren between 8 and 15 years, it was observed that family history of myopia and near work was associated with myopia. However, parental myopia was the most important factor. This finding agrees with the observations of previous studies that reported on both parental myopia and near work,[70] which therefore suggests that genetic factors may play a more notable role in the onset and progression of myopia. A recent genome wide association study on the development of myopia observed that numerous genetic factors are involved in the development of myopia.[116] The authors suggested that the eventual development of myopia may result from early eye and neuronal development.[116] Therefore, the higher prevalence of myopia among those with myopic parents in the present study may indicate that some genetic factors might have contributed strongly to the development of myopia in the study sample.

5.5 SUMMARY

In the current chapter, the results presented in Chapter 4 are discussed, starting with the demographic characteristics of the study population and followed by the prevalence and risk factors for myopia. It was found that the prevalence of myopia in the study sample was comparable to previous studies on African children. Similarly, the non-significant association of gender with

myopia was also observed by previous studies in Africa. The results of the present study on the protective effect of time outdoors compared very well with previous cross-sectional and longitudinal studies.[11,44] It was also shown in the present study that the increase of myopia with higher levels of educational attainment may be owing to the effect of overtime near work accumulated over the period of education. Consistent with the findings of Mutti et al,[70] the most important risk factor in the present study was found to be parental myopia.

The next chapter comprises a general summary of the study, based on the aims and objectives stated in Chapter 1, and also highlight the limitations encountered in conducting the study and the ways that they were managed. This is followed by recommendations and the conclusion.

CHAPTER 6

CONCLUSION

6.1 **INTRODUCTION**

In the current chapter, an overall summary of the study will be presented. The summary begins with a recap of the problem statement, as well as the aims and objective of the study. This is followed by an outline of the major findings, limitations, recommendations, significance and final conclusion.

6.2 SUMMARY

Myopia has an enormous socioeconomic impact on society. Besides having to hold books very close and sit in front of the classroom to be able to see adequately,[23] a child with myopia may develop sight-threatening complications and permanent visual impairment that may affect the child's social, educational and psychological development.[31,60]

Although, several studies have been done to determine the prevalence of REs in sub-Saharan Africa, only a few have been conducted to evaluate the probable causes of REs.[40,42,43] The focus of these studies has mainly been on age and gender, neglecting the important risk factors such as near work, parental myopia and outdoor activities. Perhaps, as a result of low prevalence of REs including myopia in African populations when compared with other parts of the world. As stated in Chapter 1, the Nigeria National Blindness and Visual Impairment Survey identified uncorrected RE as the most common cause of mild and moderate visual impairment (77.9% and 57.1% respectively) in the adult population, while in children data are limited.[40] The present study was motivated by the need to provide information on REs in school children to help improve eye health services in the schools and communities. The study examined the relationship between myopia and associated risk factors among schoolchildren in Aba, Nigeria.

The following objectives were considered:

1.   To estimate the prevalence of myopia among school children in Aba between the ages of 8 and 15 years.
2.   To investigate the association between myopia and age and gender

3. To investigate the association between myopia and environmental factors (near work, level of education, outdoor time and socioeconomic factors) in school children in Aba, Nigeria using a questionnaire.

4. To examine the relationship between family history of myopia and the development of myopia in schoolchildren in Aba, Nigeria using a questionnaire.

The present study involved children between the ages of 8 and 15 years attending primary and secondary schools in Aba, Abia State, Nigeria. The study estimated the prevalence of myopia to be 2.7%. Consistent with the result of previous studies on African children,[20,103] the prevalence of myopia was low when compared with findings from other geographic locations. As stated in the previous chapter, this finding does not underrate myopia as a sight-threatening disease. Notably, 78% of the myopia diagnosed was uncorrected, which therefore suggests that eye health services may be inaccessible to many people[102]. Lack of awareness and inadequate manpower, as well as the cost of spectacle corrections could also be contributing factors [102,103]

The present study found that both environmental and genetic factors were associated with myopia. Age as an environmental factor has an association with myopia. Myopia prevalence was observed to increase with higher age. Although, the prevalence of myopia was marginally higher in female than in male, the difference was not significant.

In the present study, of the factors affecting near work, only reading for longer hours was associated with myopia. Writing, watching TV, playing video games and computer use was not significantly associated with myopia. The results showed that myopes read an average of 5.3 hours per day while non-myopes read an average of 2.5 hours per day, supporting the hypothesis that children with myopia spend more time reading than those without myopia.[41,70] Reading involves a task of high accommodative demand,[75] (and because myopes have been reported to exhibit accommodation lag)[63] over time, this could lead to hyperopic defocus and axial length elongation and myopia development.[61]

Level of education attainment also was associated with myopia. The findings from the present study show that secondary school children have a higher prevalence of myopia than that of primary school children. After adjusting for other factors including age, the increase in myopia with level of education in the study sample remained significant, in disagreement with the theory that the increase might have been a visual condition undergoing its natural course, rather than being

stimulated by a risk factor, as myopia increases with age.[66] Previous studies found a strong correlation between education and near work [70,105] As near work indirectly leads to axial length elongation and myopia development[61], the increase in prevalence of myopia with increased level of education might have been owing to the accumulated effect of sustained near vision work over the period of education.

It was observed that myopia was negatively associated with longer duration of time spent outdoors. Non-myopic children spent twice the time spent by myopic children on playing outdoor sports and leisure activities in a week. On the contrary, the present study found no significant association between myopia and playing indoor sports. In agreement with the findings of the study by Rose et al.,[44] the protective effect of time outdoors is not related to playing sports alone but total time spent outdoors including playing sports and other leisure activities.

Socioeconomic factors were not associated with myopia in the present study. Socioeconomic factors were measured based on parental education and profession. Although the study initially found an association of myopia with fathers' higher levels of education, such association was no longer significant after adjusting for other factors in multivariate model.

Consistent with previous studies,[70,113] the present study found that family history of myopia was strongly associated with myopia. In fact, the odds of developing myopia for children with myopic parents were three times higher than any other significant factors in the present study. The rate of myopia was observed to be 41%, 31% and 28% for those with two myopic parents, one myopic parent and no myopic parents respectively, and similar to that reported by Mutti et al.[70]

6.3 STUDY LIMITATIONS

One limitation of the present study is that time spent outdoors and near work was estimated base on a method of a near work and outdoor activity questionnaire which has the potential of memory recall and misclassification bias. Using the activity questionnaire, participants were asked to estimate the time spent on those activities retrospectively. Changes in the amount of time that individual children spent on those activities may differ over the period of childhood or school years and would each act to lessen the statistical power to detect an association between time spent outdoors, near work and myopia development. Longitudinal studies would better estimate the association between myopia with time spent outdoors and near work for the different ages.

Another limitation of the study is that because of cultural sensitivity associated with questions on annual income of a person in this area, the socioeconomic status of participants where determined by questions on parents' profession and education. The education and profession of a person may not be a true reflection on his earning power. While those working in the public sector may have almost unified salary structure, those in the private establishment are paid based on the establishment policy and ability to pay. Altogether these factors may have affected the validity of the study.

6.4 RECOMMENDATIONS AND FUTURE STUDIES

To address the problem of myopia development and progression, one approach would be to regulate the physiological mechanism that controls the growth and elongation of the eye, in order to maintain a fine correlation between the dioptric components of the eye and its axial length. While we wait for breakthroughs in this area of research, the focus might be to address the issue on behavioural perspectives.

Parents and teachers should encourage their children and wards to spend more time spent outdoors, as time outdoors was found to be protective of myopia. The present study, as with previous studies,[44,105] found an association between myopia and longer duration of reading as well as higher level of education. Similarly, children should be advised to take some rest outdoors after reading for a period of time.

However, the protective mechanism of sunlight has not been understood. Therefore, future studies might aim at finding the aspect of spending time outdoors such as the amount of UV light, light intensity, the ability to have a wider field of view or any other activities performed when being outdoors that may inhibit the development and progression of myopia.

Similarly, it is not certain whether the increase of myopia with level of education as found in the present study is indirectly related to near work or motivated by the desire to study more owing to a higher intelligence quotient (IQ).[111] Future studies might look at the relationship between IQ and the development of myopia, to ascertain if educational attainment is a surrogate for IQ.[111] Future studies should also compare the effect of intensity and duration of reading on myopia.

The present study found no significant difference in the prevalence of myopia between male and female participants in the study sample. Although the findings agree with the observations of other

studies[101,102,103,104] in Africa, they disagree with studies[82,107] in other geographic locations. It may be interesting in the future to conduct a longitudinal study to examine the prevalence of myopia in male and female cohorts in Africa. This could be done by measuring the height, weight and axial length of children over a period of time. Also, the peak height velocity, which is defined as the greatest change over a period of time, should be determined for both sexes to know whether peak height velocity comes earlier in girls than in boys or at nearly the same time in both sexes.

With the high prevalence of uncorrected REs observed in the study sample, it is therefore important that decision makers should formulate policies that will increase access to appropriate and affordable eyecare in schools and communities. It is highly recommended that primary eyecare which is a component of the Primary Health Care (PHC) system of Nigeria be overhauled for efficiency and effectiveness. Optometrist should be integrated into the PHC system to compliment the services of other eye and health care professionals. The Local Government Health Authority which is saddled with the responsibility of managing PHC should ensure that each PHC center in their jurisdiction has at least an Ophthalmic Nurse to help in early detection of reduced vision, provision of basic ocular health education and prompt referral to an eyecare specialist. At the state level, government should engage the services of Optometrists and Ophthalmologists at its secondary and tertiary health facilities respectively. Qualified health professionals should coordinate the activities of the PHC centers to ensure proper delivery of eyecare services.

The importance of regular vision screening program and ocular health education cannot be overemphasised. Education authorities should ensure that regular vision screening program is carried out in both primary and secondary schools within their area of jurisdiction. Children could also be required to undergo comprehensive eye examination during their admission process, as a measure to ascertain their visual status. School timetables could be adjusted to allow students to spend ample time outdoors since inclusion of an extra 40 minutes of time outdoors significantly reduced myopia progression in school children.[94]

Finally optometrists should take note of the impact of accommodation and longer duration of reading when prescribing for myopic children. The present study found that reading for longer hours and higher level of educational attainment are associated with development of myopia which may have been owing to high accommodative demand for near work. Under-correction of myopia reduces the accommodative demand for near work and the accommodative lag associated with

development of myopia.[120] The under-corrected child should also be encouraged to spend more time outdoors since time outdoors was found to be protective of myopia.[44]

6.5 SIGNIFICANCE

Despite the limitations enumerated above, the study provides an understanding of the effects of environmental and genetic risk factors for the development and progression of myopia. The study also provides current data on the prevalence of uncorrected and corrected REs in school children in Aba. In addition, the risk factor for myopia, for which there were no such data, has been documented. Furthermore, parents, teachers and children have been properly educated on the signs and symptoms of myopia to seek help in time when they experience such problems. They have been well informed of the activities that could help to prevent myopia development and progression, such as spending more time outdoors and taking intermittent rests while reading. The larger community can also benefit from this study through the report which will be circulated through the Ministry of Health and Ministry of Education of Abia State.

Data from the present study highlighted the need for improved eyecare delivery system in schools and communities. This has further stressed the need to integrate Optometrists in the primary eyecare services of the PHC system in Nigeria to increase access to eyecare services especially at PHC level. Health and education authorities can therefore use data from the present study in drawing up plans for regular vision screening exercises and ocular health education in schools, and in particular eyecare delivery services, in communities in general. Education authorities can also use the information from this study in curriculum development.

The information from the present study can help to improve patient care and management. Eyecare practitioners will take additional measures in prescribing for myopic children especially those with lag of accommodation in order not to induce hyperopic defocus which in turn leads to axial length elongation and myopia progression. Data from the present study will also be useful for future studies including research on the control of myopia.

6.6 CONCLUSION

The aim of conducting the study was to determine the prevalence and risk factors for myopia among school children in Aba, Nigeria. The prevalence of myopia and overall prevalence of refractive error, as in other studies on African children, were relatively low when compared with

studies on children from other continents. However, a greater percentage of refractive errors was uncorrected. Parental myopia was the most important risk factor associated with myopia in the present study. Other risk factors associated with myopia include age, reading, level of education and outdoor time. It is recommended that vision screening program and ocular health education be included in school health programmes to improve access to eyecare services.

REFERENCES

1. Grosvenor T. Primary care optometry: Anomalies of refraction. 4th ed. Boston: Butterworth Heinemann; 2002.

2. Goss D, Grosvenor T. Optometric clinical practice guideline care of patient with myopia: Reference guide for clinicians. St. Louis: American Optometric Association; 2006.

3. Rosenfield M. Refractive status of the eye. In: Benjamin WJ, editor. Borish clinical refraction. 2nd ed. St Louis: Butterworth-Heinemann, 2006. p. 3–34.

4. Elliot DB. Clinical procedures in primary eye care. 3rd ed. Philadelphia: Butterworth-Heinemann,; 2007

5. The eye doctors: The myopia myth (homepage on the internet). [cited 18 May 2015]. Available from: http://www.myopia.org/page2.htm.

6. Friedman NJ, Kaiser PK. Essentials of ophthalmology. Philadelphia: Elsevier, 2007; p. 253-254.

7. Curtin BJ. The myopias. Basic science and clinical management. Philadelphia: Harper and Row; 1985.

8. Li CY, Lin KK, Lin YC, Lee JS. Low vision and methods of rehabilitation: A comparison between past and present. Cheng Gung Med J. 2002;25153-161.

9. Angel J, Wassermann DA. The epidemiology of myopia. Am J Epidemiol. 1980;111;220-226.

10. Luo HD, Gizzard G, Ling Y, Shankar A, Tan DT, Saw SM. Defining myopia using refractive error and uncorrected logMAR visual acuity > 0.3 from 1334 Singapore school children ages 7-9 years. Br J Ophthalmol. 2011;90:362-366.

11. Lin LL, Chen CJ, Hung PT, Ko LS. Nation-wide survey of myopia among schoolchildren in Taiwan 1986. Acta Ophthal Suppl. 1988;185:29-33.

12. Wu Q, Seet B, Yap EP, Saw SM, Lim TH, Chia KS. Does education explain ethnic differences in myopia prevalence? A population-based study of young adult males in Singapore. Optom. Vis Sci. 2001;78:234-239.

13. Saw SM, Katz J, Schein OD, Chew SJ, Chan TK. Epidemiology of myopia. Epidemiol Rev. 1996;18:175-181.

14. Wang Q, Klein B, Klein R, Moss S. Refractive status in the Beaver Dam Eye Study. Invest Ophthamol Vis Sci. 1994;35:4344–4347.

15. Katz J, Tielsch JM, Sommer A. Prevalence and risk factors for refractive errors in an adult inner city population. Invest Ophthlmol Vis Sci. 1997;38:334-340.

16. Matsumura H, Hirai H. Prevalence of myopia and refractive changes in students from 3 to 17 years of age Surv Ophthalmol. 1999;44:109-15.

17. Lei Y, Lei Yu, Li ZK, Gao JR, Liu JR, Xu CT. Epidemiology, genetics and treatment for myopia. Int J Ophthamol. 2011;4:658-669.

18. Vitale S, Ellwein L, Cotch MF, Ferris FL, Sperduto R. Prevalence of refractive error in the United States, 1999–2004. Arch Ophthalmol. 2008;126:1111-1119.

19. Lin LL, Shih YF, Hsiao Ck, Chen CJ. Prevalence of myopia in Taiwanese schoolchildren: 1983 to 2000. Ann Acad Med Singapore. 2004;33:27-33.

20. Naidoo KS, Raghunandan A, Mashige KP, et al. Refractive error and visual impairment in African children in South African. Invest Ophthalmol Vis Sci. 2003;44:3764-3770.

21. American Optometric Association (AOA). Myopia (nearsightedness) (0nline). St. Louis: American Optometric Association; 2014. Available from: www.aoa.org/patients-and-public/eye-and-vision-problems/glossary-of-eye-and-vision-condition/myopia

22. Gilmarin B. Myopia: Precedents for research in the twenty-first century. Clin Exp Ophthalmol. 2004;32:305-324.

23. Bovd, K. Nearsightedness (online). [cited 31 March 2014]. St Louis: American Academy of Ophthalmology; 2013. Available from: www.geteyesmart.org/eyesmart/disease/myopia-nearsightedness/index.cfm

24. Tan NW, Saw SM, Lam DS, Cheng HM, Rajan U, Chew SJ. Temporal variations in myopia progression in Singaporean children within an academic year. Optom Vis Sci. 2000;77:465-472.

25. Fan DS, Lam DS, Lam RF, et al. Prevalence, incidence and progression of myopia of school children in Hong Kong. Invest Ophthalmol Vis Sci. 2004;45:1071-1075.

26. Donovan L, Sankaridurg P, Ho A, Naduvilath T, Smith EL, 3rd, Holden BA. Myopia Progression Rates in Urban Children Wearing Single-Vision Spectacles. Optom Vis Sci 2011:89(1): 27-32

27. Wallaman J, Winawer J. Homeostasis of eye growth and the question of myopia. Neuron. 2004;43:447-468.

28. Nagra M, Logan N. Myopia control-intervention strategies. Optometry Today. CET 2014. Course code C-36384. [cited 15 December, 2014]. Available from: www.optometry.co.uk/clinical

29. Bailey G. Myopia (Nearsightedness): Definition, causes and treatment (online). [cited 18 May 2015]. Available from: www.allaboutvision/conditions/myopia.htm. St. Louis: All About Vision; 2014.

30. Mavracanas TA, Mandalos A, Peios D, et al. Prevalence of myopia in a sample of Greek students. Acta Ophthalmol Scand. 2000;78:656-659.

31. Morgan IG, Kyoto OM, Saw SM. Myopia. Lancet. 2012;379:1739-1749.

32. Arevalo JF,Ramirez E, Suarez E, et al. Rhegmatogenous retinal detachment after laser-assisted in situ keratomileusis (LASIK) for the correction of myopia. Retina. 2000;20:338-341.

33. Arevalo JF, Azar-Arevalo O. Retinal detachment in myopic eyes after laser in situ keratomileusis. Am J Ophthalmol. 2000;129:825-826.

34. Steidl SM, Pruett RC. Macular complications associated with posterior staphyloma. Am J Ophthalmol. 1997;123:181-187.

35. Vongphanit J, Mitchell P, Wang JJ. Prevalence and progression of myopic retinopathy in an older population. Ophthalmology. 2002;109:704-711.

36. Mitchell P, Hourihan F, Sandbach J, Wang JJ. The relationship between glaucoma and myopia: The Blue Mountains Eye Study. Ophthalmology. 1999;106:2010-2015.

37. Saw SM, Tong L, Chua WH, et al. Incidence and progression of myopia in Singaporean school children. Invest Ophthal Vis Sci. 2005;46:51-57.

38. Javitt J, Chiang Y. The socioeconomic aspects of laser refractive surgery. Arch Ophthalmol. 1994;112:1526-1530.

39. Chaudhry R, Ali H, Sheik NH. Frequency and underlying factors of myopia among medical students. Biomedica. 2011;27:154-160.

40. Abdull MM, Sivasubramaniam S, Murthy GV, et al. Causes of blindness and visual impairment in Nigeria: The Nigeria national blindness and visual impairment survey. Invest Ophthalmol Vis Sci. 2009;50:4115-4119.

41. Khaddar YS, Bateyha WQ, Abdul-Aziz SM, Al Shiekh-Khalil MI. Prevalence and risk indicators of myopia among school children in Amman, Jordan. East Meditter Health J. 2006;12:434-439.

42. Nigerian Optometric Association (NOA). N.O.A. report on the strategic action plan for vision 2020: The right to sight for Nigeria. Abuja: Nigerian Optometric Association; 2007-2011.

43. Kyari F, Gudlavalleti MV, Sivsubramaniam S, et al. Prevalence of blindness and visual impairment in Nigeria: The national blindness and visual impairment survey 2009. Invest Ophthalmol Vis Sci. 2009;50:4114-4120.

44. Rose KA, Morgan IG, Ip J, et al. Outdoor activity reduces the prevalence of myopia in children. Ophthalmology. 2008;115:1279-1285.

45. French AN, Morgan IG, Mitchell P, Rose KA. Risk factors for incident myopia in Australian schoolchildren: The Sydney Adolescent Vascular and Eye Study. Am Acad Ophthal. 2013;13:2100-2108.

46. Borish IM. Clinical refraction. 3rd ed. Chicago: The Professional Press, 1975; p. 5-694.

47. Ehrlich D, Braddick O, Atkinson J, et al. Infant emmetropization: Longitudinal changes in refraction components from nine to twenty months of age. Optom Vis Sci. 1997;74;822-843.

48. Mutti DO, Mitchell GL, Sinnott LT, Jones-Jordan LA, Moeschberg ML, Cotter SA. Corneal and crystalline lens dimensions before and after onset. Optom Vis. 2012;89:62.

49. Medical dictionary. Myopia definition (online). [cited 20 November 2014]. Available from: www.medical-dictionary.thefreedictionary.com/myopia

50. Yackle K, Fitzgerald D. Emmetropization: An overview. Journal of Behavioral Science. 1999;10;38-43.

51. Rabin J, Van Sluyters RC, Malach R. Emmetropization: A vision-dependent phenomenon. Invest Ophthmol Vis Sci. 1981;20:661-664.

52. Mutti DO, Mitchell GL, Jones LA, et al. Axial growth and changes in lenticular and corneal power during emmetropization in infants. Invest Ophthamol Vis Sci. 2005;46;3074-3780.

53. Manna F, Parel JM, Denham D, et al. Optomechanical response of human and monkey lenses in a lens stretcher. Invest Opthalmol Vis Sci. 2007;48:3260-3268.

54. Olivera C, Tello C, Libermann JM, Ritch R. Ciliary body thickness increase with increasing axial myopia. Am J Opthalmol. 2005;140;324-329.

55. Norton TT, Siegwart JT, Amedo AO. Effectiveness of hyperopic defocus, minimal defocus, or myopic defocus in competition with a myopiagenic stimulus in tree shrew eyes. Invest Ophthalmol Vis Sci. 2006;47;4687-4699.

56. Wallman J, Gottlieb MD, Rajaram V, Fugate-Wentzek LA. Local retinal regions local eye growth and myopia. Science. 1987;237:73-80.

57. Smith EL, Hung LF. The role optical defocus in regulating refractive development in infant monkeys. Vision Res. 1999;39:1415-1435.

58. Von N, Lewise RA. Ocular axial length in unilateral congenital cataracts and blepharoptossis. Invest Ophthalmol Vis Sci. 1987;28:750-752.

59. Mutti DO. Hereditary and environmental contributions to emmetropization and myopia. Optom Vis Sci. 2010;87: 255-264.

60. Myrowitz EH. Pediatric ophthalmology update: Juvenile myopia progression, risk factors and interventions. Saudi J Ophth. 2012;26:293-297.

61. Cooper E, Jamal N. Current status on the development and treatment of myopia. Optometry. 2012;83:179-199.

62. Hoogerheide J, Rempt F, Hoogenboom, WPH. Acquired myopia in young pilots. Ophthalmologica. 1971;163:209-215.

63. Mutti DO, Cooper ME, O`Brien S, et al. Candidate gene and locus analysis of myopia. Mol Vis. 2007;13:1012-1019.

64. Gwiazada JE, Hyman L, Norton TT, et al. Accommodation and related risk factors associated with myopia progression and their interaction with treatment in COMET children. Invest Ophthalmol Vis Sci. 2004;45:2143-2151.

65. Mutti DO, Mitchell GL, Hayes JR, et al. Accommodative lag before and after the onset of myopia. Invest Ophthalmol Vis Sci. 2006;47:837-846.

66. Carrol JP. Emmetropization. Journal of Theoretical Biology. 1982;95:135-144.

67. Leo SW, Young TL. An evidence-based update on myopia and intervention to retard its progression. JAAPOS. 2011;15:181-189.

68. He M, Hur YM, Zhang J, Ding X, Huang W, Wang D. Shared genetic determinant of axial length, anterior chamber depth and angle opening distance: The Guangzhou twin eye study. Invest Ophthalmol Vis Sci. 2008;49:4790-4794.

69. Mrugacz M. Role of the genetic factors in the development of myopia. Intech. 2013:293-303. http://dx.doi.org/10.5772/52543

70. Mutti DO, Mitchell GL. Moeschberger ML, Jones LA, Zadnick K. Parental myopia, near work, school achievement and children`s refractive error. Invest Ophthalmol Vis Sci. 2002;43:3633-3640.

71. Liang CL, Yen E, Su JY, et al. Impact of family history of high myopia on level and onset of myopia. Invest Ophthalmol Vis Sci. 2004;45:3446-3452.

72. Hornbeak DM, Young TL. Myopia genetics: A review of current research and emerging trends. Curr Opin Ophthalmol. 2009;20:356-362.

73. Morgan IG, Rose KA. How genetic is school myopia? Progress in Retinal and Eye Research. 2005;24:1-38.

74. Jones LA, Sinnott LT. Mutti DO, Mitchell GL, Moeschberger ML, Zadnik K. Parental history of myopia, sports and outdoor activities, and future myopia. Invest Ophthalmol Vis Sci. 2007;48:3524-3532.

75. Simensen B, Thorud LO. Adult onset myopia and occupation. ActaOphthalmol (Copenh). 1994;72:469-471.

76. White R. A precarious balance: Genetic versus environmental risk in the mediation of myopia. Cross Section. 2005;1:123-145.

77. Dirani M, Tong L, Gizzard G, et al. Outdoor activity and myopia in Singapore teenage children. British Journal of Ophthalmology. 2009;93:997-1000.

78. Parssinen O. The increase of prevalence of myopia in Finland. Acta Ophthamologica. 2011;90:497-502.

79. Johnson GJ. Myopia in arctic regions: A survey. Acta Ophthalmol Suppl. 1988;185:13-18.

80. Lee HJ, Jee D, Kwon JW, Lee WK. Prevalence and risk factors for myopia in a rural Korean population. Invest Ophthalmol Vis Sci. 2013;13-12478.

81. Zhao J, Pan X, Sui R, Munoz SR, Superduto RD, Ellewein LB. Refractive error study in children: Results from Shunyi district China. Am J Ophthalmol. 2000;129-435.

82. Pokharel GP, Negrel AD, Munoz SR, Ellewein LB. Refractive error in children: Results from Mechi zone, Nepal. Am J Ophthalmol. 2000;129:436-444.

83. Goldsmidt E, Jacobsen N. Genetic and environmental effects on myopia development and progression. Eye (Lond). 2014;28:126-133.

84. Wojciechowski R. Nature and nurture: The complex genetics of myopia and refractive errors. Clin Genet. 2011;79:301-320.

85. Saw SM, Hong RZ, Zhang MZ, et al. Near work activity and myopia in urban and rural school school children in China. J Pediatric Ophthamol Strabismus. 2001;38:328-333.

86. Nangia V, Jonas JB, Sinha A, Matin A, Kulkami M. Refractive error in central India: The Central India Eye and Medical Study. 2010;117:693-695.

87. Garner LF, Owens H, Kinnear RF, Frith MJ. Prevalence of myopia in Sherpa and Tibetan children in Nepal. Optom Vis Sci. 1999;76:282-285.

88. Stone RA, Lin T, Desai D, Capehart C. Photoperiod, early post-natal eye growth, and visual deprivation. Vision Res. 1995;35:1195-1202.

89. Zhou X, An J, Wu X, et al. Relative axial myopia induced by prolonged light exposure in C57BL/6 mice. Photochem Photobio. 2010;86:131-137.

90. Li T, Troilo D, Glasser A, Howland HC. Constant light produces severe corneal flattening and hyperopia in chickens. Vis Res. 1995;35:1203-1209.

91. Cohen Y, Belkin M, Yehezkel O, Solomon AS, Polat U. Dependency between light intensity and refractive development under light-dark cycles. Exp Eye Res. 2011;92:40-46.

92. Smith EL 3rd, Hung LF, Huang J. Protective effects on ambient lighting on the development form-deprivation myopia in rhesus monkeys. Invest Ophthalmol Vis Sci. 2011;53:421-428

93. Ashby R, Ohlendor FA, Schaeffel F. The effects on ambient luminance on the development of deprivation myopia in chicks. Invest Ophthalmol Vis Sci. 2009;50:5348-5354.

94. Xiang F, Zeng Y, Zhang J, Morgan IG, Rose KA, He M. Protective effect of time outdoors on the development of juvenile-onset myopia: The Guangzhou Outdoor Activity Longitudinal (GOAL) Study: A 3-year cluster randomized trial. Abstract presented at the International Myopia Conference. Asilomar, California, USA; 2013.

95. Cordain L, Easton SB, Brand M, Linderberg S, Jensen C. An evolutionary analysis of the aetiology and pathogenesis of juvenile-onset of myopia. Acta Ophthamol Scand. 2002;80:125-135.

96. Ebbesson SO, Schraer CD, Risica PM, et al. Diabetics and impaired glucose tolerance in three Alaskan Eskimo populations. The Alaska-Siberia Project. Diabetic Care.1998;21:563-569.

97. Daniel M, Rowley KG, McDermott R, Mylvaganam A, O`Dea K. Diabetes incidence in an Australian aboriginal population. An 8-year fellow- up study. Diabetes Care. 1999;22:1993-1998.

98. Beck-Nielsen H, Pedersen O, Sorensen NS. Effects of diet on the cellular insulin binding and the insulin sensitivity in young heath subjects. Diabetologia. 1978;15: 289-296.

99. Beck-Nielsen H, Pedersen O, Lindskov HO. Impaired cellular insulin binding and the insulin sensitivity induced by high-fructose feeding in normal subjects. Am J Clin Nutr. 1980;33:273-278.

100. Al Wadaani FA, Amin TT, Ali A, Khan AR. Prevalence and refractive errors among primary school children in Al Hassa, Saudi Arabia. Global Journal of Health. 2013;5:125-134.

101. Mabaso RG, Oduntan AO, Mpolokeng MBL. Refractive status of primary schoolchildren in Mpani district, Limpopo Province, South Africa. South African Optom. 2006;65:125-133.

102. Balarabe AH, Adamu I,Abubarkar A. Vision screening to detect refractive errors in three selected schools in Birnin Kebbi, North West, Nigeria. Sahel Med J.2015;18:61-65.

103. Ovenseri-Ogbomo GO, Assien R. Refractive error in school children in Agona Swedru, Ghana. *S Afr Optom.* 2010;69:86-92.

104. Muma MK, Kariuki-Wanyoike MM, Kimani K, Ilako DR, Njuguna MW. Prevalence of refractive errors among primary school pupils in Kilungu Division of Makueni District, Kenya. Medical Journal of Zambia. 2009;36:165-170.

105. You QS, Wu JL Duan JL, et al. Factors associated with myopia in school children in China: The Beijing Childhood Eye Study (online). PLOS ONE 2012;7:1-10. Available from: www.plosone.org.

106. Wu PC, Tsai CL, Hu CH, Yang YH. Effects of outdoor activities on myopia among rural schoolchildren in Taiwan. Ophthalmic Epidemiology. 2010;17:338-342.

107. Jobke S, Kasten E, Vorweik C. The prevalence rates of refractive error among children, adolescents and adults in Germany. Clinical Ophthalmol. 2008;2:601-607.

108. Maul E, Barroso S, Munoz SR, Sperduto RD, Ellewein LB. Refractive error study in children: Results from La Florida, Chile. Am J Ophthalmol. 2000;129:445-454.

109. Dandona R, Dandona L, Srinivas M, et al. Refractive error in children in a rural population in India. Invest Ophthalmol Vis Sci. 2002;43:615-622.

110. Jones-Jordan LA, Mitchell GL, Cotter SA, et al. Visual activity before and after the onset of Juvenile myopia. Invest Ophthal Vis Sci. 2011;52:1842-1850.

111. Saw SM, Shankar A, Tan SB, et al. A cohort study of incident myopia in Singaporean children. Invest Ophthalmol Vis Sci. 2006;47:1839-1844.

112. Ip JM, Saw SM, Rose KA, et al. Role of near work in myopia: Findings in a sample of Australian school children. Invest Ophthalmol Vis Sci. 2008;49:2903-2910.

113. Parssinen O, Kauppinen M, Viljanen A. The progression of myopia from its onset at age 8-12 to adulthood and the influence of heredity and external factors on myopic progression. A 23-year follow-up study. Acta Ophthalmologica. 2014;92:730-739.

114. Saad A, El-Bayoumy BM. Environmental risk factors for refractive error among Egyptian schoolchildren. Eastern Mediterranean Health Journal. 2007;13:819-828.

115. Low W, Dirani M, Gazzard G, et al. Family history, near work, outdoor activity, and myopia in Singapore Chinese preschool children. Br J Ophthalmol. 2010;94:1012-1016.

116. Kiefer AK, Tung JY, Do CB, et al. Genome-wide analysis points to roles for extracellular matrix remodeling, the visual cycle, and neuronal development in myopia. PLOS Genet 2013; 9: e1003299. http://dx.doi.org/10.1371/journal.pgen.1003299.

117. Yip VC, Pan CW, Lin XY, et al. The relationship between growth spurts and myopia in Singapore children. Invest Ophthalmol Vis Sci. 2012;53:7961-7966.

118. Lim LS, Gazzard G, Low YL, et al. Dietary factors, myopia and axial dimension in children. Am Acad Ophthalmol. 2010;117:993-997.

119. Cheng CY, Huang W, Su KC, Peng ML, Sun HY, Cheng HM. Factors modulating school myopia. Life Science Journal. 2012;9:142-149.

120. Adler D, Millodot M. The possible effect of undercorrection on myopic progression in children. Clinical ExpOptom. 2006;89:315-321.

121. Philip J, Loertscher M, Anstice N. Myopia progression: Can we control it? Optometry in Practice. 2013;14:33-44.

122. Chung K, Mohidin N, O`Leary DJ. Undercorrection of myopia enhances rather than inhibits myopia progression. Vis Res. 2002;42:2555-2559.

123. Saw SM, Gazzard G, An Enog, Tan DT. Myopia: Attempts to arrest progression. Br J Ophthalmol. 2002;86:1306-1311.

124. Fulk GW, Cyert LA, Parker DE. A randomized trial of the effect of single-vision vs bifocal lenses on myopia progression in children with esophoria. Optom Vis Sci. 2000;77;395-401.

125. Leung JT, Brown B. Progression of myopia in Hong Kong Chinese schoolchildren is slowed by wearing progression lenses. Optom Vis Sci. 1999;76:346-354.

126. Goss DA, Grosvenor T. Rates of childhood myopia progression with bifocals as a function of near point phoria: Consistency of three studies. Optom Vis Sci. 1990;67:637-640.

127. Cheng D, Woo GC, Drobe B, Schmid KL. Effects of bifocal and prismatic bifocal spectacles on myopia progression in children: Three year results of a randomized clinical trial. JAMA. Ophthalmol. 2014;132:258-264.

128. Simon B, Fox S, Ibrahim B, Philip JR. Peripheral refraction in myopia corrected with spectacles versus contact lenses. Ophthalmic Physiol Opt. 2012;32:294-303.

129. Anstics NS, Philips JR. Effects of dual-focus soft contact lens wear on axial myopia progression in children. Ophthalmology. 2011;118:1152-1161.

130. Holden B, Sankardunj P, Lazon P, et al. Central and peripheral visual performance of a novel contact lens designed to control progression of myopia. Invest Ophthalmol Vis Sci. 2011;52: E-Abstract 6518 2011.

131. Sankaridurg P, Holden B, Smith E, et al. Reduction in the rate of progress of myopia with a contact lens designed to reduce relative peripheral hyperopia. Invest Ophthalmol Vis Sci. 2011;51: E-Abstract 2220 2010.

132. Walline JJ, Grenier KL, McVey ME, Jones-Jordan LA. Mutifocal contact lens myopia control. Optom Vis Sci. 2013;90:1207-1214.

133. Cho P, Cheung SW, Edward M. The longitudinal orthokeratology investigation in children (LORIC) in Hong Kong: A pilot study on refractive changes and myopic control. Curr Eye Res. 2005;30:71-80.

134. Yen MY, Liu JH, Kao SC, Shiao CH. Comparison of the effects of atropine and cyclopentolate on myopia. Ann Ophthalmol. 1989;21:180-182, 187.

135. Shih YF, Hsiao CK, Chen CJ, Chang CW, Hung PT, Lin LL. An intervention trial on efficacy of atropine and multi-focal glasses in controlling myopic progression. Acta Ophthalmol Scand. 2001;79:233-236.

136. McBrien NA, Moghaddam HO, Reeder AP. Atropine reduces experimental myopia and eye enlargement via a non-accommodative mechanism. Invest Ophthalmol Vis Sci. 1993;34:205-215.

137. Schmid KL, Wildsoet CF. Inhibitory effects of a pomorphine and atropine and their combination in chicks. Optom Vis Sci. 2004;81:137-147.

138. Tong L, Huang XL, Koh Al, Zhang X, Tan DT, Chua WH. Atropine for the treatment of childhood myopia: Effect on myopia progression after cessation of atropine. Ophthalmology. 2009:116:572-579.

139. Chia A, Chua WH, Cheung YB, et al. Atropine for the treatment of childhood myopia: Safety and efficacy of 0.5% and 0.01% doses (atropine for the treatment of myopia 2). Ophthalmology. 2012:119:347-354.

140. Dorje F, Wess J, Lambrecht G, Tacke R, Muschler E, Brann MR. Antagonist binding profiles of five cloned human muscarinic receptor subtypes. J Pharmacol Exp Ther. 1991;256:727-733.

141. Siatkowski RM, Cotter SA, Crockett RS, Miller JM, Novack GD, Zadnik K. Two-year multicenter, randomized, double-masked, placebo-controlled parallel safety and efficacy study

of 2% pirezenpine ophthalmic gel in children with myopia. J Am Assoc Paed Ophthalmol Strabismus. 2008;12:332-339.

142. Barlett JD, Niemann K, Hounde B, Allred T, Edmondson MJ, Crockett RS. A tolerability study of pirezenpine ophthalmic gel in myopic children. J Ocular Pharm Therapeutics. 2003;19:271-279.

143. Mutti DO, Marks AR. Blood levels of vitamin D in teens and young adults with myopia. Am Acad Optom. 2011;88:377.

144. Ngo C, Saw SM, Dharani R, Flitchrosft I. Does sunlight (bright light) explain the protective effects of outdoor activity against myopia? Ophthal Physiol Optics. 2013;33:368–372.

145. Education board bulletin. Zonal education board. Umuahia, Nigeria: Ministry of Education, Abia State; 2015.

146. Faderin MA, Ajaiyeoba AI. Refractive errors in primary school children in Nigeria. Nig J Ophthal. 2001;9:10-14.

147. World Health Organization/National Eye Institute. Assessment of the Prevalence of Visual Impairment Attributable to Refractive Error or Other Causes in School Children: Protocol and Manual of Procedures: 2007. [cited 18 May 2014]Available at: http://www.who.int/blindness/causes/RESCProtocol.pdf.

148. Aldebasi YH. Prevalence of correctable visual impairment in primary school children in Qassim Province, Saudi Arabia. Journal of Optometry. 2014;7:168-176. http://dx.doi.org/10.1016/j.optom.2014.02.001

149. Parssinen O, Lyyra AL. Myopia and myopic progression among schoolchildren: A three-year follow-up study. Invest Ophthalmol Vis Sci. 1993;34: 2794-2802.

150. Goss DA. Variables related to rate of childhood myopia progression. Optom Vis Sci. 1990;67:631-636

151. Guo Y, Liu LJ, Xu L, et al. Outdoor activity and myopia among primary students in rural and urban regions of Beijing. Ophthalmology. 2013;120:277-283.

152. Zadnik, K, Sinnott, T,Cotter, SA, et al. Prediction of Juvenile-Onset Myopia. J*AMA Ophthalmol.* 2015;133:683-689. doi:10.1001/jamaophthalmol.2015.0471.

153. Karouta C. The role of bright light as a protective mechanism against the development of form-deprivation myopia in chickens (unpublished Bachelor of Applied Science (honours) degree thesis). Canberra: University of Canberra; 2014.

7.0 APPENDICES

Appendix 1: Questionnaire

Risk Factors for Myopia Survey

Survey No: …………………………......   Date: __ / __ / ___

School No: …………………………..   Class: …………..………………

Age: ……………………………………   Sex: ....…………….......

Instruction:

- Please select the option applicable to you.
- **N/A** means not applicable to me.
- **Myopia** is an eye problem where ones sees objects at near very well but does not see objects at far clearly.
- Students are supposed to answer these questions with the help of their parents/guardian.

I. Spectacles

1) Do you wear spectacles?   Yes ☐   No ☐

2) What is the purpose of you wearing spectacles?

     N/A ☐   Far sight ☐   Near Sight ☐   Both ☐

3) At what age (in years) did you start wearing spectacles?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

4) Are you still wearing the spectacles?

     N/A ☐   No ☐   Yes ☐

5) How often do you wear your spectacles?

        N/A ☐   Sometimes ☐   Fairly often ☐   Always ☐

6) Why did you stop wearing spectacles?

        N/A ☐   Don't like it ☐   Not comfortable ☐   Broken/lost ☐

II. Family history

7) How many of your parents are short sighted?

None ☐   One ☐   Both ☐

8) Which of your parents wear spectacles?

        None or N/A ☐   Mother ☐   Father ☐   Both ☐

9) Which of them can read without spectacles?

None ☐   Mother ☐   Father ☐   Both ☐

10) How many of your sisters are short sighted?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

11) How many of your brothers are short sighted?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

12) How many of your uncles are short sighted?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

13)   How many of your aunts are short sighted?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

III. Parents' education and occupational information

14)   What is the level of your mother's education?

Informal ☐   Primary ☐   Secondary ☐

College/diploma ☐   University/degree ☐   Other, specify _____

15)   What is your mother's profession?

Housewife ☐   Farmer/trader ☐   Business ☐

Teacher ☐   Artisan ☐   Politician ☐

Civil/public servant ☐   Lecturer/doctor ☐   Other, specify _____

16)   What is the level of your father's education?

Informal ☐   Primary ☐   Secondary ☐

College/diploma ☐   University/degree ☐   Other, specify _____

17)   What is your father's profession?

No job ☐   Farmer/trader ☐   Business ☐

Teacher ☐   Artisan ☐   Politician ☐

Civil/public servant ☐   Lecturer/doctor ☐   Other, specify _____

IV. Scholarly and physical activities

18) How many hours do you do reading per day?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

19) How many hours do you do writing per day?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

20)   How many hours do you use a computer per day (weekend)?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

21)   How many hours do you use a computer per day (Monday to Friday)?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

22)   How many hours do you watch television per day (weekend)?

0   1   2   3   4   5   6   7   8   9   10

Other, specify _____

23)   How many hours do you watch television per day (Monday to Friday)?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

24) How many hours do you play video games per day (weekend)?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

25) How many hours do you play video games per day (Monday to Friday)?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

26)   How many hours do you play outdoor sports/ leisure activities per week?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

27)   How many hours do you play indoor sports/leisure activities per week?

0	1	2	3	4	5	6	7	8	9	10

Other, specify _____

Appendix 2: Clinical Evaluation Form

Risk Factor for Myopia Survey – Referral Form

Survey No. _____   Date ___/ ___/ ___

School _____   Class_____

Student's name _____

Age: _____   Sex: _____   Siblings no.: _____   Region of origin_____

1) Any recurrent symptom or any complaint?

     No ☐   Visual impairment ☐   Headache ☐

     Other ☐   Specify:_____

2) History

(From) when? Transient? Intermittent? Ongoing?

Diminution of distance vision: OD ☐ OS ☐ _____

_____

Diminution of near vision   OD ☐ OS ☐ _____

_____

Headache/eyestrain   OD ☐ OS ☐ _____

_____

Itching/ rubbing of eyes   OD ☐ OS ☐ _____

_____

Redness/watering/discharge   OD ☐ OS ☐ _____

_____

Deviation   OD ☐ OS ☐ _____

_____

Further comments: _____

3) Wearing spectacles?   No ☐   Yes ☐

If yes, write down the power.

Eye	Sphere	Cylinder	Axis
OD			
OS			

4) Visual acuity

Eye	Unaided	Aided (if wearing spectacles)	Pinhole
OD			
OS			

5) Cover Test

	Ortho	Exophoria	Esophoria	Exotropia	Esotropia
Distance					
Near					

6) Ocular motility: Full ☐   Restricted ☐

    Comment if any: _____

7) Near point of convergence: _____

8) Pupil reflex

    Normal ☐   Irregular ☐   RAPD ☐

Eye	Anterior segment	Posterior segment
OD		

OS		

9) Auto ref/ ret

Eye	Sphere	Cylinder	Axis	SE
OD				
OS				

10) Subjective refraction

Eye	Sphere	Cylinder	Axis	SE	VA
OD					
OS					

Diagnosis and remarks: _____

_____

_____

_____

_____

_____

_____

APPENDIX 5: LETTER TO THE PARENTS OF THE STUDENT

Dear Sir/Madam,

Invitation to participate in a survey

I am Atowa, Uchenna Chigozirim currently pursuing a Master of Optometry degree program at University of KwaZulu-Natal, South African. As part of the fulfillment of the requirement for my study, I am conducting a research on the frequency of school myopia (**the ability to see clearly objects at near while objects at far appears blurred**) and the factors that contribute to its increase and progression in Secondary School Students. I wish to seek for your permission and consent to invite your child/ward to participate in this research.

The procedure for this research involves two stages. First a questionnaire will be given to your child to answer (with your help), questions on history of myopia in your family and some of his/her daily activities. The second stage will involve an eye test which will be carried out in your child/ward's school. Your child/ward's vision and ocular health will be assessed using standard Optometric instruments. The eye test will be conducted by licensed Optometrist and should be within the scope Optometry practice in Nigeria. The research team will be visiting their school from …. To ….Participation in this study is voluntary and any participant is free to withdraw at any stage during the survey that he/she feels to do so. Participants will be identified by numbers and not by name.

After, the survey, a report will be compiled and submitted to School of Health Science, University of KwaZulu-Natal, South Africa. A copy will also be sent to Aba Zonal Educational Management Board. The survey is strictly for research and academic purposes and there is no risk or danger involved

If you decide to grant your child/ward the permission to participate in this survey: you are kindly requested to fill out the consent form below and return it to the principal through your child/ward.

Consent form

Please complete this form and return to (name of school) by (date)

I_____

Declare that I have legal responsibility for_____

And that I am legally competent to give consent to his/her participation in the survey of prevalence and risk factors for myopia among school children in Nigeria. To be held on (date of survey)

In giving my consent, I:

- Am happy for my child to participate in the survey on prevalence and risk factors for myopia among school children in Nigeria.
- Have read the information about the project and understand what is involved.
- Have discussed participation in the project with my child and they are willing to take part
- Understand that the project is for academic purpose
- Understand that the report may be published

    Signature of parent_____

    Date _____

Igbo Translation

Mazi

Ikike isoro n'ihe omume nchocha

A bum Uchenna Chigozirim Atowa, onye na-agu akwukwo na Univasiti nke KwaZulu-Natal, South Africa n'ogo nke masta. Dika nmezu ihe di na agu ma akwukwo m, anam eme ihe nchocha n'isi okwu bu 'ihe na-akpata umu akwukwo si na-ahu ihe di nso nke oma ma hara ihu ihe di anya nke oma.' Ejim ohere nka na anaragi ikike ka nwa gi nsonye na ihe omume nkaaa.

Ihe omume nchocha di agba abua. Nke mbu agba nwagi ajuju onu n'udi nke ana akpo qeshonia na olu oyibo. Ajuju ndi kunyere ndi gbara oria anya nke anakpo mayopia(ihu ihe din so nke oma na ahughi nke di anya nke oma) na ezi na ulo gi, ogo agu m'akwukwo na oru nne na nna, ihe omume na skul na n'ulo na otutu ihe ndi ozo. Agba nke abua ga abu nyocha nke anya (eye examination) nke ndi dokinta anya (Optometrist) ga eme site na nkwdo iwu na achokota ndi oru ahu ike anya na obodo anyi Nigeria. Ndi otu ihe nchocha ga eje n'ulo akwukwo nwa gi n'ubochi … rue …. Isonye n'ihe nyocha bun a mmasi nke onye, n;ihi nka onye obula nwere ikikere isi na ya agahi esonye n'ihe omumea mgbe obula ochoro.

Mgbe emesiri ihe nchocha aga ede ihe nkowa gbarasara ya nke aga enye ndi mahadum nke KwaZulu-Natal, South Africa. Aga enyekwa ndi nchokota ulo akwokwo nke di na aba out kopi. Ebumnuche ihe nchocha bu nani maka nweta ihe nturu ugo mmuta mastas onweghi ihe itu egwu obula nke di na ya.

Oburu na ikwere inye nwa gi ikike nsoro n'ihe omume nkaa, biko dejuputa akwukwo nka so leta a ma tinye aka na ya, zighachiya site n'aka pirinsipal nke ulo akwukwo nwa gi iji gosiputa nkwenyere gi.

Akwukwo ikike

Biko, dejuputa akwukwo ma zighchiya (name of school) n'ubochi …..

Mu onwem ……………………………………………………………………na ekwu ………………………………….bu nwam. Na m tozuru oke n'onodu iwu obodu anyi inochita anya inye ya ikike isonyere na ihe omume nchochaa n'isi okwu bu ihe kpatara ufodu ndi mmadu ji n'ahu ihe din so nke oma ma ha anaghi ahu ihe di anya nke oma nke aga eme n'ubochi …….

N'inye ya ikikea, Ana ekwuputa:

- N'obi dim uto ka nwam soro n'ihe omumea
- Akowaram ihe nile bayere ihe omumea
- Mu na nwam atughariala echeche bayere ihe omumea nke okwenyere isoro n'ime ihea
- Aghotaram n'ihe nchochaa bu maka agum akwaukwo
- Na apuru ikpasa ihe achopuatara nye ohaneze.

Tinye aka abea……………..   Deti……………

<u>Onyeisi ihe omume nchocha</u>

Uchenna Atowa

Email: <u>uchechigo@yahoo.com</u>

07033369518

APPENDIX 6. CHILD ASSENT FORM

I am Uchenna Chigozirim Atowa from University of KwaZulu-Natal, South Africa. I am doing a study to find out what may be responsible for some people to see things at near very well while the things at far is not clear to them. Your school have been selected to participate is this study and I am asking you to take part in the research study because you are within the study age group (8 – 15) years.

For this research, you will be asked some questions on your activities during and after school and your family history of wearing spectacles. You will also be required to undergo an eye examination to be conducted by a qualified Optometrist to find out the status of your eyes. We will keep all your answers private, and will not show them to your teacher or parent(s)/guardian. Only people working with me will see it. You are free to withdraw from participating in the study at any point in time without any punishment from us, your teacher or the school.

I don't think that any problems will happen to you as part of this study, but if you feel any problem in the course of the study you should let me know. Your parent(s)/guardian(s) were asked if it is OK for you to be in this study. Even if they say it's OK, it is still your choice whether or not to take part. You can ask any questions you have, now or later. If you think of a question later, you or your parents can contact me

Sign this form only if you:

- have understood what you will be doing for this study,
- have had all your questions answered,
- have talked to your parent(s)/legal guardian about this project, and
- agree to take part in this research

_____

Your Name   signature   Date

_____

Name of Parent(s) or Legal Guardian(s)

Principal investigator

Atowa Uchenna Chigozirim

07033369518

Translation (Igbo language)

AKWUKWO KWENYE

Aham bu Uchenna Chigozirim Atowa, onye n'aga akwukwo na mahadum nke KwaZulu-Natal, South Africa. A name me nchocha imata ihe n'eme ndi ufodi mmadu n'ahu ihe ndi nso ma onaghi ahu nke di anya. Ahuru la ulo akwukwo gi n'out ndi ga eso n'ihe omume nka. Ejim ohere n'akpo gi ka isoro n'ihe omume a.

N'ihe nchocha aga aju gi ajuju gbasara ihe omume gi n'ulo akwukwo na mgbe ino n'ulo na ajuju gbasara ndi n'eyi ugegbe anya n'ezimulo nna gi. Aga enwe ihe nyocha anya nke dokinta n'ahu maka anya ga eme iji mara out anya gi di. Anyi agaghi ezi nne na nna gi, ndi nkuzi gi maobu ulo akwukwo ihe obula nke igwara anyi n'onodu nchocha a. Obu nani ndi mu na ha a'aruko orua ga ahu ihe ndia. Onweghi onye ga emegide gi ma oburu na ichoghi isoro n'ihe nchocha. Oburu gi ikpebie isoro inwere ikike isi eehee n'oge obula na ichoghi iga n'ihu n'ihe nyocha na-enweghi nsoghu obula.

Ihe nchochaa agaghi ebutere ginsogbu obula, kama oburu inwe nsogbu obula biko meek am mara. Any ga eme ka ndi muru gi mara maka ihe omumea kama mara n'obu gi puru ikpebi ma iga eso. I puru iju ajuju n'ihe obula n'edoghi anya mgbe obula site na akara ekwe ntim.

Tinye aka n'akwukwo a

- Ihotara ihe nile gbasara ihe nchocha
- Na azala ajuju gi nile
- Imela ka ndi muru mara maka ihe nchocha
- Ikpebiala isoro n'ihe nchochaa

Aha gi_____ tinye aka ebea_____ deti_____

Aha ndi muru gi_____

<u>Onyeisi ihe omume nchocha</u>

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