

**EXPLORING THE MANAGEMENT MODALITIES FOR A PAEDIATRIC
POPULATION PRESENTING WITH BINOCULAR VISION ANOMALIES IN
PUBLIC HEALTH CARE FACILITIES IN LIMPOPO PROVINCE, SOUTH AFRICA.**

MASTERS OF OPTOMETRY

ER Maribeng

2025

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by

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DISSERTATION

Submitted in fulfilment of the requirements for the degree of

MASTERS OF OPTOMETRY

in the

FACULTY OF HEALTH SCIENCES

(School of Health Care Sciences)

at the

UNIVERSITY OF LIMPOPO

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2025

DECLARATION

I declare that the dissertation hereby submitted to the University of Limpopo, for the degree of Masters of Optometry has not previously been submitted by me for this or any other university: that it is my own work in design and in execution, and that all material contained herein has been duly acknowledged.



16/September/2025

Maribeng ER (Ms)

Date

DEDICATION

The study is dedicated to my late mother-in-law and my late Pastor Ayodele, both of whom always encouraged me to further my studies.

To my husband and my children who were patient with me, prayed and supported me throughout the study journey.

I appreciate my parents, siblings and in-laws for always encouraging me to strive forward when I felt defeated.

To all my friends who encouraged and provided me with motivation.

ACKNOWLEDGEMENTS

I would like to extend my gratitude to my supervisors: Prof. SD Mathebula and Mr JR Ramaja for being steadfast pillars throughout my research journey and allowing me to grow as a researcher. Your mentorship, unwavering guidance and valuable lessons are very much appreciated.

I am indebted in the University of Limpopo, Optometry Department for granting me the opportunity to conduct this research project.

I am extremely grateful to my university colleagues for providing constructive advice and insightful suggestions regarding my research work.

I wish to thank the Department of Health, Limpopo Province, South Africa, for granting me the opportunity to utilise its health facilities during data collection.

I am indebted to the participants for providing me with data.

I wish to thank the Health and Welfare Sector Education and Training Authority for providing me with funding for my research.

ABSTRACT

Background and aim: Misdiagnosing and mismanaging accommodative and vergence anomalies can result in patients experiencing a poor quality of life due to poor visual status, particularly in the paediatric population. As a result, periodic binocular vision assessment is critical in the lives of children, mainly during their early growth. The current study aims to determine the management modalities used by the optometrists in the public health sectors on paediatric population presenting with binocular vision anomalies in Limpopo Province, South Africa. A thorough understanding of paediatric binocular vision management modalities by public-sector optometrists may help inform health policy and practices.

Methods: A cross-sectional descriptive and quantitative research method was adopted for the current study. Using purposive sampling, 98 optometrists practicing in the selected 43 public hospitals within the Limpopo Province were included as participants. Participants completed online self-administered questionnaires that included demographics, self-reported clinical competencies, management modalities and the availability of clinical resources. Descriptive (frequency counts, percentages) and inferential statistics (Pearson correlation) were used to analyse the data using SPSS version 29.0.

Results: More than half (56.5%) of the participants reported to have competencies in diagnosing and managing binocular vision anomalies. The most common mode of management used was spectacles (69%), and was reported to be a successful mode of treatment by 80.8% of the participants. Drugs and contact lenses were the least preferred management methods used by 1.4% of the participants. The lack of both appropriate equipment and the requisite competencies were identified as the primary reason for non-management of binocular vision anomalies by 49.8% and 41.9% of the participants, respectively. In addition, 62.9% of the participants had not attended any continuous professional development (CPD) activity within the preceding six months. Most hospitals are equipped with ophthalmoscopes, trial frames, distance and near charts, but have limited number of equipment designed for diagnosing binocular vision anomalies.

Conclusions: Half the participants demonstrated their ability to diagnose and manage paediatric binocular vision disorders. Most participants reported to lack the necessary training for binocular vision management. Periodic training for practicing optometrists in the public health sector on paediatric binocular vision anomalies is essential for ensuring quality optometric services. By attending relevant training, optometrists in public hospitals will learn the latest modalities to treat paediatrics binocular vision anomalies that will improve paediatrics quality of life. It is imperative that the government prioritise the provision of instruments for binocular vision assessment and management in all public health facilities to facilitate the efficient and effective diagnosis and management of paediatric binocular vision disorders. This practice of binocular vision will enhance the quality of optometric services both in the Limpopo Province and throughout South Africa.

Keywords: accommodation, binocular vision, contact lenses, diagnosis, management, paediatrics, patients, spectacles, vergence

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LIST OF ACRONYMS

AC/A ratio	Accommodative Convergence is to Accommodative Ratio
BV	Binocular Vision
BVD	Binocular Vision Dysfunction
CEO	Chief Executive Officer
CPD	Continuous Professional Development
DoH	Department of Health
HPCSA	Health Professional Council of South Africa
JCC	Jackson's Cross Cylinder
NFV	Negative Fusional Vergence
NSBC	Non-Strabismic Binocular Vision anomalies
PD	Pupillary Distance
PEC	Primary Eye Care
PEDIG	The Paediatric Eye Disease Investigators Group
PFV	Positive Fusional Vergence
WHO	World Health Organization

DEFINITIONS OF TERMS

Binocular vision refers to vision with two eyes that is, the special attributes experienced when both eyes are open (Steinman, Steinman & Garzia, 2000). The process of integrating and combining the images obtained by each eye into a singular perception (Evans, 2021). In this study, binocular vision refers to the use of both eyes.

Binocular vision anomalies: Miscoordination of the two eyes (Steinman *et al.*, 2000).

Management modalities: In this study, management modalities refer to the methods used to manage binocular vision anomalies.

Accommodative and non-strabismic binocular anomalies are visual dysfunctions that can interfere with an individual's performance (Wajuihian & Hansraj, 2016). In this study, the term accommodative and non-strabismic binocular anomalies refers to the conditions that result from abnormal functioning of the two eyes.

Convergence insufficiency is a condition characterised by orthophoria or low exophoria at distance, high exophoria at near and at a receded near point of convergence (Scheiman & Wick, 2008). In this study, convergence insufficiency refers to eye condition presenting in pediatrics population.

Divergence insufficiency is a condition that present with a high esophoria at distance, and slight esophoria at near (Scheiman & Wick, 2008). In this study, divergence insufficiency refers to an eye condition presenting in pediatrics population.

Fusion Vergence Dysfunction is a condition characterised by low or no degree of phoria but lower fusional vergence reserves at distance and near points (Wajuihian & Hansraj, 2016). In this study, fusional vergence dysfunction refers to an eye condition presenting in pediatric populations.

Basic Esophoria is a condition presenting with high tonic vergence and a normal AC/A ratio. (Wajuihian & Hansraj, 2016). In this study, basic esophoria refers to an eye condition presenting in pediatric populations.

Basic Exophoria is a condition in which tonic vergence is low and AC/A ratio normal (Wajuihian & Hansraj, 2016). In this study, basic exophoria refers to an eye condition presenting in pediatric populations.

Accommodative Insufficiency is a condition in which the patients experience difficulty with all tasks requiring the relaxation of accommodation (Scheiman & Wick, 2008). In this study, accommodative insufficiency refers to eye condition presenting in the pediatric population.

Accommodative Excess is a condition presenting high esophoria at near and low to moderate esophoria at distance (Scheiman & Wick, 2008). In this study, accommodative excess refers to an eye condition presenting in the pediatric population.

Accommodative Infacility is a condition in which the patient experiences difficulties changing the accommodative response level (Scheiman & Wick, 2008), i.e., the difficulties in stimulation and relaxation of the response to accommodation (Darko-Takyi, Khan & Nirghin, 2016). In this study, accommodative infacility refers to eye condition presenting in the pediatric population.

Accommodative fatigue is a condition that present with normal accommodative amplitude, but repeated stimulation of accommodation cause fatigue (Darko-Takyi *et al.*, 2016). In this study, accommodative fatigue refers to an eye condition presenting in the pediatric population.

Strabismus is a visual disorder in which the eyes do not properly align with each other when looking at an object (Ticho, 2003). In this study, strabismus refers to an eye condition presenting in the pediatric population.

Amblyopia is a disorder of sight in which the brain fails to fully process input from one eye and, over time, favours the other eye (DeSantis, 2014). In this study, amblyopia refers to eye condition presenting in the pediatric population.

Emmetropization is a process by which a normal eye has coordinated growth of its refractive components during early childhood to reach refraction near plano (Sharma, Jain, Babber & Tandon, 2015). In this study, emmetropization refers to eye condition presenting in the pediatric population.

CHAPTER 1

INTRODUCTION

1.1. INTRODUCTION AND BACKGROUND

The pediatric population is increasingly overburdened by many eye health conditions that affect their quality of life worldwide (Assi, Chamseddine, Ibrahim *et al.*, 2021). There are many visual conditions that may affect children in various ways and these include, among others, amblyopia, strabismus, accommodative and convergence disorders (Williams, Northstone, Howard *et al.*, 2008). These conditions are conventionally classified as binocular vision anomalies and are reported to be increasingly affecting many children in the developing countries (Evans, 2021). Unfortunately, all these anomalies have a negative influence on the proper functional status of the visual system and these conditions may be worse in the pediatric population. In support of this assertion, a study by Hussaindeen, Rakshit, Singh *et al.* (2017) conducted in Asian countries, revealed that binocular vision conditions lead to symptoms such as eye strain, rapid fatigue and the inability of long standing performance at near distances. These symptoms are highly prevalent among school-going children and their occurrence increase with age (Podugolnikova, 2017). Therefore, it is important for eyecare practitioners to always consider performing a comprehensive binocular vision examination for effective management on pediatric population.

Hussaindeen *et al.* (2017) reported the prevalence of non-strabismic anomalies of binocular vision among children in Tamil Nadu in India to be 31,3% in the rural areas and 29.6% in the urban's areas. In another study by Algamdi, Alluwimi, Aldekil *et al.* (2021) this challenge is again apparent because they reported the prevalence of binocular vision condition among university students to be 46%. Furthermore, the vision first programme that was designed to provide free eye examination to first graders in the public primary schools in Cleveland, United States, found several children requiring spectacles, treatment for strabismus or amblyopia (Traboulsi, Cimino, Mash *et al.*, 2008). These studies affirm the binocular vision challenges faced by young populations globally.

Accommodative and vergence anomalies among school-going children are reported in almost every part of the world. For example, in a recent study conducted in Nepal it was found that children who used digital devices had binocular vision problems such as reduced amplitude of accommodation, accommodative infacility and reduced positive fusional vergence (PFV) both at near and distance (Maharjan, Rijal, Jnawali *et al.*, 2022). Also, in a study conducted in Australia (Junghans, Azizoglu & Crewther, 2020), 45% of school children were reported to have high incidence of asthenopia related to convergence insufficiency.

Furthermore, in another study conducted in Sudan (Al-Rasheed & Elmadina, 2020), it was reported that 79% of primary school children had achieved poor academic performance due to binocular vision related problems. In other studies conducted in Sudan (Al-Rasheed, Naidoo & Clarke-Farr, 2016; Al-Rasheed, Naidoo & Clarke-Farr, 2018; Hassan, Ibrahim, Abdu *et al.*, 2018), causative factors of binocular vision dysfunctions (BVD) among school children included but not limited to, convergence insufficiency, attitudes towards spectacle wear and uncorrected refractive error. Another study conducted in Ghana (Darko-Takyi, Ntodie, Ilechie, *et al.*, 2018) confirmed the following accommodative anomalies: accommodative insufficiency 22%, accommodative infacility 10%, accommodative excess 13% and accommodative fatigue 5%. Unfortunately, all these anomalies may be associated with academic failure and poor quality of life in the pediatric population.

A study conducted in South Africa by Wajuihian and Hansraj (2016) reported the prevalence of convergence insufficiency to be approximately 24% among school-going children. In another study conducted on young children and young adults in South Africa convergence insufficiency was found to be among the most prevalent binocular vision anomalies (Pillay & Munsamy, 2021). The reported anomalies of binocular vision among school-going children are a serious cause for concern, especially in a developing country such as South Africa. Although there are a considerable number of primary eye care providers, reportedly over 4000 optometrists (HPCSA, 2023), the visual conditions of children, especially those within the pediatric population group, appear to be increasing (Wajuihian & Hansraj, 2016) with no meaningful intervention being carried out. The lack of intervention strategies may also be compounded by the absence of a dedicated directorate and/or policy that deals with eye health care matters in the South African Primary Health Care system (Sithole,

2015). Furthermore, despite the reportedly considerable number of 98 optometrists employed in the public health care sector in the Limpopo Province (Maribeng, 2024), there still appears to be no adequate direct interventions to curb the prevalence of binocular vision anomalies among that province's pediatric population.

Despite a thorough literature search, there were no records found on the management of binocular vision anomalies on the pediatric population in the public health care sector in South Africa, and specifically in Limpopo Province. Therefore, the current study sought to establish the management modalities of pediatric binocular vision anomalies in the public health sector in Limpopo Province with a view to documenting current practices.

1.2. PROBLEM STATEMENT

Binocular vision anomalies such as accommodative and vergence anomalies may lead to poor quality of life if left unattended (Evans, 2021), irrespective of the population involved. Unfortunately, with the pediatric population, possible longer years of suffering present a completely different phenomenon that should be attended to expeditiously. It now follows that maintaining good binocular vision status plays an essential role in the lives of the pediatric population, especially in their early years of development. Therefore, it is imperative for optometrists to perform a thorough visual examination and diagnose and manage of these anomalies effectively at an early stage. Unfortunately, there has been a numerous and consistent referrals of paediatric patients from the optometrists in neighboring health care facilities to the university eye clinic for binocular vision assessments and management. On the other had other district facilities refers patients of this conditions to the tertiary institutions. Based on these interactions, the researcher has deduced that in most instances, there is an unnecessary preponderance of intra-referrals and inter-referrals to optometrists and ophthalmologists respectively. The observation prompted inquiries regarding the extent to which paediatric patients with binocular vision are managed in the public health care sectors. Further more, the researcher observed certain skills gaps in the management of binocular vision by optometrists, particularly those working in the public health sector through conferences and webinars, it became apparent that the

management of binocular vision anomalies is a challenging task. Under managed or incorrect management of binocular vision may lead to difficulties in reading and writing (Hossain, Iftekhar, Naznin *et al.*, 2022). It is therefore imperative for optometrist, particularly the low economic community dependant, to fully manage paediatric patients presenting with binocular vision patients. Also, the researcher has noted that spectacles were a common option to be considered in the management of binocular vision anomalies. Regretfully, however, the researcher could not confirm if these spectacles were specifically adapted to manage pediatric accommodative and vergence disorders. It is, therefore, possible that some optometrists have challenges in managing the anomalies of binocular vision in the pediatric population. Notably, a study by Opoku-Baah, Mohammed, Afari *et al.* (2014) which was conducted in Ghana revealed that eye care providers in hospital settings in the country faced various challenges in the management of binocular vision anomalies and these included availability of appropriate equipment and inadequate knowledge and skills for the management of binocular vision. It is, therefore, possible that optometrists in the current context of the Limpopo Province may also be experiencing similar challenges, thus, influencing their possible lack of interest in managing pediatrics' binocular vision anomalies. Further more there is no current documented management modalities on binocular vision on pediatric population in the Limpopo province. In view of these challenges, the current study sought to investigate pediatric binocular vision management modalities employed by optometrists in the public health sector facilities in the Limpopo Province. The understanding of pediatric binocular vision management modalities by optometrists working in the public sector may possibly inform health policy direction regarding the creation of a pediatric binocular vision management model in this province.

1.3. SIGNIFICANCE OF THE STUDY

It is anticipated that the findings of this study will provide insights into the different management modalities of pediatric binocular vision used by optometrists in public health settings, specifically in the Limpopo Province and in South Africa in general. Such information could be useful in informing clinical and public health practice to improve pediatric binocular vision outcomes in an understudied province. The

outcomes of the study will raise awareness and influence the management practices which will likely result in accurate diagnosis and management of binocular vision anomalies on paediatric patients. With dissemination of the findings through workshops and publications, there is a potential for improving skills, knowledge and competences of the optometrists in public health sectors. The findings have a unique and contextual contribution which is empirical, practical and theoretical in approach for resource-constraint settings. Practitioners are guided from the findings on how to manage patients when there is lack of equipment and relevant optical devices in a settings. The study makes policy and practice recommendation to influence how the law-makers address deficiencies that are brought by non-clinical but institutional resource deficiencies.

1.4. AIM OF THE STUDY

The aim of the study was to determine the management modalities used by the optometrists in the public health sector on paediatric population presenting with binocular vision anomalies in Limpopo Province, South Africa

1.5. RESEARCH OBJECTIVES

The objectives of this study were:

- To determine the self-reported clinical competencies of optometrists in investigating and diagnosing paediatric binocular vision anomalies in the public sector.
- To describe the management modalities for paediatric binocular vision anomalies adopted by optometrists in the public health sector, Limpopo Province.
- To describe the availability of clinical resources for examining, diagnosing and managing paediatric binocular vision anomalies in the public health sector.

1.6. RESEARCH QUESTIONS

The research questions framed for the study were:

- What are the self-reported clinical competencies of public sector optometrists in investigating paediatric binocular vision anomalies?
- What are the management modalities for paediatric binocular vision anomalies applied by optometrists in the public health sector in Limpopo Province?
- What are the available clinical resources for managing paediatric binocular vision anomalies in the public health sector?

1.7. CHAPTER STRUCTURE

The study chapters are delineated as shown below:

Chapter One provides the background to the study, together with the study's aim, problem statement, research objectives and research questions.

Chapter Two presents the review of related literature pertaining to the objectives of the study. It cover the self-reported clinical competencies of optometrists in investigating paediatric binocular vision anomalies, the management modalities for paediatric binocular vision anomalies and the availability of clinical resources for managing paediatric binocular vision anomalies in the public health sector.

Chapter Three outlines the research methodology of the study that includes the research design and setting, study population and sampling, data collection tool, data collection procedure, reliability and validity of the study and data analysis.

Chapter Four presents the study's results and their interpretation.

Chapter Five highlights the discussion of the research results presented in Chapter 4.

Chapter Six presents the research summary, recommendations and conclusion.

CHAPTER 2

LITERATURE REVIEW

2.1. INTRODUCTION

This chapter will provide a pertinent and relevant literature review on the description of binocular vision; the current state of the prevalence of paediatric binocular vision conditions and their presenting symptoms; the clinical investigation of anomalies of binocular vision; the self-reported clinical competencies of optometrists in investigating paediatric binocular vision anomalies; the various management modalities employed for paediatric binocular vision anomalies and the availability of clinical resources for managing paediatric binocular vision anomalies in the public health sector.

2.2. DESCRIPTION OF BINOCULAR VISION

Binocular vision is the process of the coordinating and integrating the images separately received by the two eyes into a single percept (Evans, 2012). Adequate binocular function depends on the normal anatomical development of the visual apparatus, well-coordinated movements of the eyes and the system through which the brain receives and intergrades the monocular signals from the two eyes (Evans, 2021). Evans (2021) further stated that an effective binocular vision system is constituted by two components that are the sensory and motor systems. These systems are designed not simply for redundancy, but primarily to allow both eyes to work together to extract information from the environment (O'Connor & Tidbury, 2018). Therefore, this practice implies that good coordination between the two systems gives rise to clear, single and comfortable vision that enables individuals to see the world as it is. Unfortunately, anomalies of binocular vision also affect the paediatric population, thus, affecting their normal visual development and academic progression (Christian, Nandakumar, Hrynychak *et al.*, 2017) and may even limit their capacity to participate effectively in some social activities. The binocular instability is led by fusional deficiency and poor general health associated with neurosis, fatigue and debility among others (Evans, 2021). In view of the importance of stable binocular vision

status, it, therefore, is important for primary eye care (PEC) providers, such as optometrists, to adequately respond when presented with paediatric binocular vision problems.

2.3. ANOMALIES OF BINOCULAR VISION AND THE SYMPTOMATIC IMPACT ON PAEDIATRIC POPULATION.

Understandably, a good near vision and binocular vision function plays a significant role in children's academic school performance (Dirani, Zhang, Goh *et al.*, 2010). Abnormal binocular visual development may lead to anomalies of binocular vision that may impact the patient's academic performance. Anomalies of binocular vision may present considerable challenges to the quality of life among the paediatric population, thus, adversely affecting their school activities and other socially important events during their developmental years. These anomalies are characterized by symptoms such as blurred vision, diplopia, asthenopia, difficulty in focusing on different distances, headaches, loss of concentration and avoidance of tasks (Opoku-Baah *et al.*, 2014; Wajuihian, 2021). These symptoms are primarily aggravated by prolonged visually demanding near-centred tasks (Wajuihian, 2021). A study conducted in Portugal by Nunes, Monteiro, Ferreira *et al.* (2019) confirmed that visual complaints associated with binocular anomalies suggest a decreased visual efficiency that can result in poor school performance. These anomalies included accommodative excess and convergence, accommodation and divergence insufficiency. The authors recommended that children and teenagers who experience headaches, somnolence while reading and loss of concentration when performing near activities, among other visual stress complaints, should be subjected to an evaluation of their binocular vision and accommodative status.

In support of the above findings, Metsing and Ferreira (2012) investigated the visual status of mainstream and learning-disabled schools in Johannesburg, South Africa and the findings indicated that both groups of learners presented with visual deficiencies including accommodation, vergency deficiencies and poor ocular motilities, that could contribute negatively towards their learning skills. In another study by Ovenseri-Ogbomo and Eguegu (2016), diplopia and headaches were the most

frequently reported symptoms by participants who presented with vergence dysfunction. Poor binocular vision can have a negative impact not only on learning skills but also sports, judgement of distance, eye contact and motion sickness (Kaiti, Dahal, Shyangbo *et al.*, 2020).

A Nigerian study conducted by Ovenseri-Ogbomo and Eguegu (2016) on university students reported vergence dysfunctions to present diplopia and headaches that have serious implications on academic activities and the symptoms have the propensity to prevent the student from studying for a long period. Although this study had not engaged children as participants, it is possible that the ocular strains experienced by participants in this study could be extrapolated to paediatric populations. Several recent studies have described the importance of binocular vision and the negative impact on the quality of life suffered by individuals with binocular vision disorders (Al-Rasheed, 2020; Atiya, Hussaindeen, Kasturirangan *et al.*, 2020; Christian, Nandakumar, Hrynychak *et al.*, 2018; Metsing & Ferreira, 2012; Nunes *et al.*, 2019; O'Connor & Tilbury, 2018).

The upsurge in computer usage and other smart technological devices may constitutes a challenge on binocular vision among the paediatric population. In an attempt to discover more information regarding the prevalence of such activities, a recent study by Maharaj, Rijal, Jnawali *et al.* (2022) reported that the higher duration of exposure to digital devices among school-aged children might be associated with various eye and visual related problems. Similarly, a study by Almalki, Alblowi, Aldosari *et al.* (2023) confirmed the impact of increased digital device usage during the COVID-19 pandemic lockdown on inflating ocular strains symptoms. Although, the study failed to enlist children as participants, the possibility of children experiencing the symptoms remains high. The parameters of binocular vision, such as accommodative facility, accommodative amplitude; and positive fusional vergences, deteriorate with greater exposure to digital devices (Maharaj *et al.*, 2022). In support of this assertion, Pillay and Munsamy (2021) explored the prevalence of convergence insufficiency in young population and mapped the association between the convergence insufficiency, near work and e-device usage which affirmed that convergence insufficiency is a common disorder among children and young adults who spend a significant portion of time consumed by near tasks.

Many schools are implementing E-learning models, thus, Pillay and Munsamy (2021) recommended the need for research studies to focus on the visual effect of prolonged near focus with e-devices among the youth. In support of this assertion, a retrospective study on children with reading problems by Christian, Nandakumar, Hrynychak *et al.* (2018) revealed that although the number of children with binocular vision problems is not significantly high, the affected children are more likely to experience important visual challenges. It, therefore, is important for the optometrists to provide a binocular vision assessment for all children, especially those who have been identified with reading problems.

2.4. ANOMALIES OF BINOCULAR VISION AND THEIR CLINICAL SIGNS

In a study conducted by Darko-Takyi *et al.* (2016), it was reported that anomalies of binocular vision are classified as either vergence disorders or accommodative disorders. The review reported that patients with accommodative disorders may have had secondary vergence disorders, or vice versa, due to the control of the interactive negative feedback loop for the two systems. Hence, the presence of convergence insufficiency may result with a significant lead of accommodation, or the presence of accommodative insufficiency may result with a significant esophoria, that suggests the prevalence of convergence insufficiency solely or combined with accommodative excess. Accommodative anomalies are characterised by inadequate accommodative accuracy and sustainability, inadequate amplitudes, flexibility and facility (Sternier, Gellerstedt & Sjöström, 2004). Scheiman and Wick (2008) classified accommodative anomalies into four groups: accommodative insufficiency, accommodative excess, accommodative infacility and ill-sustained accommodation. Vergence anomalies, however, originate from the differences in the heterophoria measurements between distance and near. Scheiman and Wick (2008) categorised vergence anomalies on the AC/A ratio findings. The three categories being Low AC/A ratio, Normal AC/A ratio and High AC/A ratio. Vergence anomalies presenting with low AC/A ratio are convergence insufficiency and divergence insufficiency, while those presenting with normal AC/A ratio are basic esophoria, basic exophoria and vergence dysfunctions. Vergence anomalies presenting with a high AC/A ratio are convergence excess and divergence excess. Several studies have suggested that accommodation and non-

strabismic binocular vision dysfunctions are commonly encountered in optometric practice (Cacho-Martinez, 2014; Franco, Moreira, Fernande *et al.*, 2022; Wajuihian, 2019; Wajuihian & Hansraj, 2016).

2.5. PREVALENCE OF PAEDIATRIC BINOCULAR VISION ANOMALIES

The prevalence of binocular vision anomalies has been studied in different countries. A study by Hussaindeen, Rakshit, Singh *et al.* (2017) conducted among the rural and urban populations in Tamil Nadu reported the prevalence of non-strabismic binocular vision anomalies to be 30% in both populations. The study classified convergence insufficiency the most prevalent condition with the prevalence of 17% followed by accommodative infacility with the prevalence of 7%. The findings of Hussaindeen *et al.* (2017) further indicated the necessity for optometrists in public health care facilities to strengthen their skills in managing these binocular vision anomalies. A clinical study conducted by Franco, Moreira, Fernandes *et al.* (2022) in Spain, reported the prevalence of convergence insufficiency to be 7.1%, accommodative insufficiency to be 11.5% and accommodative infacility to be 5.8%. Franco *et al.* (2022) further reviewed the prevalence of binocular vision in a study of different populations and reported as follows: the prevalence of accommodative disorders was reported to be 9.4% and binocular vision disorders to be 30% on a population of an optometry clinic in Spain. In another study conducted in Spain with a population of university students, accommodative disorders prevalence was reported to be 17% and binocular vision disorders to be 15.3% (Porcar & Martinez-Palomera, 1997). In Iran, accommodative disorders was reported to be 7.2% and binocular vision disorders to be 12.1% on a population of optometry clinics (Hoseini-Yazdi, Yekta, Nouri *et al.*, 2015). Furthermore, accommodative disorders prevalence of 15% and binocular vision disorders of 27% was reported among university students in the USA (Richman & Laudon, 2002). Similarly, accommodative disorders were reported as 16.8% and binocular vision disorders as 4.3% (Hokoda, 1985).

Various studies have reported convergence insufficiency to be the most prevalent binocular vision anomaly among binocular vision dysfunctions. In a study conducted in South Africa by Metsing and Ferreira (2012), the prevalence of accommodative and

vergence dysfunction among 3rd and 4th graders in mainstream schools reported that 12.3% of their study population presented with poor accommodation amplitudes, 17% had poor convergence amplitudes and 21% of the population had poor vergence facility. Metsing and Ferreira (2012) further reported that the vergence infacility was higher than any other conditions with a prevalence of 21.9%.

Moodley (2008) conducted a retrospective analysis of the amplitude of accommodation, accommodative facility and accuracy of accommodation findings from primary school vision screening in South Africa, and found that reduced monocular facility of accommodation is more significant than any other accommodative anomalies. The findings indicated that 24% of the study population presented with reduced monocular amplitude of accommodation, 26% presented with reduced binocular accommodative facility, 30% presented with binocular accommodative infacility and 27% presented with high MEM. Therefore, providing appropriate pediatric binocular vision management modalities would benefit the public.

2.6. THE SCOPE OF OPTOMETRY

Optometrists as the primary health care practitioners of the eye and the visual system, provide comprehensive eye and vision care that includes refraction and dispensing; detection, diagnosis and management of diseases in the eye and the rehabilitation of the conditions of the visual system (Gammoh, Lewandowska, *Neuville et al.*, 2024). An Eye Care Competency Framework (ECCF) has been developed by WHO to enable the planning and development of an eye workforce with standards, competencies and activities (WHO, 2022). The ECCF provides the entry-level competencies expected from optometrists as primary vision and eye care providers within the health care team (Gammoh *et al.*, 2024). Notwithstanding the ECCF, not all countries have regulated practice guidelines for optometrists. For instance, Arvind, Clarke-Farr and Naidoo (2021) highlighted the lack of regulatory optometry bodies in India with a varying scope of optometry practice, with professionals holding either relevant diplomas or degrees. Degree holders were deemed to be more skilful and competent in assessing patients eye-related problems.

The Health Professional Council of South Africa (HPCSA) provides guidelines delineating the competencies and skills that degree holder optometrists should have concerning the assessment of paediatric patients (HPCSA, 2023). According to HPCSA (2023) an assessment of paediatrics should be classified according to the patient's age. The regulations classify the assessment in infants and toddlers, preschool children and school-aged children.

The HPCSA (2023) lists the following specific tests to be performed for the assessment of binocular vision during paediatric examination: a comprehensive case history; visual acuity measurements; cycloplegic refraction or age-appropriate retinoscopy or subjective refraction; binocular vision assessment and eye health assessment. Binocular and accommodative function of paediatric patients was classified according to the age of the patient. Infants and toddlers assessment procedures included: Cover test; Angle Kappa and Hirschberg test; Krimsky test; Bruckner test; and Versions Near point of convergence. While preschool children (3-5 years) included the following procedures: Cover test; Positive and negative fusional vergences (prism bar/step vergence testing); Near Point of Convergence – objective (NPC); Stereopsis; Monocular estimation method (MEM) retinoscopy or similar dynamic retinoscopic method; Versions; and Measurement of amplitude of accommodation/accommodative facility. The school age children's binocular assessment included: Cover test; Near point of convergence (NPC); Positive and negative fusional vergences; Accommodative amplitude and facility; accommodative convergence/accommodation (AC/A) ratio; fusional vergence amplitude; vergence facility; negative relative accommodation (NRA) and positive relative accommodation (PRA) tests; monocular estimation method (MEM) retinoscopy or any other related retinoscopy method; Stereopsis; Versions - assessment of stability of fixation; saccadic function; and pursuit function. The HPCSA (2023) further provided a list of the standard equipment required to elicit proper diagnosis and management of binocular vision anomalies.

2.7. CLINICAL INVESTIGATION OF ANOMALIES OF BINOCULAR VISION.

A comprehensive binocular vision investigation in paediatric patients includes the following tests: binocular red reflex; visual acuity or fixation pattern; stereoacuity; cover/uncover test; broad H and versions tests; near point of convergence; visual fields assessment; step vergence test; push-up method; monocular estimate and indirect ophthalmoscope (Evans, 2021; Olsen, Harris, Mizuiri *et al.*, 2017; Scheiman & Wick, 2008).

The binocular red reflex testing is performed to observe any subtle differences in the appearance of the red reflexes. The visual acuity is assessed using the fixation pattern. Sensory evaluation is conducted through stereoacuity testing. Motor evaluation is assessed by prism cover/uncover test. Ocular motility testing is assessed with a broad H test and versions in all cardinal points. Visual field testing is assessed with the confrontations visual field testing. Pupillary examination is used to assess the size, the symmetry, the shape of the pupils and the pupillary response to light. Determination of refractive error is assessed with retinoscopy or subjective refraction to diagnose amblyopia and refractive error. Vergence testing to assess the near point of convergence and fusional vergence amplitude is measured with step vergence for distance and near. The amplitude of accommodation is assessed with push-up method, accommodative facility to assess the stamina of accommodation and also the monocular estimate method to assess the accommodative response. The indirect ophthalmoscope test is employed to assess the anterior and posterior anatomical segment of the eye.

2.8. SELF-REPORTED CLINICAL COMPETENCIES OF OPTOMETRISTS IN INVESTIGATING PAEDIATRIC BINOCULAR VISION ANOMALIES.

The practice of binocular vision examination is decertifying in developing countries such as India (Thite, Jaggernath, Chinanayi *et al.*, 2015). However, the frequent practice of these core optometric service will certainly improve the competence and skills of the optometrists in diagnosing and managing paediatric eye conditions (Hussaindeen *et al.*, 2017). HPCSA clinical guidelines for paediatric eye examination (HPCSA, 2023), stipulate the minimum test to be performed on paediatric patients,

however not all the optometrist are capable of following the HPCSA guidelines. Several studies were conducted on the assessment of the competencies of the optometrists on assessing, diagnosing and managing binocular vision anomalies. These investigations confirmed that not all the optometrists practice a full optometry scope (Boadi-Kusi, Ntodie, Mashige *et al.*, 2015; Maake & Moodley, 2018; Ocansey, Abu, Nii Armah *et al.*, 2020; Thite, Jaggernath, Chinanayi *et al.*, 2015). Ocansey (2020) reported 57% of the optometrist in Ghana performed binocular vision assessment on preschoolers as compared to 43% who did not perform the binocular vision assessment. Furthermore, Ocansey *et al.* (2020) generated self-assessment questionnaires relating to the working experience of the optometrists in Ghana to determine if the full scope of optometry is practiced. The findings indicated that 54% of the participating optometrists did not practice the full scope of optometry, stipulating the lack of basic training on the paediatric module during their undergraduate training as the one of the hindrances.

In India, Thite *et al.* (2015) assessed the frequency of the utilisation of binocular vision abilities and skills in both public and private sectors. This study reported 45,1% of the optometrists to have practiced these disciplines. Thite *et al.* (2015) further stated that postgraduate optometrists had sufficient skills and knowledge on the clinical use of Prism Bar, Synoptophore, Maddox wig and rod amongst other practices. In South Africa, Maake and Moodley (2018) reported 54.5% of the optometrists to have provided services related to binocular vision. According to the provided data, it is plausible that optometrists in developing countries have less clinical competence and skills in the assessment of binocular vision anomalies. In confirmation of the said statement, Ocansey *et al.* (2020) reported that occlusion therapy was less often applied as the management modality for paediatric conditions. Additionally, Boadi-Kusi, Ntodie, Mashige *et al.* (2015) stated that the traditional role of the optometrists in public health facilities in Ghana is to provide refractive services and ocular disease management. Therefore, both the practice and competences of binocular vision assessment need improvement in developing countries.

2.9. MANAGEMENT OF BINOCULAR VISION ANOMALIES

The management of binocular vision anomalies is crucial because it can help prevent permanent or irreversible issues related to binocular vision. Corrective lenses should be prescribed when a risk factor is present to prevent the development of amblyopia (Leat, 2011). The American Optometry Association (2002) established guidelines for the clinical practice in managing paediatric patients with strabismus and amblyopia. These guidelines encompassed, among other aspects, the management of refractive error, amblyopia, strabismus as well as accommodative and vergence dysfunction. Leat (2011) additionally provided recommendations regarding when to prescribe spectacles or not based on the refractive errors of various age groups. This study also mentioned that many authors advise assessing infants' and toddlers' refractive errors before prescribing glasses because these might hinder the critical emmetropization process.

2.9.1. The use of spectacles and drugs for the management of binocular vision anomalies.

Children in school should be given prescription glasses to enhance their eyesight if necessary. This practice is particularly significant for children experiencing difficulties with near vision, esophoria or esotropia, an increased lag in accommodation, anisometropic amblyopia, or severe refractive errors that result in impaired vision, including children who are aphakic or pseudo-aphakic (Leat, 2011). Uncorrected refractive error of more than one dioptre in between may lead to anisometropic amblyopia that may be caused by myopia, hyperopia or astigmatism (Sen, Singh & Saxena, 2022). Sen *et al.* (2022) indicated that optical treatment alone may be successful for the treatment of unilateral amblyopia in children less than seven years old. However, the spectacle treatment has shown to have superior effects in children with better baseline VA and lesser anisometropia. Emmanuel, Burns and Thompson (2023) highlighted that optical correction of refractive error improves the VA of both unilateral and bilateral amblyopia, Emanuel *et al.* (2023) further indicated that optical correction could alter the angle of strabismus in accommodative esotropia, decrease the angle of deviation in moderately accommodative esotropia and/or correct the deviation in fully accommodative esotropia.

There are various binocular vision management modalities such as occlusion, orthoptic exercises, overminus lenses, added plus lenses, prisms and surgical procedures available in addition to the correction of refractive error and observation of the conditions. Sen *et al.* (2022) reported on the concept of occlusion therapy and penalisation/ pharmacological therapy. According to Sen *et al.* (2022) subsequent occlusion or eye patching can be used to treat partial or residual anisometropic or strabismic amblyopia after an adequate period of optical correction. This management modality can be given full time or part time depending on the severity of the amblyopia. Sen *et al.* (2022) further stated that occlusion therapy is more successful with patients who are less than 15 years of age with baseline worse VA.

Emmanuel, Burns and Thompson (2023) shared the same sentiments and stated that patching may be more effective in older children and teenager children. Emmanuel *et al.* (2023) reported that penalisation/pharmacological treatments are used on patients whose VA is not improving based on spectacles treatment alone, also on patients with hyperopia on the sound eye and patients who are not cooperating well with occlusion therapy. The sound eye is penalised by atropine 1% to not take part in the near tasks. Sen *et al.* (2022) stated penalisation is used successfully on children with moderate amblyopia and it is reported to have similar outcomes as occlusion therapy. Therefore, penalisation can be considered as the first line in amblyopia therapy or in case of occlusion therapy failure. The Paediatric Eye Disease Investigators Group (PEDIG) evaluated the effectiveness of amblyopia treatment modalities and demonstrated successful treatment outcomes with a parttime patching regiment and pharmacological penalisation. The PEDIG demonstrated that occlusions and atropine treatment provided similar visual and stereoacuity outcomes in children of 3-15 years of age with moderate amblyopia, however, penalisation has gained increased acceptance as the treatment of choice, particularly in children with hyperopic refractive error. The PEDIG further found that patients with moderate amblyopia demonstrated visual gain on occlusion of the sound eye for two hours a day, and the same visual gain is demonstrated on occlusion of the sound eye for six hours a day. In patients with severe amblyopia PEDIG demonstrated visual gain on occlusion of the sound eye for six hours a day and the same visual gain is demonstrated on occlusion of the sound eye for 12 hours a day. Therefore, occlusion therapy should be one of the frequently used management modalities for binocular vision anomalies.

2.9.2. The use of vision therapy for the management of binocular vision anomalies.

Vision therapy also is one of the prescribed management protocols for binocular vision anomalies such as convergence insufficiency, basic exotropia, convergence excess, divergence excess and divergence insufficiency (Aletaha, Daneshvar, Mosallaei *et al.*, 2018). Studies on the management of convergence insufficiency have reported a combination of in-office and home-based vision therapy to be more effective than any other management plan such as base-in prisms and over- minus lenses (Mohamed & Alrasheed, 2023; Rovick, 2022; Scheiman, Kulp, Cotter *et al.*, 2020). Rovick (2022) listed tests such as the Brock String, pencil push-ups, vergence jump, prism flippers, dot cards among others to encourage convergence. The mentioned training procedures can be used as home- and office- based therapy. Home-based computer programs have been proved very effective in the treatment of convergence insufficiency (Serna, Rogers, McGregor *et al.*, 2011). Rovick (2022) also reported that the combination of home and in office-based therapy has been successful for patients.

Rovick (2022) reviewed a study by Birnbaun (1999) that evaluated three sample groups of convergence insufficiency patients and divided them into three groups. Group 1 received home- and office-based therapy, group 2 received only home-based therapy and group 3 did not receive any vision therapy. Among the three groups it was indicated that there is clinical improvement of signs and symptoms of convergence insufficiency mainly in the use of both home- and office-based orthoptics. However, Scheiman, Mitchell, Cotter *et al.* (2005) reported office-based therapy as the most effective vision therapy. It was concluded in from the reviewed literature that convergence insufficiency is amenable to treatment (Barrett, 2009; Ghosh, 2024).

2.9.3. The use of over-minus for the management of binocular vision anomalies

The use of over-minus on the patient's spectacles is another method of controlling strabismus through the use of stimulated accommodation (Song, LI, Qian *et al.*, 2023). It is a frequently prescribed non-surgical treatment modality for intermittent exotropia

in cases in which minus lenses stimulate accommodative convergence, reduce the angle of exotropia or trigger reflex convergence. The amount of over minus prescribed ranged from 0.50D to 5.00D (Chen, Holmes, Chandler *et al.*, 2016). This management modality is used by different authors including the PEDIG (2021) in evaluating the control of intermittent exotropia and the improvement stereopsis on intermittent exotropia cases. The paediatric eye disease investigators group (2021) conducted a randomised clinical study evaluating the long-term effectiveness of over minus spectacles in modifying distance intermittent exotropia control. The study evaluated 56 clinical sites to evaluate the long-term effectiveness of over-minusing therapy on the intermittent exotropia patients. The study found that the group of participants that used over-minus lenses for 12 months achieved both distance and near control of fusion than the group of participants that used the minus lenses for 3 months and the non-overminus group of participants. Furthermore, it was explored that change in distance exotropia control (DE) was more significant than near exotropia control (CI). Chen, Holmes, Chandler *et al.* (2016) evaluated the short-term effectiveness of over-minus lenses of -2.50D over a cycloplegic refraction. The evaluation was performed on the improvement of distance exotropia in children aged 3-6 years. The study found that children with over-minus lenses had a better control of distance exotropia. Feng, Jiang, Bai *et al.* (2021) conducted a randomised study to evaluate the efficacy of over-minus lenses combined with prism spectacles in 60 children aged 3-6 years with intermittent exotropia and reported that exotropia control at distance and near are more significant within the observed group. Feng *et al.* (2021) voiced a concern that over-minus lens can induce myopia and the 'squint can possibly reoccur on the withdrawal of the lenses however, myopia shift was not observed in their study. Therefore, over-minus therapy was found to be an effective management modality for intermittent exotropia by a variety of authors.

2.9.4. The use of added lenses for the management of binocular vision anomalies.

Added-plus lenses is another management modality used clinically to manage convergence excess, accommodation insufficiency, accommodation excess and

accommodative esotropia conditions (Martínez, Muñoz & Ruiz-Cantero, 2009). Plus lenses reduce the near accommodative demand and restore accommodative amplitudes to normal range (Hussaindeen & Murali, 2020). Hussaindeen and Murali (2020) reviewed the treatment options for accommodative insufficiency and revealed that plus lenses and vision therapy remains the standard treatment protocol for this condition. Wahlberg, Abdi and Brautaset (2010) measured the amplitude of accommodation and accommodative response using an add of +1.00DS and +2.00DS. In a comparison of the two additional powers, the +1.00DS was found to increase the amplitude of accommodation and reduction of associated symptoms. Wahlberg *et al.* (2010) recommended that a minimum number of near addition plus lenses is beneficial in restoring accommodative amplitudes. Plus-added lenses are more effective in the management of convergence excess conditions (Scheiman & Wick, 2008).

A study by Shin, Park and Park (2009) indicated some similarities in symptoms, clinical signs and management protocol between accommodative insufficiency and convergence excess. The two conditions present with reduced PRA and fail to clear minus lenses on binocular accommodative facilities, that both needed plus additional lenses and vision therapy as standard mode management (Scheiman & Wick 2008). Similar to convergence excess esotropia – a condition of high esotropia at near than at distance – plus additional lenses have been used as the first management protocol (Awadein, Gouda, Elhilali *et al.*, 2023). The influence of the added plus lenses in this regard is due to the high AC/A ratio that presents with convergence excess esotropia (Awadein *et al.*, 2023).

2.9.5. The use of prism for the management of binocular vision anomalies

Prisms are transparent, solid, triangular refractive mediums with a base and apex (Antony, 2017). This author further described the functions of the prism and the principles and stated that a prism of one diopter power produces an apparent displacement of one centimetre to an object situated at one meter. According to Antony (2017) prisms refractive mediums are used to measure the magnitude of a deviation, to measure fusional reserves, or train binocular vision anomalies. Antony

(2017) also stated that the orientation of the prism base depends on the deviation measured or the deviation trained. Heydarian, Hashemi, Jafarzadehpour *et al.* (2020) stated that prisms can be used on patients with a deviation of less 20 to 25DS, while the concern with the high magnitude was the increased weight on the spectacles and the distortions. These authors additionally stated the different strategies used for prism prescription. These included prescribed various prisms: prisms to neutralise the angle of deviation; relieving prisms to reduce the angle of deviation in order to reduce the fusional vergence demand; and overcorrection prisms to induce diplopia and stimulate fusional convergence. However, Antony (2017) and Portela-Camino (2024) stated that prisms are used clinically as diagnostic and therapeutic tools in resolving diplopia for binocular vision anomalies such as convergence insufficiency; divergence insufficiency; nystagmus and incomitant large and combined strabismus. Heydarian (2020) stresses the effectiveness of base-out prisms in increasing the demand of fusional convergence. Loba, Gotz-Więckowska, Hautz *et al.* (2022) described the guidelines for the management of strabismus in children and indicated prisms as tools that could be used to manage small angle strabismus, accommodative strabismus with good binocular vision potential, intermittent exotropia of the convergence insufficiency type, paralytic and post-traumatic strabismus, esotropia for distance, non-accommodative concomitant esotropia, decompensated latent strabismus and residual. Loba *et al.* (2022) further indicated that the aim of prism treatment is to reduce the symptoms of diplopia, relieve compensating head postures and reduce the psychosocial challenges.

2.9.6. The use of referral for the management of binocular vision anomalies

Sukati, Moodly and Mashige (2019) conducted a study in Swaziland and reported that many eye health professionals do not have knowledge of the referral guidelines and standard paediatric ophthalmic practice guidelines. Another study conducted in Ghana that sought to determine optometrist's abilities to screen, diagnose and manage paediatric ocular conditions and to assess the optometrist's possession of the requisite instrumentation for investigating paediatric optometry, revealed that most optometrists did not practice a full-scope of binocular vision assessment (Ocansey *et al.*, 2020).

This omission leads to the mismanagement of patients presenting with binocular vision cases. The study further revealed that anisometropia and strabismus cases were referred to an ophthalmologist, a practice that questions the level of competency of the optometrists in managing paediatrics binocular vision cases. In another study conducted in Ghana, it is reported that some hospitals' optometry practices are based on ocular disease management rather than refraction and binocular vision procedures (Boadi-Kusi, Ntodie, Mashige *et al.*, 2015). This result indicates a weak integration in optometry services in public health sectors. The study further stated that instrumentation was a challenge in many hospitals, although phoropter, slit lamp and ophthalmoscopy equipment are readily available in many hospitals.

2.10. PUBLIC HEALTH SECTOR RESOURCES AND HEALTH PERSONNEL CARING FOR THE VISUAL NEEDS OF THE PAEDIATRIC POPULATION.

WHO framework for health-care quality advocates for an effective, safe, people-centred, timely, equitable, integrated and efficient eye care system (Burton, Ramke, Marques *et al.*, 2021). The achievement of WHO goals depends on the availability and access to quality services. The major impeding factors against success include costs, shortage and maldistribution of well-trained personnel and lack of suitable well-maintained equipment and consumables (Burton *et al.*, 2015). Lack of accessibility to eye services and lack of public awareness regarding how and where to seek eye care services are some of the reasons why patients remain visually impaired in Nigeria (Aghaji, Gilbert, Ihebuzor *et al.*, 2018). Several studies from different parts of the world reported visual impairment as a significant public health concern, particularly in low- and middle-income countries in which eye care is provided at primary health care centres (Aghaji *et al.*, 2018; Burton *et al.*, 2021; Lilian, Railton, Schaftenaar *et al.*, 2018; Yashadhana, Zhang, Yasmin *et al.*, 2020). Hence most ophthalmologists are concentrated in the urban areas and people in the rural areas must travel long distances to access professional eye care.

South Africa is among the developing countries with poor accessibility of optometrists or eye care services in public health facilities, however, the level of eye care has been improved as a result of a slight increase in the number of optometrists employed in the

public health facilities (Maake & Moodley, 2018). Maake and Moodey (2018) further indicated in their study that the majority of optometrists in KwaZulu-Natal, who are based in rural or semi-rural areas, are rendering outreach services to different local facilities. These initiatives provide improvement in the accessibility of eye care services.

According to researchers (Lillian, Railton, Schaftenaar *et al.*, 2018; Maharaj *et al.*, 2011) lack of dedicated directorate for eye health care in South Africa poses a serious problem to children's visual health. Maharaj *et al.* (2011) also highlighted the ratio of the optometrists employed in the public sector and the paediatric population in South Africa and concluded that most South African children have extremely limited access to any form of eye care services. Therefore, the perspective of health services particularly with regard to eye care was negatively skewed to that of the private sector and were offered mainly in urban areas.

Lack of instrumentation, inadequate exposure to skills, limited time for paediatric examination, lack of paediatric oriented clinical settings, non-compliance from parents, lack of a referral centre for complex conditions, difficulties in co-managing the patients with an ophthalmologist, are major contributing factors to the limited optometric services offered by the public health service in most developing countries (Ocansey *et al.* 2020). To support this assertion, Boadi-Kusi *et al.* (2015) stated that there was a limited number of phoropters in public facilities in Ghana. Furthermore a notable challenge was the absence of residential optometrists and the presence of ophthalmologists in the facilities and the fact that emphasis was placed on the ocular health assessment. Therefore, optometry speciality modules, such as paediatric binocular vision assessment, are not practised. In a study conducted in South Africa, Maake and Moodley (2018) reported on the lack of equipment and time constraints in the facilities, and recommended appropriate equipment to optimise the services provided to the community. Maake and Moodley (2018) stated the distribution of optometrist is skewed between rural, urban and semi-urban areas with few optometrists practising in the rural areas. The prioritization of binocular vision assessment, training and resources in the public sector for optometrists is necessary to minimize unnecessary referrals to ophthalmologists.

2.11. CHAPTER SUMMARY

This chapter reviewed relevant literature on the aspect of the prevalence of binocular vision anomalies in paediatric populations, the symptomatic impact of these anomalies, the presenting of clinical signs and how these anomalies are investigated. The reviewed literature discussed the self-reported competencies of the optometrist on the management of binocular vision condition, the current employed management modalities and the reported clinical resources available in the public health sector.

CHAPTER 3

METHODOLOGY

3.1. INTRODUCTION

The previous chapter delineated a review of relevant literature. This chapter provides the research methodology used to investigate the objectives of the study. It includes the research design and setting, study population and sampling, data collection tool, data collection procedure, reliability and validity of the study and the data analysis.

3.2. RESEARCH DESIGN

A cross-sectional, descriptive quantitative approach was adopted for this study. According to Brink, Van der Walt and Van Rensburg (2018), descriptive study designs may be used to develop theory, identify problems with current practice, justify current practices, make judgements or determine what other researchers in similar situations are investigating. Therefore, a descriptive design was used in this study to assist the researcher to understand the management modalities of binocular vision anomalies on paediatric populations by optometrists in the public health sector because it provides an overview of the phenomenon as it presents naturally.

3.2.1. Study Population

The study population included all registered optometrists working in the public health sector of Limpopo Province, South Africa. All 98 optometrists working in this sector with more than 12 months working experience were invited to participate in the study and required to provide their written consent to taking part in the research process.

3.2.2. Research study setting

The study was conducted in public hospitals in the Limpopo Province. The province is composed of 5 districts municipalities and has a total population of 6.6 million (Moultrie & Dorrington, 2024). There are 43 hospitals and community health centres that are mainly situated in the rural areas, because the majority of Limpopo residents reside in rural areas.



Map of Limpopo Province

3.2.3. Population sampling

i. Sampling and sample size

In this study, a purposive sampling approach was used to select the participants. This method of selecting participants is based on the researchers' judgement regarding which potential participants will be able to provide the required information. The Krejcie and Margan (1970) table was used to determine the sample size which suggest that for population size of 100, a sample size 80 must be used. In this study the population size was 98 and according to the Krejcie and Margan (1970) 80 participants were supposed to be included, however all the 98 were included to improve the response rate and accuracy of the results. All 43 public hospitals in Limpopo Province with an optometric service were included in the study and the participants included all the optometrists employed in the public health sectors in the Limpopo Province. The scope of practice for binocular vision and paediatrics is outlined in the HPCSA (2023) guidelines document.

ii. Inclusion and Exclusion

All the resident optometrists in the public hospitals with more than 12 months working experience were included and were required to provide written consent to participating in the research process. In hospitals with more than one optometrist, the optometrist with the greatest experience was requested to fill the equipment list. Optometrists who did not sign the required online consent form or were on sick leave during data collection period were excluded from the study.

3.3. ETHICAL CONSIDERATIONS

The study commenced after receiving the ethical clearance from Turfloop Research Ethics Committee (TREC) (see Appendix A: TREC number REC-0310111-031 at the University of Limpopo). Permission to conduct the study was granted by the Provincial Department of Health, Limpopo Province to gather data (see Appendix C). After following all due processes, permission was granted to collect data from the different facilities and to interact with the optometrists in their facilities. The researcher sent a questionnaire link to all optometrists in the selected study site through emails and telephone application (see Appendix B). Participants completed the self-administered questionnaires and upon its completion the data was automatically saved in the google drive. The data was stored in a computer with a secure password and only the researcher had access to the both the password and the computer. All participants were made aware that participation was voluntary and informed that confidentiality would be maintained throughout the research process. To this end, the researcher signed the confidentiality agreement form and the participants remained anonymous throughout the study.

3.4. DATA COLLECTION TOOL

A self-administered questionnaire consisting of closed ended questions adapted from a validated questionnaire (Suttle, Wong, Anderton, Kim & Lee, 2003) was modified to suit the current study and then utilised to gather data for objectives one, two and three from optometrists working in public health facilities. The questionnaire was evaluated and endorsed by established researchers in the Department of Optometry, University of Limpopo, to review the content and construct validity of the questions in relation to the objectives of the study. The questionnaire was compiled in English and consisted 27 survey items separated into of four sections. Section A included the demographic

information of the participants such as locality, gender, race, postgraduate qualifications and number of years in practice. Section B pertains to the participants' self-reported competencies with respect to identifying binocular vision anomalies using various clinical approaches and their perception on binocular vision training received during undergraduate tutelage. The item questions in section B included Likert scale statements utilising five points scale 1 to 5, where 1 was poor and 5 was excellent. The summation of 4 and 5 was perceived as competent while the summation of 1 and 2 and 3 was perceived as not competent. Section C included 15 categorical and closed-ended question items related to common problems that patients often presented to the optometrists as well as their inherent remedial or management protocols in line with current best practices. In addition, Section C further evaluates the success rate of the commonly used management methods, the instruments available in the facilities and issues related to participation in continuous professional development (CPD). Section D includes the table used to collect evidence of the available binocular vision resources in the public health sector. The optometrist with the greatest experience in the hospital was requested to fill the table in Section D.

3.5. DATA COLLECTION PROCESS

A self-administered google form questionnaire was used to collect data. Participants were recruited through e-mail and WhatsApp. A link containing the invitation letter, consent form and the questionnaire was send to all the optometrists working in the public health sector whose mobile numbers and email address had been previously requested from the Provincial Manager, Health Department, Limpopo Provincial Government. Only those participates who had signed the consent form had access to the questionnaire and took part in the study. The google form automatically generated a feedback report on the completed questionnaires. Participants were advised to complete the questionnaires during their spare time in order to avoid disturbing the day-to-day operations of the public health facilities in which they were practising. The data collection process took place during March, April and May 2024. The most experienced Optometrist was instructed to complete a clinical equipment list table attached on the questionnaire to determine the binocular vision assessment resources available in different facilities to address research objective three.

3.6. DATA ANALYSIS

All data contained in the google forms were imported to Statistical Package for Social Sciences (SPSS), version 29. Descriptive statistics were used to analyse the categorical variables. Data was presented in frequencies and percentages and summarised in the form of tables and figures. In addition, inferential statistics (Spearman's correlation) was applied to show the relationship between the self-reported clinical competencies with the knowledge and performance of the participating optometrists operating in the Limpopo public health sector. The level statistical significance was set at $p\text{-value} < 0.05$.

3.7. CHAPTER SUMMARY

This chapter delineated the adopted methodology deemed suitable to determine the self-reported competencies of the study participants on the management of binocular vision anomalies and the management modalities of these participants on binocular vision anomalies as well as assessing the available clinical resources for the management of binocular vision.

CHAPTER 4

RESULTS

4.1. INTRODUCTION

This chapter presents the analysis of the data collected in the current study that includes the following: the participants' demographic characteristics, their self-reported clinical competencies on the management of binocular vision anomalies, the management modalities used for binocular vision anomalies by the optometrists operating in the public health facilities in Limpopo Province, as well as the resources available in these facilities.

4.2. DEMOGRAPHIC CHARACTERISTICS

Questionnaires were completed by 62 participants, giving a response rate of 63% ($n=62$). The majority of participants who responded (72.6%) were female while 27.4% were male. After completing a Bachelor Degree of Optometry, almost 50% of participants did not undergo further training, 34% had obtained additional certificates and 16% had obtained postgraduate degrees such as Masters of Optometry, Masters in public health and Masters in business administration. Most of the participants (35.5%) practice in the Capricorn District of the Limpopo Province followed by 19.4% who practice in the Sekhukhune District. Other demographic information including years of practice, additional educational qualifications, employment contracts and the district in which the hospital is located are shown in Table 4.1 below.

Table 4.1. Demographic characteristics of the participants

Variable	Frequency (n)	Percentage (%)
Gender		
Male	17	27.4
Female	45	72.6
Race		
Black	62	100
White	0	0
Coloured	0	0
Years of practice		
Less than 5 years	0	0
6-10 years	11	17.7
11-15 years	31	50
More than 16 years	20	32.3
Additional qualifications		
None	28	45.2
Additional Certificate	21	33.9
Diploma	3	4.8
Masters (Optometry)	2	3.2
Masters (MPH)	7	11.3
Master of Business Administration	1	1.6
Employment		
Full time	62	100
Part-time	0	0
District		
Capricorn	22	35.5
Mopani	8	12.9
Sekhukhune	12	19.4
Vhembe	10	16.1
Waterberg	10	16.1

4.3. OBJECTIVE 1: The self-reported clinical competencies of optometrists in the public health sector.

Table 4.2 shows that 78.96% ($n=49$) of the participants consult more than 11 children in public health facilities monthly while 6.45% ($n=4$) participants reported to consult less than five children per month (figure 4.1). However, sixty-five percent ($n=40$) of participants reported to consult between 0-5 children who present with binocular vision anomalies monthly. Thirteen percent of the participants reported to consult more than 11 children with binocular vision conditions (figure 4.2).

Table 4.2: Percentage of participants reporting on children presenting in public health facilities.

Variable	Frequency (<i>n</i>)	Percentage (%)
Number of children consulted in public health facilities per month.		
0-5	4	6.45
6-10	9	14.52
11-15	13	20.9
More than 16 children	36	58.06
Number of children presented with binocular vision anomalies per month.		
0-5	40	64.52
6-10	14	22.48
11-15	1	1.61
More than 16 children	7	11.29

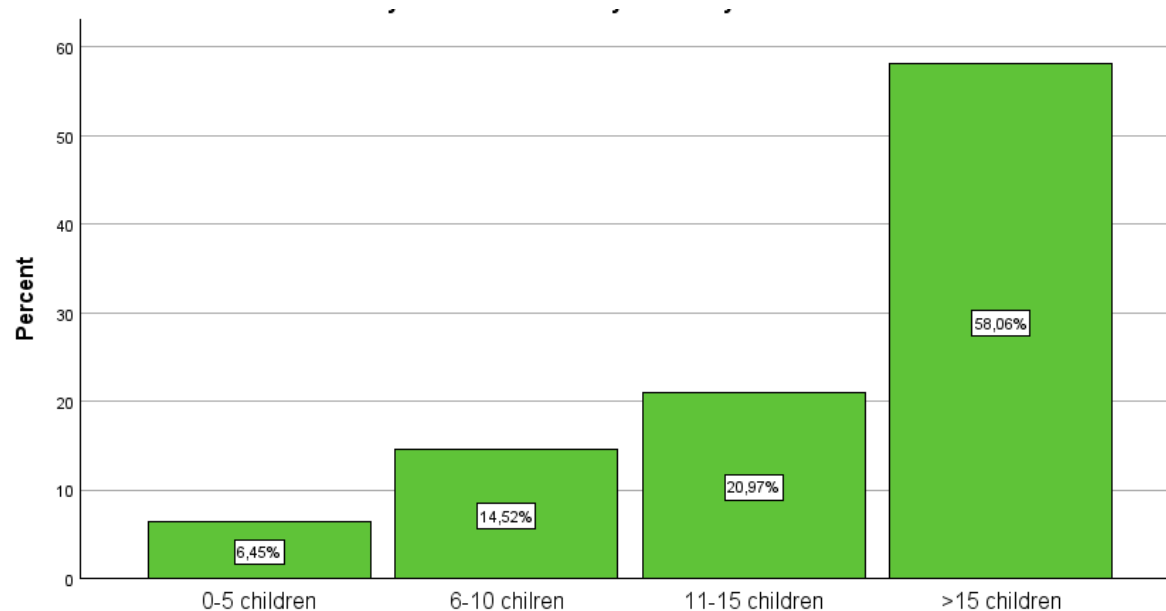


Figure 4.1: Percentage of participants reporting on number of children presenting in public health facilities.

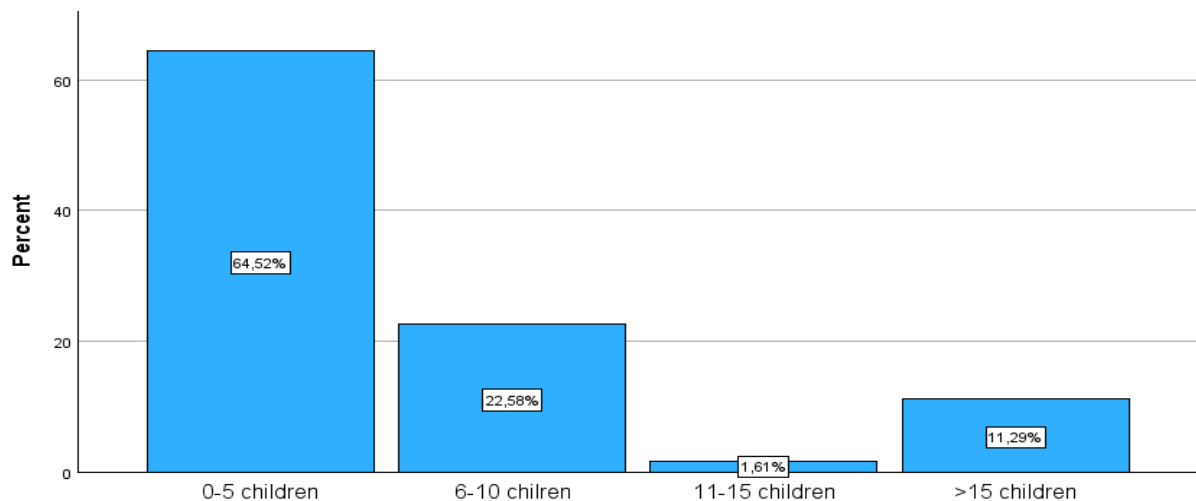


Figure 4.2: Percentage of participants reporting on number of children presenting with binocular vision conditions in public health facilities.

Table 4.3 below reveals that less than half (38.7%) of participants have perceived themselves to have an adequate (good and excellent) knowledge regarding common binocular vision anomalies. In excess of a third of participants (35.5%) perceived themselves to have adequate (good and excellent) knowledge on taking binocular vision case history, while 43.5% ($n=27$) of the participants perceived themselves to have an average knowledge, and only 3.2% ($n=2$) had poor knowledge. Almost 10% ($n=6$) of participants have poor knowledge on performing paediatric binocular examinations. Additionally, only 38.6% ($n=24$) of the participants reported being competent (good and excellent) in identifying binocular vision anomalies.

Table 4.3: The self-reported clinical competencies of optometrists in the public health sector.

Knowledge about common binocular vision anomalies.	Frequency (n)	Percentage (%)
Poor	2	3.2
Fair	12	19.4
Average	24	38.7
Good	15	24.2
Excellent	9	14.5
Knowledge in binocular vision case history taking.		
Poor	2	3.2
Fair	11	17.7
Average	27	43.5
Good	13	21.0
Excellent	9	14.5
Knowledge in performing paediatric binocular examinations.		
Poor	6	9.7
Fair	18	29
Average	23	37.1
Good	9	14.5
Excellent	6	9.7
Knowledge in identifying binocular anomalies		
Poor	2	3.2
Fair	16	25.8
Average	20	32.3
Good	17	27.3
Excellent	7	11.3

The proficiency of the application of skills acquired during undergraduate training, the frequency of Continuous Professional Development (CPD) attendance and its associated usefulness, as well as other variables are reported in Table 4.4 Twenty-seven (44%) of the participants reported having received average skills from undergraduate training. It is a concern that 15 (24.2%) participants have never attended any CPD activity. Approximately 45 (72.6%) participants found the attendance of CPD activities useful. However, 93.5% of the participants stated a preference for attending an advanced course in binocular vision that comprises both theory and practical activities.

Table 4.4: Proficiency skills acquired during undergraduate training and Continuous Professional Development (CPD) attendance”

Adequacy of skills learned from undergraduate training on the management of paediatrics and binocular visions.	Frequency(n)	Percentage (%)
Poor	2	3.2
Fair	11	17.7
Average	27	43.5
Good	13	21
Excellent	9	14.5
CPD activity workshop attendance on binocular vision		
Never attended	15	24.2
Less than 3 months	2	3.2
3-6 months	4	6.5
More than 6 months	39	62.9
The usefulness of the skills obtained from CPD workshops		
Not useful	0	0
Less useful	2	3.2
Useful	15	24.2
Very useful	18	29
Extremely useful	13	21
Benefit from attending an advanced course in binocular vision		
Yes	62	100
No	0	0
Preferred course binocular vision		
Theory	1	1.6
Practical	3	4.8
Both theory and practical	58	93.5

4.4. OBJECTIVE 2: Management modalities of binocular vision by optometrist in the public health sector.

In their assessment of the most commonly seen binocular vision anomalies, 60 participants reported the most frequently seen condition is strabismus, followed by 51 participants who stated it is amblyopia. Divergence excess was the least seen condition reported by only 8 participants. These and other seen binocular vision anomalies are reported in Figure 4.3 below.

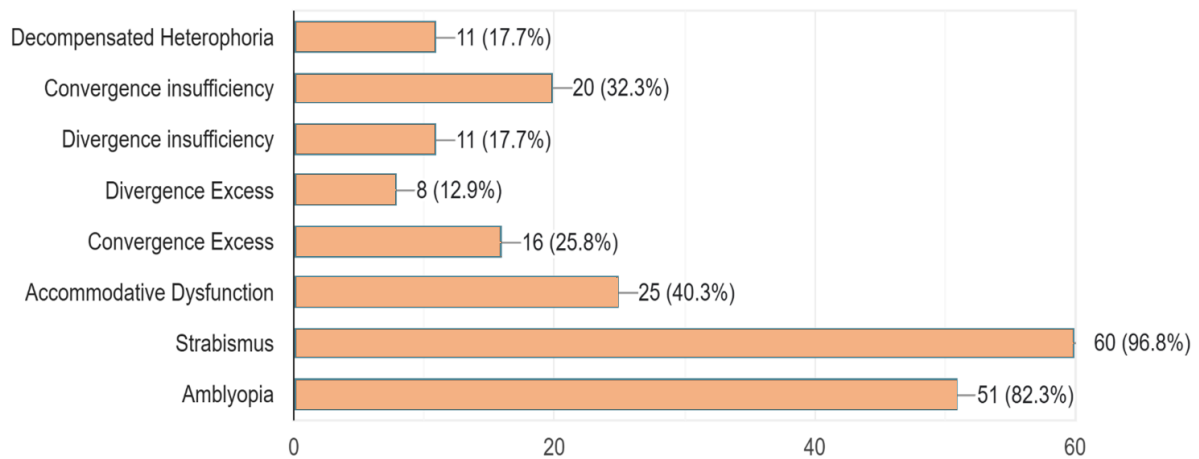


Figure 4.3: Common reported binocular vision anomalies in the public health facilities.

Approximately 56.5% ($n=35$) of the participants reported competencies for managing binocular anomalies while 27 (43.5%) participants admitted to not managing these anomalies. Table 4.5 below presents the following responses: 49 (79%) participants reported a lack of availability of equipment as the reason for not managing binocular vision anomalies; 24 (41.9%) participants indicated that they did not have the requisite competencies, while 18 (29%) participants reported a lack of a conducive working station.

Table 4.5: Reason for non-management of binocular vision anomalies.

Do you manage binocular vision anomalies?	Frequency (n)	Percentage (%)
Yes	35	56.5
No	27	43.5
Possible reasons for non-management of binocular vision anomalies. (Some participants responded more than once.)		
Inadequate competencies	24	41.9
Lack of necessary equipment	49	79
Lack of time	5	8.1
Insufficient staff	11	17.7
Non availability of space	18	29

Table 4.6 below shows the responses of participants in relation to the use of cycloplegic refraction. Approximately 48.4% of the participants reported never performing cycloplegic refractions. Only a few (8.1%) reported regularly using this method for refraction.

Table 4.6: Frequency of cycloplegic use in the clinical settings.

Frequency of cycloplegic refraction	Frequency (n)	Percentage (%)
Never	30	48.4
Less often	21	33.9
Most often	6	9.7
All the time	5	8.1

Cycloplegic refraction results were considered for accommodative dysfunction cases by 35.5% ($n=22$) of the participants and hyperopic conditions by 32.2% ($n=20$) of the participants. Normal retinoscopy results were considered for 67.7% cases of hyperopia. Other findings are shown in Table 4.7 below.

Table 4.7: Number of spectacle prescriptions based on cycloplegic or normal retinoscopy for different binocular anomalies.

Binocular anomalies	Tests			
	Cycloplegic		Normal retinoscope	
	<i>n</i>	%	<i>n</i>	%
Hyperopia	20	32.2	42	67.7
Strabismus	28	45.2	33	53.2
Amblyopia	13	21	49	79
Accommodative cases	22	35.5	40	64.5

The below results show that different forms of management were considered for various anomalies of binocular vision. These approaches include spectacles (69.1%) that appears to be the primary management modality for all common anomalies, followed by referral (24.9%). Sixty-nine ($n=43$) percent of the participants reported to prescribe spectacles for convergence insufficiency and 16 (9.7%) used vision therapy for the same condition. Divergence insufficiency patients 7 (11.3%) participants reported to use prism. None of the participants used drugs to manage amblyopia. The least form of management (1.6%) considered by participants in the management of these anomalies was contact lenses. Details of other forms of management for different binocular vision anomalies are as shown in Table 4.8 below.

Table 4.8: Management modalities reported by the participants for the common paediatric binocular vision disorders.

Binocular anomalies	Management modalities						
	Spectacles	Added lenses	Contact lenses	Prism	Vision therapy	Drugs	Referral
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Decompensated Heterophoria	43 (69)	4 (6.5)	0 (0)	8(12.9)	8 (12.9)	1 (1.6)	18 (29)
Convergence insufficiency	43 (69)	7 (11.3)	0 (0)	5 (8.1)	16 (9.7)	0 (0)	14 (23)
Divergence insufficiency	38 (61)	4 (6.5)	0 (0)	7(11.3)	10 (16.1)	1 (1.6)	11 (18)
Divergence excess	40 (65)	3 (8.4)	0 (0)	5(8.1)	13 (21)	1 (1.6)	15 (24.2)
Convergence excess	47 (76)	6 (9.7)	0 (0)	6 (9.7)	13 (21)	1 (1.6)	12 (19)
Accommodative dysfunction	46 (74)	10(16.1)	1 (1.6)	2 (3.2)	12 (19)	2 (3.2)	11 (17.7)
Strabismus	39 (63)	6 (9.7)	0 (0)	4(6.5)	12 (19)	0 (0)	23 (37)
Amblyopia	47 (76)	2(3.2)	1 (1.6)	1 (0)	11 (17.7)	0 (0)	19 (31)

Table 4.9 below shows the degree of success for various management modalities for any given binocular vision anomaly. Spectacles (80.8%) and patient referral (71.2%) were rated to be the most successful management protocols employed by the participants (figure 4.4). Contact lenses (77.4%) and prisms (77.4%) were reported to be less successful management modalities.

Table 4.9: Success rate of management plan approach

Binocular anomalies	Most successful	Less successful	Not successful
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Spectacles	56 (90.3)	6(9.7)	0 (0)
Added lenses	20 (32.3)	18 (29)	24 (38.7)
Contact lenses	6 (9.7)	8 (12.9)	48 (77.4)
Prism	1 (1.6)	13 (21)	48 (77.4)
Vision therapy	14 (22.6)	30 (48.4)	18 (29)
Drugs	15 (24.2)	14 (22.6)	33 (53.2)
Referral	43 (69.4)	16 (23)	3 (4.8)

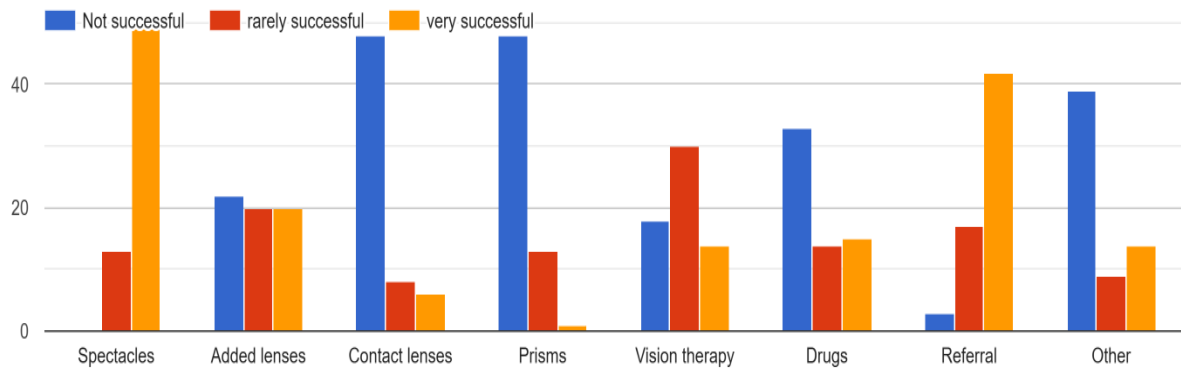


Figure 4.4: The success rate of management plan approach

Table 4.10 below depicts the correlations of self-reported clinical competencies with the knowledge and performance of optometrists practising in the public health sector in Limpopo Province using Spearman's correlation. There is a high degree of correlation between all the competency indicators with knowledge and performance, that were also highly significant at p -value of 0.001.

Table 4.10: Correlations of self-reported clinical competencies with knowledge and performance

Correlations	Correlation (<i>r</i>)	<i>p</i> -value
Your knowledge about binocular vision anomalies- Competency in taking binocular vision case history	0.9	0.001
Your knowledge about binocular vision anomalies- Competence in performing paediatric binocular examination	0.8	0.001
Your knowledge about binocular vision anomalies - Competent in identifying binocular anomalies.	0.8	0.001
Your knowledge about binocular vision anomalies- Undergraduate training on paediatrics and binocular vision	0.7	0.001
Competency in taking binocular vision case history- Your knowledge about binocular vision anomalies.	0.9	0.001
Competency in taking binocular vision case history- Competence in performing paediatric binocular examination	0.9	0.001
Competency in taking binocular vision case history- Competent in identifying binocular anomalies.	0.9	0.001
Competency in taking binocular vision case history- Undergraduate training on paediatrics and binocular vision	0.7	0.001
Competence in performing paediatric binocular examination- Your knowledge about binocular vision anomalies.	0.8	0.001
Competence in performing paediatric binocular examination -Competency in taking binocular vision case history	0.9	0.001
Competence in performing paediatric binocular examination- Competent in identifying binocular anomalies.	0.8	0.001
Competence in performing paediatric binocular examination- Undergraduate training on paediatrics and binocular vision	0.7	0.001
Your knowledge about binocular vision anomalies.	0.8	0.001
Competent in identifying binocular anomalies- Competency in taking binocular vision case history	0.9	0.001
Competent in identifying binocular anomalies- Competence in performing paediatric binocular examination	0.9	0.001
Competent in identifying binocular anomalies- Undergraduate training on paediatrics and binocular vision	0.7	0.001
Undergraduate training on paediatrics and binocular vision - Your knowledge about binocular vision anomalies.	0.7	0.001
Undergraduate training on paediatrics and binocular vision - Competency in taking binocular vision case history	0.7	0.001
Undergraduate training on paediatrics and binocular vision - Competent in performing paediatric	0.7	0.001
Undergraduate training on paediatrics and binocular vision - Competent in identifying binocular anomalies.	0.7	0.001

4.5. OBJECTIVE 3: Availability of binocular equipment in public health facilities per district.

Table 4.11 below shows the number of hospitals that has eye units in the Limpopo and the number of the optometrists in the province. The province has 35 eye units and 98 optometrists.

Table 4.11 Number of hospitals and practitioners in each district.

Number of instruments per district						
	Capricorn	Waterberg	Mopani	Vhembe	Sekhukhune	Total
Number of hospital	9	7	6	6	7	35
Number of practitioners per district	27	18	14	15	23	98

Table 4.12 below shows the distribution of the equipment list as per the district. Only the binocular vision equipment is listed in this study, taking into account the number of minimum standards and the essential equipment required for the assessment of binocular vision anomalies as set out by the HPCSA (2023). All the 35 hospitals participating in this study had Snellen visual acuity charts, tumbling e charts, near charts, trial cases and direct ophthalmoscopes. The majority of these hospitals had retinoscopes, autorefractors, phoropters, pupillary distance (PD) rulers and trial frames. However, there is a lack of certain equipment that measures binocular status such as stereoacuity booklets, RAF rulers, polaroid lenses, prism bars, Maddox rods, Maddox wings, prisms and accommodative facility lenses. None of the facilities had synoptophores, mallet units and neutral density bars. The distribution of binocular equipment is skewed across all the facilities irrespective of whether it is district, regional or tertiary facility.

Table 4.12: Distribution of equipment list per district.

Number of instruments per district						
Instruments	Capricorn	Waterberg	Mopani	Vhembe	Sekhukhune	Total
Snellen chart	26	35	20	12	17	110
Illiterate E	17	26	17	9	12	81
LogMAR chart	4	6	3	3	1	17
Near chart	13	12	11	8	15	59
Near picture chart	4	6	3	3	5	21
Isolated chart	1	1	5	3	1	11
Retinoscope	10	11	7	10	10	48
Autorefractor	10	8	2	5	7	33
Trial lens set	15	16	10	10	16	67
Trial frame	12	16	11	11	16	66
PD ruler	20	17	16	11	22	86
Phoropter	10	6	6	8	12	42
Projector	10	8	4	2	8	32
JCC	14	12	10	7	13	56
Duochrome chart	9	2	4	6	9	30
Thorington card	2	0	1	3	2	8
Neutral density filters	1	0	0	0	0	1
Pinhole	11	17	11	8	14	61
Occluder	13	18	16	15	19	81
Raf rule	4	5	4	1	6	20
Maddox rod	9	6	5	1	8	28
Maddox wing	1	2	5	0	2	10
Red/green goggles	9	5	6	6	2	28
Prism flippers	1	7	5	0	0	13
Accommodative flippers	2	0	4	3	0	9
Prism bar	2	4	3	9	0	18
Mallet units	0	0	0	0	0	0
Penlight	5	8	11	8	9	41
Direct ophthalmoscope	19	14	12	12	23	80
Stereoacuity charts	5	7	1	5	0	28
Polaroid lenses	6	6	3	7	4	26
Synoptophore	0	0	0	0	0	0
Testing rooms	12	10	11	8	13	54

4.6. CHAPTER SUMMARY

This chapter outlined the results of the participants' demographic characteristics, their self-reported clinical competencies in managing binocular vision anomalies, the management modalities employed by optometrists in public facilities, and the available resources in these facilities. All of the above factors were displayed in frequency and percentage tables and figures.

CHAPTER 5

DISCUSSION

5.1. INTRODUCTION

Chapter one provided an overview of the research study, Chapter Two provided the review of relevant literature, Chapter Three provided the methodology utilised in the study. The previous chapter provided the presentation, interpretation and analysis of the data collected in the study. In the current chapter, a detailed discussion of the findings is presented. This presentation will focus on the demographic information of the participant's followed by a discussion of the findings with respect to the objectives of the study.

5.2. DEMOGRAPHIC INFORMATION OF THE PARTICIPANTS

A response rate of 62% was achieved for the current, which is greater than the recommended 50% (Sataloff & Vontela, 2021), the response rate is commendable. The study was conducted in Limpopo Province, which is composed of five district municipalities, namely, Capricorn, Mopani, Sekhukhune, Vhembe and Waterberg. The province is predominantly rural with a population of over 6.6 million people (Moultrie & Dorrington, 2024). This study site was chosen because the researcher resides and practices optometry in Limpopo Province and, as a result, it was a convenient choice for data collection. Furthermore considering that the hospitals under study are situated in rural areas, where affordability is likely a concern, the community relies on the services provided by the hospitals. Consequently, adequate provision of healthcare services is essential. All five districts, as alluded to above, were included as the study sites of the current study. Specifically, health care facilities with optometrists in each district were considered as the study sites. Notably, most of the health care facilities and hospitals in particular, are located in the rural and semi-rural areas of the Limpopo Province.

According to the recent census conducted by Statistics South Africa 2022, the race distribution across all the districts in this province is predominantly African (Moultrie & Dorrington, 2024). Also, the results showed that the highest percentage of the population is located within the Capricorn District Municipality, thus, giving credence to the relatively high number of participants (35.5%) from that district in the study. The

least number (12.9%) of participants were based in Mopani District, which is reported to be mainly rural (Statistics South Africa, 2022).

In this present study, most of the participants (72.6%) were female optometrists practicing in public health facilities in Limpopo Province of South Africa. This figure is consistent with the findings of a study by Opoku-Baah *et al.* (2014) who focused on the aspects of management of binocular vision anomalies in eye care facilities in Ghana, in which female eye care practitioners were found to be more highly qualified than male practitioners. Similarly, a study by Van der Merwe, Van Zyl, Gibson, Viljoen *et al.* (2016) involving medical schools in South Africa, demonstrate that the selection process favours female students, with a reported 62.2% representation. This fact is likely to be the case in the other health care programmes offered at various universities within South Africa. Therefore, it is not surprising that the number of participating female optometrists was higher than males in this study. Statistics SA 2022 that states the country's population comprises more females than males by 51% (Moultrie & Dorrington, 2024) further supports this fact.

The years of experience in any profession have the propensity to correlate with the level of expertise of the professionals concerned. In the optometric profession, personal experience has revealed that the greater the years of experience in practice, the greater the proficiency in discharging clinical skills. In the current study, all participants (100%) have more than 5 years experience, suggesting that they were possibly more capable of handling paediatric patients presenting with binocular vision anomalies. Although only a few (3.2%) participants reported possessing some form of postgraduate degree in optometry (that presumably would equip them with a higher level of skills for paediatric patient management) their years of experience should provide them with an equally high level of confidence for handling any patients presenting challenges within their clinical setting. In previous studies conducted elsewhere, it is reported that accumulated years of optometry practice have a high correlation with the competency skills in the management of paediatric binocular vision anomalies (Ocansey *et al.*, 2020; Rodríguez-Zarzuelo, Gómez-Niño & Martín-Herranz, 2023)

5.3. OBJECTIVE 1: To determine the self-reported clinical competencies of optometrists in the public health sector in investigating paediatric binocular vision anomalies.

The optometry profession has been constantly evolving in the past decades. To date, an optometrist is expected to be competent in a battery of various clinical skills according to the approved scope of optometry in the South African context. An optometrist is a primary health care professional responsible for conducting eye examinations with a purpose of diagnosing visual impairments and ensuring clear, comfortable and effective vision. They also correct refractive errors through the provision of spectacle lenses, contact lenses and vision therapy to the public (Sithole, 2015). In this context, optometrists are required to use all their clinical skills in patient care including aspects of vision therapy and orthoptics.

Ordinarily, as also indicated in the definition, any optometrist should have adequate competencies to manage all patients presenting with binocular vision problems. Unfortunately, anecdotal evidence suggests that not all optometrists have an interest or adequate skills in binocular vision, thus, presenting a challenge for those patients who may need such services. This study assessed the self-reported competencies of optometrists in relation to the clinical examination of paediatric patients with binocular vision anomalies presenting in the public facilities. In the context of this study, optometrists reported to be consulting more than fifteen children per month, however less than five children consulted with binocular vision anomalies on monthly basis as indicated in table 4.2. In this situation, it can be deduced that not all patients who presented for eye examination needed refractive services but others required binocular vision services. In agreement with this assertion, a study conducted in Spain by Lara, Cacho, García *et al.* (2001) revealed that, in a sample of 265 patients presenting at an optometric clinic, 59 had binocular vision disorders and, as such, they did not require refractive error correction but special binocular vision care. Notably, the positive diagnosis of binocular vision anomalies requires a set of clinical competencies in the subject matter to enable drawing a conclusion. Therefore, in the context of the present study, the participants (56.5%) perceived themselves as possessing the required clinical competencies to diagnose and manage patients presenting with binocular vision anomalies.

Although some of the participating optometrists reported to positively diagnose patients with binocular vision anomalies, it is possible that there will have been undiagnosed binocular vision anomalies by the 43.5% of participants who reported not to manage binocular vision conditions (table 4.5). Even more concerning is that anomalies of binocular vision tend to affect paediatric patients more than the rest of the population (Evans, 2021). A study by Wajuihian and Hansraj (2016) conducted among Black school-going children in the KwaZulu-Natal Province of South Africa, reported that about 13.2% of the children had some form of binocular vision anomalies. Although this finding may not be generalised to suggest a similar prevalence across the country, it is possible that the situation will be somewhat similar in other South African provinces. Therefore, there is a need to capacitate all optometrists, especially those who show no interest in binocular vision care.

Continuous Professional Development (CPD) initiatives may play an integral role in stimulating interest in the subject matter, much to the benefit of all those who may present with anomalies of binocular vision, including children. The essence of CPDs is that there must be a link between the needs of the community and the performance gaps on the side of the practitioners for quality improvement (Wheeler & Chisholm-Burns, 2018). In the context of managing paediatric patients, the competency level for performing an examination and being able to identify binocular vision anomalies may be cumbersome considering the number of children presenting with binocular vision anomalies in public health settings. Notably, clinical competencies and confidence are built on exposure to different clinical cases, availability of resources; space to provide the services and frequent attendance at clinical workshops and CPDs. Unfortunately, the participants in this current study demonstrated apathy to CPD programmes on binocular vision. For example, the majority (62.9%) had not attended any recent CPD activity in the previous six months, and 24.2% had never attended any CPD activity on binocular vision as presented in table 4.4. This finding underscores the need for designing strategic interventions to stimulate attendance of CPD workshops by optometrists in the public health sector. Some of these initiatives should focus on strabismus, vergence and accommodation system dysfunction to capacitate these optometrists with revitalised skills for the management of the paediatric population's visual challenges, the participants demonstrated in table 4.4 to have interests in theory and clinical postgraduate training on binocular vision management.

Public health care facilities receive a considerable number of paediatric patients (França & McManus, 2017). In this present study, 13.2% of paediatric patients are reported to have presented with some form of binocular vision anomalies, in addition to the possibility of a few others that may have been misdiagnosed. A study conducted in India, reported that 31.5% of the school-going children in the rural population of Tamil Nadu were diagnosed with some form of vergence and accommodation system dysfunction (Hussaindeen *et al.*, 2017). The possible cause of this variation may not necessarily be attributed to misdiagnosis alone considering the relatively high population in India, thus, possibly contributing towards in a higher number of those with vergence and accommodation anomalies. Hussaindeen *et al.* (2017) reported binocular vision anomalies to be more prevalent among school-going children and further highlighted that the prevalence increases with age due to an increased reading and excessive near work. In support of this assertion, a recent study by Maharjan *et al.* (2022) reported on the increased use of electronic devices and found reduced monocular and binocular accommodative facilities to be more common in school-going children. As one of the leading economies on the African continent, it is expected that South Africa may have more children exposed to the use of electronic devices, that are freely provided in some schools and, as such, there is a higher possibility that with excessive near work on these devices, vergence and accommodation anomalies may be highly prevalent (Ali, Morshedy, El-Zahhar *et al.*, 2024).

Binocular vision anomalies are complex ocular conditions that require skilled and competent optometrists to adequately provide proper diagnosis and management. Therefore, optometrists seeing paediatric patients presenting with these anomalies should be adequately skilled. Unfortunately, misdiagnoses still occur in some instances (table 4.5). The aspect of misdiagnoses is an important public health concern especially for a paediatric population that may suffer longer due to the expected number of years of social discomfort and poor quality of life. Unfortunately, even among paediatricians, frequent errors of misdiagnosis are experienced and are reported to cause some form of harm to the patients (Singh, Thomas, Wilson *et al.*, 2010). It, therefore, is expected that eye care providers such as optometrists may also experience the same challenges as paediatricians, but in the case of the former, this problem may be because of a lack of interest in the management of binocular vision disorders, especially when it is children presenting with these challenges.

Unfortunately, their visual system is susceptible to interference during the developmental stages (Evans, 2021) and since some of these conditions are not manifest, they have the propensity to affect visual performance exceedingly, and affected children may experience reading difficulties resulting in poor academic performance

5.4. OBJECTIVE 2: To describe the management modalities for paediatric binocular vision anomalies by optometrists in the public health sector.

As stipulated under objective 1, visual challenges in the paediatric population present a serious public health challenge that cannot be ignored. The quality of life of this population should not be affected by challenges that can be easily ameliorated, especially if there is a political will to capacitate eye care providers who offer optometric care. Optometrists with the requisite clinical skills for paediatric binocular vision care are an important human resource in providing primary health care. These personnel should be supported to discharge their clinical skills and practice their scope to their full potential for the benefit of all, especially children presenting with binocular vision anomalies. While discharging their responsibilities, there must be a commensurate array of equipment to incite interest in managing any presenting vergence and accommodation disorders in their given setting. As indicated herein, especially in the context of the optometric fraternity in South Africa, not all optometrists have interest in the management of binocular vision anomalies. However, in the current study, more than half (56.5%) of the participants reported managing binocular vision anomalies as reported in table 4.5, thus, indicating that there are optometrists in the public hospitals who have interests in managing binocular vision patients. On the contrary, 43.5% of the participants who reported not managing binocular vision anomalies cited lack of relevant equipment as the main contributing factor. This finding further suggests that, although there may be optometrists interested in the management of binocular vision anomalies, they may be handicapped by the unavailability of adequate equipment, appropriate space and other facilities required practicing their skills optimally.

A study conducted in Ghana on the management of binocular vision anomalies in eye care facilities has revealed that the availability of appropriate equipment for patient

care had an influence in the interest of practitioners in patient care (Opoku-Baah *et al.*, 2014). In the same study, it was reported that inadequate training in the management of binocular vision anomalies was significantly ($p = 0.001$) associated with lack of interest in managing these conditions (Opoku-Baah *et al.*, 2014). It is, therefore, possible that issues such as inadequate training and lack of equipment meant for binocular vision anomalies management may also be influencing the management modalities of these conditions in the South African context.

In the current study, when patients presented with binocular anomalies, optometrists used various modalities to manage the conditions. Spectacle correction (69.1%), added lenses (9%), prisms (15%), drugs (1.2%), contact lenses (0.4%), vision therapy (17.1%) and referral (24.9%) were used in the management of various binocular vision anomalies as stipulated in table 4.8. Spectacle correction was the most common management modality considered by participants. Sen *et al.* (2022) indicated the significant of optical treatment for unilateral amblyopia in children less than seven years old and stated that spectacle treatment has shown to have superior effects in children with better baseline VA and lesser anisometropia, therefore spectacle correction should be considered as the first form of management in many binocular vision problems, in exception of conditions that are prone to be worsened by the spectacles correction. However, in some instances, the choice of this method may not necessarily be informed by clinical considerations, but also by the kind of available resources at the disposal of eye care practitioners. Another factor could be that spectacle correction may be the cheapest options compared to the other ones mentioned above. For example, in other related studies (Birch, 2013; Scheiman *et al.*, 2002; Sharma *et al.*, 2015) conducted outside the African continent, in addition to the management modalities adopted by the participants in this study, other different treatment modalities used included pencil-push up therapy, home-based vision therapy, office-based vision therapy, combination of psychophysical, electrophysiological, imaging, risk factor analysis and fine motor skill assessment. Apart from the requisite skill to apply these management modalities, they may have high-cost implications that may not be affordable for most patients seeking treatment in the identified study sites. This finding suggests that even though there is a need to upskill optometrists, much emphasis must be placed on the acquisition of appropriate

equipment and other relevant facilities that may aid in the improvement of approaches to binocular vision anomalies management.

In the context of the current study, it appears that vergence and accommodation dysfunction anomalies were managed using somewhat limited management options. However, most vergence and accommodation anomalies may require different management approaches as is the case in the previously mentioned studies (Birch, 2013, Scheiman *et al.*, 2002, Sharma *et al.*, 2015). The kind of binocular vision anomalies that were identified in the current study included amblyopia, strabismus, accommodative dysfunction, divergence excess, convergence excess, divergence insufficiency, convergence insufficiency and decompensated heterophoria. Some of these anomalies were also identified in studies by Ocansey *et al.* (2020) and Opoku-Baah *et al.* (2014) that were conducted in a relatively low-resource environment in Ghana. In this context, the management modalities were somewhat similar to those considered in our study because they were limited to mainly spectacle correction, thus, confirming the preponderance that this may be considered the most easily accessible cheaper option and may have been prescribed even in cases in which they were not clinically indicated to resolve binocular vision anomalies. For example majority of the participants preferred to use spectacles for the management of CI and DI over vision therapy and prescription of prisms. Again, this further finding suggests that other management options may not have been considered due to a scarcity of appropriate equipment and related facilities.

The relatively high number of binocular vision anomalies, diagnosed by optometrists in the current study, may be considered a positive development in the greater context of practicing the full scope of optometry. However, there is no identified exhaustive management protocols, except those mentioned earlier. Although other studies (Hussaindeen *et al.*, 2017; Hussaindeen *et al.*, 2018; Sah, Yadav, Chauhan *et al.*, 2024) found convergence insufficiency and accommodative insufficiency to be the leading anomalies of binocular vision, in the current study, strabismus accounted for the highest form of binocular vision anomalies at a reported 96.7% of the participants, followed by amblyopia (51%), while the highest management modality for both conditions was spectacle correction at a reported 69.1% and this result was found to be not statistically significant ($p = 0.44$). The least common vergence anomaly found was divergence excess (8%). The findings in this study are inconsistent with the

results of a study by Metsing and Ferreira (2012) which found that vergence infacility was the most common binocular vision anomaly among school-going children in South Africa. The differences in the current and that of Metsing and Ferreira (2012) may be attributed to the variations in the application of clinical skills in dealing with paediatric binocular vision patients. In the South African optometric education system, there are no specialties and, as such, only a few optometrists have an interest in binocular vision, thus, leading to a paucity of the much-needed skills in this area of interest. Furthermore, the paucity of binocular vision anomalies management skills may inadvertently lead to these variations in the diagnosis of presenting anomalies that may lead to the advent of serious cases of false positive and negative incidences affecting the paediatric population. In view of these challenges, there is a pressing need for the development of postgraduate courses in various areas of interest including binocular vision and paediatrics.

A notable concern is that almost half (48.4%) of the participants never performed cycloplegic refraction on those patients that were diagnosed with strabismus and amblyopia. This deficiency could be associated with lack of requisite qualifications to perform cycloplegic refraction. In this present study, the qualifications of the participants do not have significant correlation with cycloplegic refraction performance ($p = 0.016$). Observably, most optometrists who qualified before the advent of certificates in diagnostics are inherently presumed not to have the skill to use drugs as part of patient examination. However, the current cohort of young optometry graduates are equipped with diagnostic skills because this aspect now forms part of their undergraduate training in all South African universities in which a Bachelor of Optometry Degree programme is offered.

Despite all the challenges that participants in the study may have on their daily operations, spectacles prescriptions were considered as the first line of management protocol in managing most binocular vision and refractive conditions, it would be commendable if spectacles are used in cases where they were not necessarily considered as a affordable corrective option only but used as an appropriate mode of management for binocular vision anomalies. Spectacle correction is generally considered to correct full refractive accommodative esotropia, decompensated heterophoria and further reduce the angle of strabismus in strabismic amblyopia and mixed amblyopia. In agreement with this management modality, Emmanuel *et al.*

(2023) highlighted that spectacle correction improves VA in both unilateral and bilateral amblyopia. The researcher additionally suggested that spectacle correction may change the angle of strabismus in accommodative esotropia, thereby reducing the degree of deviation in moderate accommodative esotropia, or even reduce the angle of deviation to zero or phoria phase in full accommodative esotropia (Emmanuel *et al.*, 2023). Therefore, in this context, spectacle correction was used optimally as the best corrective option for the diagnosed anomalies.

Although spectacle correction is considered the best option in some instances, as stipulated above, there are other considerations in patient management that should be considered. For example, in paediatric patients, in some cases spectacles may interfere with the emmetropization process. Therefore, observation may be the only form of management especially in children younger than six years. In confirming this positional standpoint, Sharma *et al.* (2015) denotes that in children, spectacles can only be prescribed when there is demonstrable amblyopia, heterotropia and nystagmus. In addition, care should be taken to ensure that even when the correction of these anomalies is considered, there is some form of under correction, especially for preschool children, to allow for the process of emmetropization to continue. Furthermore, in some instances, cycloplegic refraction should be the optimum standard of care and examination in order to obtain the correct amount of refractive error, while still considering the aspect of emmetropization (Leat, 2011)

In view of the above, with only 18% of the study participants using vision therapy for the management of amblyopia, it is important to highlight that the majority of the participants (76%) considered spectacle correction for amblyopia as the first form of correction. Table 4.8 revealed indications of mismanagement of several conditions. Sixty-nine percent ($n=43$) of participants relied on spectacles to address CI as stipulated in table 4.8. This highlights a significant gap in clinical knowledge, given that vision therapy is the recommended approach for CI conditions. The primary management approach for divergence insufficiency includes the use of prisms; however, a significant majority, 61% ($n=38$), favoured spectacles over prisms. Penalisation is considered an effective management modality for amblyopia and strabismus (Emmanuel *et al.*, 2023); however, none of the participants utilized pharmacological interventions for the management of either condition. In addition to the reports of insufficient equipment, limited space, and overcrowding, there is a

notable indication of a knowledge gap. As indicated earlier, this practice may be because of inadequate training or not having diagnostic privileges to enable them to administer such drugs. This finding further supports the of advocating of postgraduate programmes in diagnostic privileges for the betterment of patient management, especially for earlier qualified graduates.

Although the majority of the participants (75%) in the current study did not consider vision therapy as the leading management protocol, there is strong evidence on the efficacy of vision therapy on the management convergence insufficiencies (Aletaha *et al.*, 2018; Barrett, 2009). This finding contradicts the assertions of some of the participants in the study who reported that vision therapy was less successful. In its nature, vision therapy requires ample time to administer, with stringent follow-up requirements for observation. Unfortunately, increased numbers of patients requiring vision therapy and poor patients compliant may be additional reasons influencing the inclination towards spectacle use in the management of binocular vision anomalies. With higher numbers of patients requiring vision therapy, there are high possibilities of poor adherence to instructions by the treating practitioner, thus, leading to poor treatment outcomes. Although some types of vision therapy equipment may be costly for patients from lower socio-economic standings, the use of a push-up therapy is considered one of the best cheaper options available (Aletaha *et al.*, 2018). However, as is the case with any other vision therapy options, including office-based therapy, poor compliance may often lead to a higher failure rate, hence the participants in this study prefer other treatment modalities, especially spectacles. For example, in the case of office-based therapy, it is required that patients should visit the hospital frequently and such a visit is often associated with high costs for transportation. Additionally, other factors that may influence non-adherence could be time constraints and the availability of staff in the eye clinics within the public hospitals. Surprisingly, spectacles corrections would not manage all binocular vision anomalies but participants rated spectacles to be the most successful rate management modality for all the binocular vision anomalies.

Another important consideration that may be a contributory factor in the utilisation of vision therapy could be a combination of a lack of appropriate equipment and no interest by optometrists in the public hospitals to procure them. To confirm the former assertion, Maake and Moodley (2018) conducted a study on the services provided

within the health districts in Kwazulu-Natal province and reported that the minimum standards of optometry care were incorporated in patient management due to lack of equipment and time constraints. In agreement with this finding, a study conducted in the same province by Gasa, Karim, Gangat *et al.* (2019) also reported that the lack of equipment in the health care facilities affect the capacity of the facilities to train undergraduates students adequately during the decentralised clinical training. This finding indicates that poor infrastructure has an influence on the extent to which the scope of optometry is practised in the public health care facilities. In addressing the latter possibility, Opoku-Baah *et al.* (2014) recommend clinical workshops and in-service training to ensure improvement in the number of hospitals managing binocular vision. This suggestion may be an important consideration for optometrists working in these facilities in the context of this study. Also, if these workshops are linked to CPD points, that are a requirement to remain registered as an independent optometrist with the relevant statutory body, the uptake of training slots may be higher, thus, influencing interest in the management of binocular vision anomalies through vision therapy interventions.

In order to align with the prescripts of the statutory body that oversees the training of optometry graduates in South Africa, it is important for all practising optometrists to observe the minimum procedure guidelines to be considered during binocular vision examination that include taking case history, performing an adequate binocular vision examination, identifying binocular vision anomalies and providing proper management modality to these anomalies. These procedures are the minimum required competencies and skills a newly graduate should possess at the exit level from tertiary institutions (HPCSA, 2023). As stipulated earlier, postgraduate training in the management of the paediatric population may contribute immensely to changing the landscape of eye care in the public health facilities.

5.5. OBJECTIVE 3: To describe the availability of clinical resources for examining, diagnosing and managing binocular vision anomalies in the public sector.

Instrumentation plays a crucial role in detecting binocular vision anomalies in the paediatric population. In consideration of this aspect, the current study also investigated the availability of clinical equipment needed in the management of various binocular vision anomalies. In all the study sites included, basic equipment for general ocular refraction were invariably considered more important than others. This practice may be because of a relatively higher number of patients presenting with symptoms of visual impairment than any other disorder.

It may further be assumed that, since most optometrists, included as participants in the current study, were not inclined to assess patients for binocular vision anomalies, they did not advocate for the procurement of equipment that could be used only in the management of binocular vision anomalies. For example, in some of the study sites, only a bare minimum of appropriate equipment was available for use. However, there were a few others that reported having adequate equipment for the management of binocular vision anomalies. The absence of adequate equipment for the management of binocular vision has far reaching implications. Such inadequacy of equipment may exacerbate bias towards generic refractive error assessment even in patients who could benefit from binocular vision anomalies considerations. Typically, the lack of adequate resources for binocular vision assessment may result in a redundancy among optometrists who have an interest in the management of binocular vision anomalies.

Unfortunately, the lack of adequate equipment to be used in the management of binocular vision anomalies suggests that there are certain patients who may have been considered as being true negatives for a specific condition yet, they were actually false negatives. As a confirmation, in recent times, the researcher has observed that some patients are not given the appropriate treatment even though they may have been showing symptoms of binocular vision anomalies. Such occurrences have a telling negative effect on the paediatric population that may inadvertently suffer longer due to the absence of a binocular vision attendant in some instances.

As reported in the results section, there are various types of equipment that were used in the management of binocular vision anomalies. These included snellen acuity charts, phoropters, trial frames, ophthalmoscopes, occluders, red/green goggles, prism bars and thorington charts. Although this equipment is important in binocular vision, its unequal distribution is a major cause for concern. Also, some other appropriate equipment such as mallet units, synoptophore and neutral density filters, that should, ideally, form part of basic equipment, were not reported in any of the study sites. This deficiency suggests that, although some participants reported interest in managing binocular vision anomalies, the extent to which such an engagement with binocular vision patients was undertaken may not necessarily be up to standard and most probably not even satisfactory. Therefore, with the advent of myopia among children using electronic devices at a close range, there is a need for advocacy to fully introduce binocular vision clinics in all the districts that were included in the current study.

In some of the study sites, there were no staff members (optometrists) of appropriate rooms for binocular vision anomalies management. Equipment for binocular vision management requires a dedicated space for storage that should, ideally, be manned by optometrists who have a special interest in this area. In common with other studies (Boadi-Kusi *et al.*, 2015; Thite *et al.*, 2015), the challenge of inadequate staff and the non-availability of consulting rooms has been reported. The lack these important resources could have a negative effect on the quality of optometry service delivery in public health facilities. Therefore, there is need to address these issues to improve the current optometry service delivery in public health facilities not only in Limpopo Province but throughout South Africa.

5.6. CHAPTER SUMMARY

This chapter has elucidated the competencies of optometrists within the Limpopo DoH. It demonstrated that slightly over half of the optometrists in the DOH manage binocular vision anomalies and of the 43.5% of participants who reported not managing these anomalies, the primary reason noted was the lack of appropriate equipment. Consequently, it is essential to enhance training and procurement to optimise optometry service delivery in public health institutions

CHAPTER 6

CONCLUSION

6.1. INTRODUCTION

This chapter presents the research summary, recommendations and conclusion.

6.2. SUMMARY

This study has revealed that spectacle correction is the most preferred management modality for binocular vision anomalies in a paediatric population. Although this may be the case, there are other corrective measures at the disposal of the participants that should, in the view of the researcher, have received more prominence. For example, some of the participants variably considered vision therapy in some instances, a management modality that is highly associated with the management of these anomalies especially in the context of paediatric population. Their choice of spectacle correction should be viewed favourably considering the availability of appropriate equipment for the management of binocular vision problems even in the general optometric population. However, although this may be the case, their inclination towards spectacle usage for a wide range of various binocular vision anomalies may also be an indication of incapacity to manage.

Incapacity may be informed by infrastructural challenges and other inherent problems within the public health sector. Notably, insufficient training may also be a contributory factor in a perceived lack of interest that results in serious incapacity. To this end, in order to address the research problem and subsequently answer the research questions, findings pertinent to the objectives of the study cast some light into the inclination of one method of management over many others that may even be more suitable. For example, objective one of the study sought to determine the self-reported clinical competencies in managing binocular vision anomalies for the paediatric population. Majority (56.5%) reported having confidence in managing binocular vision anomalies with 69% using spectacles as the first choice of management. As already indicated, this choice may be informed by other contributory factors including but not limited to incapacity due to poor training, lack of appropriate equipment and poor infrastructure, among others.

The second objective of the study sought to describe the management modalities for binocular vision anomalies in a paediatric population and as already alluded to, spectacle considerations were the most preferred. Care must be taken to highlight that considering spectacle correction before any other advanced form of management may not necessarily be due to lack of appropriate training. There are instances where spectacle correction is the best method of intervention. However, there is a possibility that some of the patients may have been considered for spectacle correction prematurely. Such a consideration, as already indicated, may be as a result of lack of interest and incapacitation.

The clinical context of the public health care facilities included in the study were not adequately equipped for paediatric population and these findings were addressed in the context of the third objective of the study. For example, most of the equipment were for general optometric care excluding those required specifically for use in the management of patients with binocular vision anomalies. By extension, the lack of appropriate equipment goes with lack of infrastructure designed for the care of paediatric patients with binocular vision anomalies. It can thus be deduced that the earlier mentioned issues of incapacity may be as a result of this perceived lack of support for specialized equipment for binocular vision assessment and subsequent management.

In view of the circumstances leading to an assortment of challenges that possibly gave rise to inadequacies in the management of binocular vision anomalies, there is a need for advocacy to fully introduce binocular vision anomalies assessment and management in the public health care settings. Recent communication by the Board for Optometry and Dispensing Opticians on the introduction of specialties in the optometric profession is an important indication that there is a need for focusing on introducing specialty care for certain sections of the population. While the issue of specialties in the profession is seemingly still under discussion, the aspect of CPD should be emphasized for all interested optometrists in order to build the much needed capacity for managing the anomalies of binocular vision in a paediatric population.

6.3. LIMITATIONS

The limitations of this study are worth noting. The survey was conducted online and some of the participants may have had limited ability to access their emails and WhatsApp links, thus, explaining the small sample size of the study – a fact that limits the generalisation of the findings to other contexts in the province studied and elsewhere within South Africa. In addition, the self-reported nature of the questionnaire does not exclude the issue of bias regarding the responses of the participants.

6.4. RECOMMENDATIONS

Based on the findings of the study, the following recommendations are formulated:

- There is need for periodical training of practicing optometrists in the public health care sector on the management of binocular vision anomalies. This training will expose optometrists to the latest evidence-based scientific methods of handling paediatric binocular vision anomalies to improve health outcomes;
- Government should prioritise the issue of equipment for binocular vision management in all the public health facilities to contribute towards efficient and effective diagnoses and the managing thereof; this practice will, in turn, improve the quality of optometric services in the setting; and
- Future research should endeavour to focus on the design and development of protocols that may be considered in the management of paediatric binocular vision anomalies involving practicing optometrists. Also, improvements in policy directives should be treated as a matter of paramount importance and, as such, relevant stakeholders should be in the forefront of making important changes.

6.5. CONCLUSIONS

In this study, the following conclusions are drawn:

- Half of the participants demonstrated their competency in diagnosing and managing paediatric binocular vision anomalies;
- The majority of the participants are not adequately trained to perform binocular vision activity;

- Strabismus and amblyopia are the most diagnosed binocular vision anomalies;
- The most common mode of binocular vision management used by the participants is spectacles that are rated as the most successful mode of treatment;
- The major constraining issue in the management of binocular vision is the lack of appropriate equipment and space; and
- Most hospitals are equipped with ophthalmoscopes, trial frames, distance and near charts but do not possess adequate relevant equipment to diagnose binocular vision anomalies.

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APPENDIX A: ETHICAL APPROVAL



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TURFLOOP RESEARCH ETHICS COMMITTEE

ETHICS CLEARANCE CERTIFICATE

MEETING: 22 May 2023
PROJECT NUMBER: TREC/123/2023: PG
PROJECT:

Title: Exploring the management modalities for pediatric population presenting with binocular vision anomalies in public health care facilities in Limpopo Province, South Africa.
Researcher: ER Maribeng
Supervisor: Prof SD Mathebula
Co-Supervisor: Mr. JR Ramsja
School: Health Care Sciences
Degree: Master of Optometry

PROF D. MAPOSA

CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: REC-0310111-031

Note:

- i) This Ethics Clearance Certificate will be valid for one (1) year, as from the abovementioned date. Application for annual renewal (or annual review) need to be received by TREC one month before lapse of this period.
- ii) Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee, together with the Application for Amendment form.
- iii) PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.

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APPENDIX B: QUESTIONNAIRE

QUESTIONNAIRE

**EXPLORING THE MANAGEMENT MODALITIES FOR PEDIATRIC POPULATION
PRESENTING WITH BINOCULAR VISION ANOMALIES IN PUBLIC HEALTH
CARE FACILITIES IN LIMPOPO PROVINCE, SOUTH AFRICA.**

Instructions: Fill in the questionnaire by marking with (X) in blocks provided or insert value where applicable. Example, ☒ Capricorn district.

SECTION A: Socio-Demographic information		
1.	District	☐ Capricorn district ☐ Mopani district ☐ Vhembe district ☐ Waterberg district ☐ Sekhukhune district
2.	Gender	☐ Male ☐ Female
3.	Race	☐ African ☐ White ☐ Coloured ☐ Indian
4.	Type of employment	☐ Part-time ☐ Full time
5.	Number of years in practice	☐ 5 Year or less ☐ 6-10 Years ☐ 11-15 Years ☐ 16 Years or More
6.	In addition to your Bachelor Optometry, which additional qualifications in optometry or related fields do you hold? Choose more than one where applicable.	☐ None ☐ Diploma ☐ MOptom ☐ MPH ☐ MBA ☐ Other ☐ Master's degree ☐ certificate ☐ Other: Specify _____
SECTION B: Self-reported clinical competencies		
7.	How many children consult in your facility in one month?	_____ children
8.	How many children are presenting with binocular vision anomalies per month?	_____ children
9. On a scale of 1-5, 1 meaning poor and 5 meaning excellent, rate yourself on the following questions: 9.1- 9.5		
9.1	your knowledge about binocular vision anomalies?	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
9.2	your competency in taking binocular vision case history?	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
9.3	Competence in performing paediatric binocular examination?	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
9.4	Will you consider yourself competent in identifying binocular anomalies?	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
9.5	Do you think the undergraduate training on paediatrics and binocular vision adequately equipped you to independently assess and manage paediatrics patients?	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
10.	When was your last CPD activity workshop on binocular vision?	☐ 1 - never attended ☐ 2 - less than 3 months ☐ 3 - three (3) - 6 months ☐ 4 - more than 6 months
11.	If 2- 4 above, using a scale from 1 to 5 grade the usefulness of the skills obtained from CPD workshops	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
12.	Do you think you will benefit from attending an advanced course in binocular vision?	☐ Yes ☐ No If yes , would you prefer to do ☐ Theory sessions only ☐ Practical sessions Only ☐ Theory and Practical sessions

SECTION C: Management modalities of binocular vision

13.	Do you manage paediatric patients presenting with binocular vision anomalies?	☐ Yes ☐ No If No, what are the possible reasons? Choose more than one option if applicable. ☐ I do not have adequate competencies ☐ I do not have necessary equipment ☐ I do not have time to assess binocular vision patients ☐ We are under staffed ☐ We do not have enough space
14.	What type of paediatric binocular vision anomalies do you frequently come across? NB: Choose the appropriate condition/s, where applicable	☐ Decompensated Heterophoria ☐ Convergence insufficiency ☐ Divergence insufficiency ☐ Divergence Excess ☐ Convergence Excess ☐ Accommodative Dysfunction ☐ Strabismus ☐ Amblyopia ☐ Other(specify)_____
15.	Indicate how frequent do you perform cycloplegic refraction on paediatric patients?	☐ Never ☐ less often ☐ most often ☐ all the time
16.	Indicate how you prescribe spectacles for the following anomalies.	Hyperopia: ☐ Cycloplegic results ☐ Normal retinoscope results Strabismus: ☐ Cycloplegic results ☐ Normal retinoscope results Amblyopia: ☐ Cycloplegic results ☐ Normal retinoscope results Accommodative cases: ☐ Cycloplegic results ☐ Normal retinoscope results
17.	What management method/s do you employ on your paediatric patients presenting with Decompensated Heterophoria? Choose more than one option where applicable.	☐ Spectacles ☐ Added lenses ☐ contact lenses ☐ Prisms ☐ vision therapy ☐ Drugs ☐ Referral ☐ other specify_____
18.	What management method/s do you employ on your paediatric patients presenting with Convergence Insufficiency? Choose more than one option where applicable.	☐ Spectacles ☐ Added lenses ☐ contact lenses ☐ Prisms ☐ vision therapy ☐ Drugs ☐ Referral ☐ other specify_____
19.	What management method/s do you employ on your paediatric patients presenting with Divergence Insufficiency? Choose more than one option where applicable	☐ Spectacles ☐ Added lenses ☐ contact lenses ☐ Prisms ☐ vision therapy ☐ Drugs ☐ Referral ☐ other specify_____

20.	What management method/s do you employ on your paediatric patients presenting with Divergence Excess? Choose more than one option where applicable	☐ Spectacles ☐ Added lenses ☐ contact lenses ☐ Prisms ☐ vision therapy ☐ Drugs ☐ Referral ☐ other specify_____
21.	What management method/s do you employ on your paediatric patients presenting with Convergence Excess? Choose more than one option where applicable	☐ Spectacles ☐ Added lenses ☐ contact lenses ☐ Prisms ☐ vision therapy ☐ Drugs ☐ Referral ☐ other specify_____
22.	What management method/s do you employ on your paediatric patients presenting with accommodative dysfunction? Choose more than one option where applicable.	☐ Spectacles ☐ Added lenses ☐ contact lenses ☐ Prisms ☐ vision therapy ☐ Drugs ☐ Referral ☐ other specify_____
23.	What management method/s do you employ on your paediatric patients presenting with strabismus? Choose more than option where applicable.	☐ Spectacles ☐ Added lenses ☐ contact lenses ☐ Prisms ☐ vision therapy ☐ Drugs ☐ Referral ☐ other specify_____
24.	What management method/s do you employ on your paediatric patients presenting with Amblyopia? Choose more than one option where applicable.	☐ Spectacles ☐ Added lenses ☐ contact lenses ☐ Prisms ☐ vision therapy ☐ Drugs ☐ Referral ☐ other specify_____
25.	Choose the appropriate number that correspond to the percentage of the most employed management plan in your facility.	• Spectacles; 1☐0% 2☐ 1-20% 3☐ 21-39% 4☐ 40-59% 5☐60- 80% 6☐>80% • Added lenses; 1☐0% 2☐ 1-20% 3☐ 21-39% 4☐ 40-59% 5☐60- 80% 6☐>80% • Contact lenses 1☐0% 2☐ 1-20% 3☐ 21-39% 4☐ 40-59% 5☐60- 80% 6☐>80% • Prisms; 1☐0% 2☐ 1-20% 3☐ 21-39% 4☐ 40-59% 5☐60- 80% 6☐>80% • Vision therapy 1☐0% 2☐ 1-20% 3☐ 21-39% 4☐ 40-59% 5☐60- 80% 6☐>80% • Drugs -1☐0% 2☐1-20% 3☐21-39% 4☐40-59% 5☐60-80% 6☐>80% • Referral; 1☐0% 2☐ 1-20% 3☐ 21-39% 4☐ 40-59% 5☐60- 80% 6☐>80% • other 1☐0% 2☐ 1-20% 3☐ 21-39% 4☐ 40-59% 5☐60- 80% 6☐>80%
26.	Rate the success of each management plan used in your facility.	• Spectacles: 1☐not successful 2☐rarely successful 3☐very successful • Added lenses:1☐not successful 2☐rarely successful 3☐very successful

		• Contact lenses: 1 ☐ not successful 2 ☐ rarely successful 3 ☐ very successful • Prisms: 1 ☐ not successful 2 ☐ rarely successful 3 ☐ very successful • Vision therapy: 1 ☐ not successful 2 ☐ rarely successful 3 ☐ very successful • Drugs: 1 ☐ not successful 2 ☐ rarely successful 3 ☐ very successful • Referral: 1 ☐ not successful 2 ☐ rarely successful 3 ☐ very successful • Other: 1 ☐ not successful 2 ☐ rarely successful 3 ☐ very successful
27.	What are the factors that influence the usual management given to patients who appear with binocular vision abnormalities? Choose more than one option if applicable.	☐ I do not have adequate competencies ☐ I do not have necessary equipment ☐ I do not have time to assess binocular vision patients ☐ We are under staffed ☐ We do not have enough space

SECTION D: Please indicate the number of equipment available in your facility e.g zero(0) if not available and 1, 2,3,.....as many as available. TO BE FILLED BY CHIEF OPTOMETRIST/MOST EXPERIENCED OPTOMETRIST IN THE FACILITY.

Instruments	Number of instruments	Instruments	Number of instruments
Number of Hospital		Number of practitioners per district	
Snellen chart		Pinhole	
Illiterate E		Occluder	
LogMAR chart		Raf rule	
Near chart		Maddox rod	
Near picture chart		Maddox wing	
Isolated chart		Red/green goggles	
Retinoscope		Prism flippers	
Autorefractor		Accommodative flippers	
Trial lens set		Prism bar	
Trial frame		Mallet units	
PD ruler		Penlight	
Phoropter		Direct Ophthalmoscope	
JCC		Stereoacuity charts	
Duochrome chart		Polaroid lenses	
Thorington Card		Synoptophore	
Neutral Density filters		Autorefractor	
Testing rooms			

APPENDIX C : LIMPOPO PROVINCE DEPARTMENT OF HEALTH APPROVAL



LIMPOPO

PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
HEALTH

Ref : LP_2023-11-007
Enquires : Legodi P
Tel : 015-293 6028/6410
Email : Malesela.Legodi@dhsd.limpopo.gov.za

MARIBENG ER

PERMISSION TO CONDUCT RESEARCH IN DEPARTMENTAL FACILITIES

Your Study Topic as indicated below;

EXPLORING THE MANAGEMENT MODALITIES FOR PEDIATRIC POPULATION PRESENTING WITH BINOCULAR VISION ANOMALIES IN PUBLIC HEALTH CARE FACILITIES IN LIMPOPO PROVINCE, SOUTH AFRICA.

1. Permission to conduct research study as per your research proposal is hereby Granted.
2. Kindly note the following:
 - a. Present this letter of permission to the Office of Clinical Executive Director and /or office of District Executive Manager a week before the study is conducted.
 - b. This permission is **ONLY** for Hospitals in Limpopo province.
 - c. In the course of your study, there should be no action that disrupts the routine services or incur any cost on the Department.
 - d. After completion of study, it is mandatory that the findings should be submitted to the Department to serve as a resource.
 - e. The researcher should be prepared to assist in the interpretation and implementation of the study recommendation where possible.
 - f. The approval is only valid for a 1-year period.
 - g. If the proposal has been amended, a new approval should be sought from the Department of Health
 - h. Kindly note that, the Department can withdraw the approval at any time.

Your cooperation will be highly appreciated.

Head of Department

5/2/2024

Date

pp

Private Bag X8302, Polokwane 0700
Fidel Castro Ruz House, 18 College Street, Polokwane 0700
Tel: 015 283 8000. Fax: 015 283 8211. Website: www.doh.limpopo.gov.za

The heartland of Southern Africa - *development is about people!*

APPENDIX D: CERTIFICATE OF ENGLISH LANGUAGE EDITING

CERTIFICATE OF ENGLISH LANGUAGE EDITING

a Dissertation to be submitted in fulfilment of the requirements for the
Degree Master of Optometry in the Faculty of Health Sciences,
(School of Health Care Sciences) at the University of Limpopo
entitled

Exploring the Management Modalities for Paediatric Population Presenting
with Binocular Vision Anomalies in Public Health Care Facilities in Limpopo
Province, South Africa,

by Maribeng ER, (200200253),

Supervisor: Prof. SD Mathebula,

Co-Supervisor: Mr JR Ramaja, 2025.

has been subjected to an English language edit by

Dr Barbara Basel

(The Reference List and Appendices were not edited. The edits still have to be
checked and implemented by the student.)

D.Litt. University of Pretoria,
MA Potchefstroom University,
BA UNISA

Vice President of the Council of English Academy of Southern Africa

Associate Member Professional Editors' Guild

Past Lecturer in English Literature, Linguistics, Communication and Business

English for 10 years at Pearson Institute for Higher Education (previously Midrand
Graduate Institute), Cape Town Campus.

Academic Editing – PhD, MA, MBA, MCom, MEd, MPM proposals, theses and
journal articles in a wide range of disciplines.

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4 February 2025