THE PREVALENCE OF ANIRIDIA AND ASSOCIATED VISUAL AND OCULAR COMPLICATIONS AMONG LEARNERS IN SCHOOLS FOR THE VISUALLY IMPAIRED IN CENTRAL SOUTH AFRICA

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DECLARATION

"I, Sherazadh Hatia, declare that the Master's degree research dissertation that I herewith submit for the Master's Degree in Optometry at the University of the Free State is my independent work and that I have not previously submitted it for a qualification at another institution of higher education."

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ABSTRACT

Introduction

Aniridia is a rare, sight-threatening ocular disorder characterised by partial or complete absence of the iris. It can affect multiple ocular structures and lead to visual complications. According to our knowledge, there is currently no recent published research on aniridia in the South African population, thus it would be beneficial to investigate the prevalence of aniridia and describe the ocular and visual complications in South Africa.

Therefore, the aim of this research was to determine the prevalence of aniridia among learners in visually impaired schools in central South Africa (Free State and North West) and to describe its visual and ocular complications. In order to achieve the aim, the number of participants that had partial and complete aniridia was determined using an ophthalmoscope. Thereafter, the visual and ocular complications in participants with aniridia were determined.

Methods

A prospective descriptive study was conducted on learners in three visually impaired schools in central South Africa. A total of 117 consenting learners were screened with an ophthalmoscope to determine the presence or absence of aniridia and only the participants identified with aniridia were further examined. The visual acuity of the participants with aniridia was determined using a logMAR visual acuity chart, the refractive error was determined using an autorefractor, the intraocular pressure was measured using an iCare tonometer to determine the risk for glaucoma and the anterior and posterior segment of the eye was examined using a slit lamp, 90D lens and gonioscopy lens to determine the complications associated with aniridia. Results for each participant were recorded and participants who required further management were referred to the local Ophthalmology clinic. Data analysis was performed by the Department of Biostatistics (University of the Free State). Prevalence was calculated by dividing the number of participants with aniridia by the total number participants included in the study.

Results

Four participants were identified as having aniridia and thus the prevalence of aniridia was found to be 3,4% (4 out of 117). The ages of these participants were 10, 13, 17 and 20 years. Visual acuity for each eye individually ranged from no light perception to 0.86 logMAR (6/38). Corneal complications such as pannus, opacification and vascularisation were seen in all of the participants. Some form of cataract was seen in all four participants. The IOP ranged between 11mmHg and 19mmHg in 3 of the participants and was outside of the normal range (7mmHg – 21mmHg) in the 4th participant. Gonioscopy showed 75% of participants with grade 4 angles and the remaining participant with grade 2 angles. Cup-to-disc ratios varied between 0.5 and 0.8 with no glaucomatous changes. Foveal hypoplasia was present in 75% of participants and nystagmus was present in all of the participants. One participant presented with membrane-like structures in the posterior chamber of both eyes, making a view of the fundus unobtainable.

Conclusion

The prevalence found (3,4%) is representative of one school (Christiana School for the Blind in the North West) from the three that were included, not the whole of South Africa. Cataracts and nystagmus were the most prevalent ocular complications found in this group. The foveal hypoplasia and corneal abnormalities in conjunction with some form of cataract and nystagmus are all contributors to the reduced visual acuity observed in these participants. The findings from this study contribute to new information regarding aniridia in regions of central South Africa and enables the comparison of results with research conducted in other parts of the world. This research also provides information about the most recent prevalence of aniridia in this part of South Africa. Further research can be done in other parts of the country to support and add to these results.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

LIST OF ABBREVIATIONS

AAK – Aniridia Associated Keratopathy

AN-1 – Aniridia 1

AN-2 – Aniridia 2

AN-3 – Aniridia 3

BCVA – Best Corrected Visual Acuity

D – Dioptres

ETDRS – Early Treatment Diabetic Retinopathy Study

IOP – Intraocular Pressure

logMAR – Log of Minimum Angle of Resolution

NLP – No Light Perception

OCT – Optical Coherence Tomography

PAX6 – Paired Box Gene 6

PTC – Premature Termination Codon

WAGR – Wilms tumour, Aniridia, Genitourinary abnormalities and Intellectual disability

WHO – World Health Organisation

WT1 – Wilms' Tumour 1

VA – Visual Acuity

CHAPTER 1: INTRODUCTION

1.1 Introduction

In this chapter, aniridia will be defined and the causes of aniridia will be described. The ocular structures involved, signs, symptoms and differential diagnoses will also be mentioned. Aniridia will then be discussed according to the genetics, systemic associations, management and prognosis. The problem statement, aim and objectives of this study will also be discussed in this chapter. Finally, the outline of the dissertation will be described.

1.2 Definition

Aniridia is a rare ocular disorder which is characterised by partial or complete absence of the iris.[1] The word aniridia comes from Greek, meaning “without iris”.[2] The condition was first described by Barrata in 1818.[3]

Inheritance can be either autosomal dominant (familial) pattern or sporadic with a *de novo* autosomal dominant mutation being responsible for an estimated two thirds of all these cases.[3,4] There have been minimal reports of recessively inherited aniridia.[3,5] Aniridia can also be acquired by trauma.[6] No racial or gender preference has been identified.[3,7]

1.3 Embryology of aniridia

The iris starts developing at approximately six weeks of gestation, by which time closure of the embryonic fissure should be complete. An iris coloboma, which is located inferonasally, is formed when the embryonic fissure does not fuse completely anteriorly. The anterior rim of the optic cup starts to develop around the anterior lens surface in the last week of the first trimester. This part of the optic cup is separated from the ectoderm by mesoderm. The iris stroma is formed from the peripheral mesoderm and the pigmented iris epithelium is formed by the optic cup’s edge, which is neuroectoderm. By the twelfth week of gestation, the anterior epithelial layer gives rise to the iris sphincter muscle but the dilator muscle only develops at the sixth month.

During the second half of the first trimester, the vascular system of the iris and the pupillary membrane develop.[8]

1.4 Causes of aniridia

There are three theories regarding the causes of aniridia, namely the ectodermal, mesodermal and excessive remodelling theory.[9-11] According to the ectodermal theory (also known as the neuroectodermal theory), aniridia is due to the incomplete formation of the optic cup during the 12th to 14th week of gestation, resulting in an abnormal framework for structural development. Associated defects in other structures which develop from the neuroectoderm, such as iris absence and foveal hypoplasia, support this theory.[3]

The mesodermal theory describes a lack of proliferation or blockage of mesodermal element proliferation. This theory affects the development of structures during the 2nd month of gestation. Should the mesoderm not properly separate the anterior optic cup rim from the ectoderm, growth of the anterior ectoderm will be obstructed. An alternative method for the mesoderm to cause aniridia would be interference with optic cup rim growth due to a persistent remnant of the blood vessels that are present during the development of the lens. These blood vessels normally atrophy once development is complete however if this does not occur, a hypoplastic iris may result. Although this theory is supported by the presence of optic nerve hypoplasia, the association between neuroectodermal defects and aniridia is not accounted for.[3]

The previous theories described the development of aniridia due to defects in structural development. The excessive remodelling theory does not describe the failure of formation of structures but instead states that portions of iris develop and iris regression or cell death then occurs.[10] This regression is said to be caused by abnormalities in the cells or their chemical compounds.[7] This may be supported by the presence of persistent iris strands in some cases of aniridia.

1.5 Ocular structures involved, signs and symptoms of aniridia

Aniridia affects the cornea, anterior chamber, ciliary body, the lens and the retina, resulting in reduced visual acuity and in some cases glaucoma and cataracts.[4,5,7,10,12-21]

A small iris remnant is usually visible with gonioscopy or histological examination.[3] Histological findings have shown small portions of iris, a hypoplastic ciliary body and either a normal, immature or malformed anterior chamber.[7] Advanced cases of aniridia have shown the absence of dilator and sphincter muscles in only stubs of iris tissue. Older patients demonstrated extensive peripheral anterior synechia between the iris stump and posterior cornea.[3,7]

Fluorescein angiography done on individuals with aniridia has shown an early vascular loop in the residual iris portion and late leakage from the pupillary margin.[7] This may be beneficial for diagnosing aniridia in indistinct cases.[1]

The main complaints of individuals with aniridia are blurred vision, glare and light sensitivity. In most cases, visual acuity is reported to range between 6/30 and 6/60 however, it may even be as reduced as light perception or blindness.[4,5]

The distinctive feature of aniridia is partial or complete iris absence. Other signs include ptosis, meibomian gland dysfunction, aniridia associated keratopathy (AAK), microcornea, glaucoma, ectopia lentis or lens subluxation, cataract, optic nerve and foveal hypoplasia, nystagmus and strabismus.[22]

1.6 Differential diagnosis

Differential diagnoses for aniridia include developmental defects of the anterior segment (such as iris coloboma), albinism and Gillespie syndrome.[4,7,20]

1.7 Genetics

Two genetic loci were identified for aniridia: chromosome arm 2p (AN1) and chromosome 11 (AN2).[7] The paired box gene 6 (*PAX6*) was initially called *AN* and later changed due to the homology to the *Pax6* gene in mice.[23] Aniridia has been classified as AN-1 which is autosomal dominant and accounts for 66% of cases, AN-2 which is sporadic and accounts for 33% of cases and AN-3 which is autosomal recessive and accounts for the remainder of cases (Table 1).[7]

Table 1: Classification of aniridia.[7]

AN-1	Autosomal dominant, 66% of cases with complete penetrance but variable expressivity. No systemic associations.
AN-2	Sporadic, 33% of cases with a 30% risk of Wilms' tumour before 5 years (Miller syndrome).
AN-3	Autosomal recessive, remainder of cases and associated with intellectual disability and cerebellar ataxia (Gillespie syndrome).

The *PAX6* gene on chromosome 11p13 is involved in ocular and central nervous system development during embryogenesis.[4,10,12,16,23] At an early stage, *PAX6* manifests on the surface and neuroectoderms and thereafter in the evolving ocular cells (cornea, lens, ciliary body and retina).[24] The human 14-exon *PAX6* gene consists of a paired domain, a homeodomain and a C-terminal transcriptional activation domain. The *PAX6* gene is responsible for the release of regulators such as *PAX2*, structural proteins and retinal transcription factors during the development of the eye.[12]

As of 4 August 2018, the *Leiden Open Variation Database*[25] has reported a total of 491 different heterozygous mutations that have been identified in the *PAX6* gene. Most of the mutations were found to be in exons 5 and 6; 70,22% were substitutions and 18,47% were deletions. The mutation in the *PAX6* gene results in 50% reduced overall protein activity due to loss of function of an allele.[26] Various other ocular abnormalities, apart from aniridia, are linked to *PAX6* gene mutations such as anophthalmia, some anterior segment defects and isolated foveal hypoplasia.[27] Few patients with aniridia

do not have mutations in the *PAX6* gene however, the percentage has not been specified.[28]

All types of mutations have been identified, including whole gene deletions due to cytogenetic rearrangements involving chromosomal band 11p13, missense, nonsense and frameshift mutations.[4,5,7,10,12-21,23] Initially, it was thought that whole gene deletions were the cause of aniridia, such as the theory of inactivation in a single allele of the *PAX6* gene.[29] Thereafter, it was discovered that mutations resulting from the creation of a premature termination codon (PTC) into the *PAX6* coding region was another cause for aniridia.[12] It has been noted that approximately 92% to 99% of mutations that are responsible for aniridia are due to the creation of a PTC.[4,12,23]

The replacement of one amino acid by another (missense mutation) has been reported to be responsible for 2% of aniridia cases.[4,12,23] Nonsense mutations may result in the production of short proteins with no biological activity, which is similar to 'loss-of-allele' mutations.[23]

1.8 Systemic associations

Two main systemic syndromes have been identified that have the possibility of being associated with aniridia, namely Wilms' tumour, aniridia, genitourinary abnormalities and retardation (intellectual disability) [WAGR] and Gillespie syndrome. When aniridia is associated with WAGR syndrome, the cause is deletion of 11p13 involving both the *PAX6* and Wilms' Tumour 1 (WT1) genes.[10] This association is referred to as Miller syndrome.[7] Miller *et al.,* (1964) was the first to describe the relationship between Wilms' tumour and aniridia in detail.[30] Gillespie syndrome describes the association between aniridia, intellectual disability and cerebellar ataxia and affects approximately 2% of the aniridic population. No link has been found between the *PAX6* gene and Gillespie syndrome and these individuals are not susceptible to developing Wilms' tumour.[7]

Aniridia has also been described as a feature in Bardet-Biedl syndrome, Biemond syndrome, Rieger's syndrome, Ring chromosome 6 syndrome, Smith-Lemli-Opitz syndrome and XXXXY syndrome.[7,10,14,20]

1.9 Management

Genetic counselling is important when investigating the risk of offspring inheriting a genetic mutation and being affected by aniridia.[4,20]

Refractive error is usually managed with spectacles and low vision aids, where necessary, and social support is given in cases of severe visual impairment.[4] Glare and photophobia are managed with the use of coloured contact lenses, tinted lenses or iris implants.[4,7,10,16,20]

1.10 Prognosis

The visual prognosis associated with aniridia is commonly very poor however in a less common, more variant form of aniridia, individuals presenting without a *PAX6* mutation have somewhat unaffected vision.[3,16,23,28]

1.11 Problem statement

Aniridia is a serious sight-threatening condition which can result in a number of ocular complications (corneal opacity, glaucoma, cataract and lens luxation or subluxation) that reduce the quality of life of the affected individuals and may even result in low vision or blindness.[4,5] However, these complications can be managed if individuals are educated regarding the management options available. Currently, only two published studies have been published on the South African population, one of which was focused on a specific family and the other which investigated causes of visual impairment and blindness in schools for the blind in South Africa.[31,32] There is currently no recent published research regarding the prevalence of aniridia and the ocular and visual characteristics in the central South African population. Thus, it would be beneficial to investigate the prevalence in central South Africa and describe the visual and the ocular characteristics of individuals with aniridia.

1.12 Aim

The aim of this research was to determine the prevalence of aniridia, the visual and ocular complications of aniridia among learners in visually impaired schools in central South Africa (Free State and North West).

1.13 Objectives

To achieve the aim, the objectives of this study were:

- To determine how many participants have partial and complete aniridia using an ophthalmoscope.
- To determine the associated visual and ocular complications:
    - To determine the visual acuity of the participants with aniridia using the logMAR chart
    - To determine the approximate refractive error of participants with aniridia using an autorefractor.
    - To assess the intraocular pressure using the iCare tonometer in order to determine the risk for glaucoma.
    - To assess the anterior and posterior segment using a slit lamp, 90D lens and gonio lens to determine the complications associated with aniridia.

1.14 Outline of the dissertation

In this first chapter, an overview of aniridia is given. In Chapter 2, a literature review of relevant literature and previous studies will be presented. In Chapter 3, the methodology utilised is outlined. Chapter 4 will present the results obtained. Chapter 5 will be a discussion of the results obtained in relation to previous studies. Conclusions and recommendations are detailed in Chapter 6.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The following chapter will review the previous studies on aniridia with regard to the prevalence of aniridia and the associated ocular complications. The majority of the studies reviewed were conducted outside of South Africa, mainly in Europe and Asia.

2.2 Incidence

The incidence of aniridia is reported to vary between 1:64 000 and 1:96 000.[3] It has been reported that 1,4% individuals affected by Wilms' tumour are affected by aniridia as well, compared to the incidence in the general population.[7]

2.3 Prevalence of aniridia

Edén *et al.,*[33] investigated the epidemiology of aniridia in Sweden and Norway. The Swedish participants were identified from hospitals and the Norwegian participants from the Norwegian Association for Aniridia. A total of 181 participants were included (123 from Sweden, 58 from Norway). The participants' ages ranged from 6 weeks to 79 years, the mean age in the entire region was 29 years and the median age was 25 years. A prevalence of 0,00139% was found for both countries, specifically 0,0014% in Sweden and 0,0013% in Norway.

A similar study by Edén *et al.,*[34] researched the prevalence of aniridia in teenagers. The recruitment of participants was done in an almost identical manner to the previously mentioned study, with the inclusion of low vision clinics from Sweden. A total of 52 participants with ages between 6 weeks and 19 years were included from Sweden and Norway. This study was conducted in a similar manner as the abovementioned one. The prevalence was only calculated for the Swedish population and was found to be 1:47 000 (0,002%), the mean age was 12 years and the median age was 14 years. Sporadic aniridia was reported in 52% of the entire study population, 47% in Sweden and 63% in Norway independently. Familial inheritance was found in 17 families, 11 of which were from Sweden.

Wawrocka *et al.,*[17] examined a Polish family from which five of the individuals presented with a mild phenotype of aniridia. All members were born from uneventful pregnancies and psychomotor development was normal. The ages of the participants were not specified however it was mentioned that the sample consisted of three generations of the family. The medical history of the participants was unremarkable. The prevalence of aniridia was described to be between 1:64 000 (0,0016%) and 1:96 000 (0,00104%).

O'Sullivan, Gilbert and Foster[32] conducted a cross-sectional survey in schools for the blind in South Africa which examined the causes of severe visual impairment and blindness in learners. The survey consisted of a complete ocular examination performed by the ophthalmologist. Five hundred and sixty-four learners suffered from severe impairment or blindness. The prevalence of aniridia among the learners with visual impairment was 1,77%.

2.4 Ocular complications in aniridia patients

2.4.1 Ptosis and other eyelid abnormalities

Literature reviews have reported that approximately 10% of aniridia patients present with ptosis.[4] Hingorani *et al.,*[12] evaluated the eyes of 43 individuals with *PAX6* mutations to detect ocular abnormalities in the United Kingdom. The ages of the participants ranged from less than 1 year to 57 years, 28 were adults and 26 participants were of female gender. There were 7 reported cases of sporadic occurrence, with the remaining cases being familial. Medical records and notes were evaluated and re-examinations performed for incomplete records. It was reported that 4 participants (9%) had bilateral ptosis, 2 of whom developed ptosis in response to keratopathy. The others had true ptosis without corneal abnormalities and 1 had blepharophimosis in addition to ptosis.

2.4.2 Aniridia Associated Keratopathy

Abnormalities with limbal stem cells are considered as the main cause of corneal complications, resulting in AAK or corneal opacities.[4,5,7,10,12,14,16,20] The incidence of corneal complications, including AAK, is reported to range between 20% and

90%.[10,15,20] The probable cause is a gradual decline in the number of limbal stem cells resulting from microenvironmental changes accompanied by the genetic abnormalities of these cells and their mediators on the sclero-limbal area and iris base.[35]

According to observations reported in the article by Angmo *et al.,*[7] the clinical morphology of the limbus in an individual with aniridia is abnormal and lack the palisades of Vogt, which serve as markers for corneal stem cell differentiation. In addition, the peripheral corneal epithelium contains a significant numbers of goblet cells compared to normal epithelium which is stratified squamous epithelium and does not contain any goblet cells.

In addition to limbal stem cell deficiency, AAK is also characterised by impaired epithelial cell adhesion, conjunctivalisation and corneal vascular pannus. These complications usually occur after childhood, causing the cornea to gradually become thickened and vascularised from the periphery inwards. This makes the cornea prone to recurrent erosions, ulceration, subepithelial fibrosis and vision threatening opacification.[10,36]

Park *et al.,*[13] conducted a retrospective study on 31 Korean participants with aniridia from 1996 to 2007 at Kangnam St. Mary's Hospital to examine the clinical features which presented in association with aniridia. All participants had bilateral aniridia however, 2 participants had phthisis bulbi in 1 eye each, thus 60 eyes were included. Ages of the participants ranged from under 10 years to over 40 years and 15 of the participants were male. There were 22 cases of familial inheritance and 9 sporadic cases. Varying degrees of AAK were reported in 71,6% of eyes.

Netland *et al.,*[15] conducted a descriptive case series on individuals from the United States of America Aniridia Foundation International to determine the prevalence of ocular and systemic complications. The 83 participants were aged between 1 and 67 years and 66% were female. Sporadic inheritance was found in 65% of cases (54) and the remaining were familial. The reported prevalence of AAK was 45%.

Chang *et al.,*[21] retrospectively examined the medical records of 60 Korean individuals (120 eyes) who had aniridia to determine the prevalence and clinical course of ocular and systemic associations. The initial and final findings of ocular examinations between 1990 and 2010 were compared. Ages of the participants upon diagnosis of aniridia ranged from 23 days to 321 months and 55% of participants were female. A family history of aniridia was reported in 32% of participants and 60% reported no family history, the remaining participants reported no information. AAK was found in 68% of participants (82 eyes).

2.4.3 Other corneal abnormalities

Corneal abnormalities can be seen in the form of pannus, epithelial ulcers, arcus juvenilis and microcornea.[7] Thickening of the epithelium is usually accompanied by neovascularisation, initially in the superficial layers at the 6 and 12 o'clock positions. The neovascularisation progresses to involve the entire circumference and thickness of the cornea.[7]

A case report which focused on a family of 6, 4 of which had aniridia, from a traditional South African tribe (Ndebele) was conducted by David, MacBeath and Jenkins[31] to study the association between aniridia and microcornea. The ages of the family members varied between 8 years and 42 years old. The corneas of both eyes were measured in each participant however, the instrument used for measurement was not mentioned. Microcornea was observed in all 4 affected members.

A descriptive case series by Valenzuela and Cline[37] done in Vancouver, Canada describes the findings of 33 participants (66 eyes) with aniridia between 1999 and 2003. These participants were further monitored for at least 2 years after 2003. Thirty percent of participants reported no family history of aniridia (sporadic). The remaining 23 participants (69%) reported a family history of aniridia and 20 of them were examined (two families). The first family consisted of 12 individuals with ages ranging between 6 and 65 years and the second family consisted of 8 individuals. The ages of individuals in the second family was not stated. Slit lamp examination and anterior segment photography revealed corneal pannus in all individuals from the first family. Corneal defects were not specifically reported on for the second family.

De La Paz *et al.,*[35] conducted a retrospective comparative interventional case study on 45 patients diagnosed with congenital aniridia at the Centro de Oftalmología Barraquer in Barcelona. Twenty-one of the participants were male and the participants' ages varied from 3 months to 56 years old. Nineteen were found with familial inheritance and the remainder with sporadic occurrence of aniridia. All cases of aniridia were bilateral however only 88 eyes were included due to 2 participants presenting with phthisis bulbi. De La Paz *et al.,*[35] reported that circumferentially invading fibrovascular tissue, which suggests limbal stem cell insufficiency and conjunctivalisation, was found on the peripheral cornea in 58% of eyes. Twenty-seven percent of eyes were found to have some form of corneal opacity (either resembling pannus-like scarring and / or smooth avascular nodules resembling Salzmann's degeneration), epithelial defect or corneal ulceration. Clinical information from medical records were used to make the diagnoses of corneal abnormalities and anterior segment photographs were taken on follow-up visits to confirm the diagnoses.

Edén *et al.,*[34] described the clinical signs in 52 participants with aniridia. Anterior segment examination with a slit lamp, ophthalmoscope and digital photographs revealed that corneal clouding was present in 64% of eyes (66 of 104).

Hingorani *et al.,*[12] reported that of the total participants, 16 (37%) presented with corneal complications upon slit lamp examination. These corneal abnormalities were expressed as corneal epithelial instability, stromal opacity and vascularisation due to limbal stem cell deficiency and mainly appeared in adults.

Lee *et al.,*[14] performed a retrospective cohort study on 22 eyes (11 participants) in Ireland from 1985 to 2007 to investigate the ocular and visual outcomes in aniridia. At initial examination, 4 patients were under 1 month of age, 4 under 2 years and the remaining participants were above the age of 2 years. Four participants (36%) were reported to have autosomal dominant aniridia and 3 (27%) had sporadic aniridia. Slit lamp examination revealed that 6 participants (54%) had corneal abnormalities, 4 participants (36%) had corneal decompensation and 2 eyes developed recurrent corneal ulcers.

Netland *et al.,*[15] reported that dry eye was present in 53% of participants. Gramer *et al.,*[16] examined 30 individuals with aniridia between the ages of 9 to 69 years at the University Eye Hospital, Germany. The aim of the study was assessing the age at initial examination, age at diagnosis of glaucoma, most recent VA, prevalence of familial aniridia and the prevalence of ocular and systemic complications related to aniridia. Approximately 33% of participants reported the presence of aniridia in their family. In this study. Gramer *et al.,*[16] reported corneal opacities in 26,6% of participants.

Gregory-Evans *et al.,*[38] enrolled a family of 4 with aniridia into a clinical and molecular genetic study. The family members were aged between 5 and 53 years and 3 were female. Anterior segment imaging was done with an OCT. Two of the family members was reported to have corneal abnormalities, one more severe with dense scarring and peripheral neovascularisation. Chang *et al.,*[21] reported microphthalmia with sclerocornea in 1 participant.

Schanilec & Biernacki[5] conducted a retrospective study on 25 individuals (48 eyes) at Vanderbilt Eye Institute in America on participants with aniridia whose ages ranged from 20 months to 71 years. Slit lamp examination revealed corneal abnormalities in 89% of individuals.

Chang *et al.,*[39] conducted research on a Korean family with isolated aniridia. The boy, aged 1 month, and his sister, aged 4 years, both presented with bilateral complete aniridia. Neither of the parents had aniridia however, the father had ocular complications as well. The boy presented with corneal oedema and a hazy optic disc of the right eye and the sister had previously undergone surgical intervention for progressive bilateral corneal ulcers.

The medical records of 64 aniridic patients (128 eyes) with glaucoma were retrospectively reviewed by Jain *et al.,*[40] in India. Forty-two participants were male and the age at diagnosis varied between 5 to 47 years. A family history of aniridia was reported by only 32% of participants. Corneal keratopathy was present in 38% of

aniridics (47 eyes) and microphthalmia was found in 1% (2 eyes). Twenty-six percent of participants had developed phthisis bulbi in at least one eye.

2.4.4 Iris abnormalities

David, MacBeath and Jenkins[31] reported the presence of iris remnants in all 4 participants. A temporal crescent remnant of the iris was visible in 4 eyes of 3 participants.

Valenzuela and Cline[37]reported ectropion uvea in 1 of the participants from those with sporadic aniridia and in 5 from the second family. There was nearly total iris absence in the first family whereas iris defects ranged from atypical colobomas to a hypoplastic iris in the second family. Edén *et al.,*[34]reported a lack of visible residual iris in 86% of eyes.

Optical coherence tomography (OCT) was conducted successfully by Lee *et al.,*[14] on 5 eyes to measure the anterior angle's size and the iris root thickness. A narrow angle was identified in 3 eyes and an angle distorted by fibrous tissue in 2 eyes. All 5 eyes were reported to have iris hypoplasia.

2.4.5 Glaucoma and ocular hypertension

The incidence of glaucoma is estimated to range between 6% and 75%[3,5,7,10,13,15,21] though it is generally accepted as 50%[41]. Glaucoma is more likely to develop between the preteen and teenage years.[7,10,15,20,21] Thus, individuals with aniridia require regular examinations for the detection of glaucoma.[4] Eden *et al.,*[34] has reported that a smaller defect of the iris was less likely to result in the development of glaucoma.

Grant and Walton[41] have developed a theory regarding the pathogenesis of glaucoma in aniridics however, the changes have not been documented. The theory suggests that iris tissue does not cover the trabecular meshwork in the first few years of life but is instead open. In individuals who will develop glaucoma, it is believed that structural changes occur in the first twenty years. Extensions of iris stroma, which look similar to anterior synechiae, extend and adhere anteriorly to the trabecular meshwork's drainage region. Gradually a sheet will be formed from these extensions which covers

the majority of the filtration area, which results in the glaucoma.[41] Routine gonioscopy helps to monitor the angle structures and detect deviations that might lead to closed angle glaucoma. Schlemm's canal has been reported to be absent in many infants and a larger amount of pigment has been found in the angle.[3]

Applanation tonometry was used by David, MacBeath and Jenkins[31] to measure the intraocular pressure (IOP) in all 4 affected members. The IOPs ranged between 6mmHg and 20mmHg however, the times at which the IOPs were taken was not stated. In addition, gonioscopy was performed and 360° closed angle was seen in 1 eye with the remaining 7 being reported as normal.

Valenzuela and Cline[37] found glaucoma to be present in 30% of participants and reported it as the leading cause for vision loss. Seven of these were due to angle closure by the iris stump and 3 were open angle glaucoma, as found with gonioscopy. Blindness as a result of glaucoma was reported in 6% (2) of individuals.

De La Paz *et al.,*[35] reported that 64% of the participants with aniridia presented with glaucoma and although all IOPs were controlled with either medical or surgical intervention, all affected participants had decreased visual field sensitivity. Edén *et al.,*[34] reported glaucoma in 27% of eyes, 8% of these reported to be congenital. IOPs were taken using applanation tonometry however, the values were not stated. Applanation tonometry was performed by Lee *et al.*[14] Glaucoma was reported in 45,5% of the participants. Park *et al.,*[13] reported glaucoma in 51,6% of eyes (31), 38,7% (12) of these were newly diagnosed and 54,8% (17) were already on treatment.

The ages of participants at first diagnosis of glaucoma, maximum recorded IOP measurement and medical history were noted by Gramer *et al.*[16] Age upon diagnosis ranged from 9 to 59 years, with 30% being before the second decade of life. It was reported that 66,7% of their participants had glaucoma. A marked increase in glaucoma incidence was seen from 40 to 49 years, which seemed to indicate an association between increased age and glaucoma incidence in individuals with aniridia. Visual field measurements and gonioscopy were also performed, however no results were discussed.

Gregory-Evans *et al.,*[38] reported that 3 of their participants were already being treated for glaucoma. Tonometry was performed using an iCare or Puff tonometer. Glaucoma was found in 46% of participants by Netland *et al.,*[15] and the age of diagnosis in the participants ranged from birth to 58 years.

Intraocular pressure measurement was taken with the TonoPen by Chang *et al.,*[21] and ocular hypertension was diagnosed if IOP remained above 21mmHg in individuals using IOP-lowering medication. Ocular hypertension was reported in 20% of examinable eyes, from a total of 93 eyes (47 participants). At initial examination, 8 eyes presented with ocular hypertension and by final examination 11 eyes had developed ocular hypertension.

Schanilec & Biernacki[5] reported glaucoma in 64% of their participants, 86% of these being over the age of 18 years. Han *et al.,*[2] examined a Korean family in which four members of three consecutive generations had congenital aniridia. Two of the participants were reported on, both with bilateral aniridia. One of the participants, who was 34 years, was reported to have secondary glaucoma. Chang *et al.,*[39] reported glaucoma in both the brother and sister. The brother presented with an IOP of up to 28mmHg and his sister had undergone surgical intervention for glaucoma 2 years prior.

Jain *et al.,*[40] evaluated the initial IOP of the participants reviewed and it was reported to range between 20mmHg and 69mmHg between both eyes. The final IOP in 98% of the participants, excluding those with no light perception, was less than 18mmHg.

2.4.6 Cataract

Cataracts have been reported to develop in between 50% and 85% of aniridia patients.[3-5,7,10,14,15,20,21,23] Early lens opacities may be noted at birth but will not affect vision until later in childhood and the teenage years.[3] Angmo *et al.,*[7] reported that the types of cataract found are anterior polar, pyramidal, nuclear, lamellar and cortical.

Aniridic fibrosis syndrome, characterised by the growth of a retrocorneal and retrolenticular fibrotic membrane from the root of the iris remnant which causes entrapment or displacement of the intraocular lens, might occur after multiple intraocular operations.[4]

David, MacBeath and Jenkins[31] reported the presence of cataracts in both eyes of one of the family members from their case report. The lens was examined through a slit lamp by Valenzuela and Cline.[37] Cataracts were reported in only the first family (12 individuals) but 3 individuals from the second family had pigmented deposits on the both surfaces of the lens and 1 had an inferior lenticular coloboma in an eye. All of the aniridia participants that were diagnosed by De La Paz *et al.,*[35] had crystalline lens opacities. Cataracts were found in 64 eyes (63%) out of 101 eyes which were examinable by Edén *et al.*[34] Forty-four percent of these cataracts were congenital. Hingorani *et al.,*[12] reported that 11% of participants presented with and 30 participants (69,8%) were later found to have cataracts. Eight (72%) of the participants (14 eyes) presented with cataract, as reported by Lee *et al.*[14] From 40 eyes who had not undergone cataract extraction, cataracts were found in 82,5% of eyes (33) by Park *et al.*[13] Gramer *et al.,*[16] found congenital cataracts in 76,7% of individuals. Two participants from the study by Gregory-Evans *et al.,*[38] had already undergone cataract operations and the remaining 2 were reported to have cataracts. Cataracts were identified in 71% of participants by Netland *et al.*[15] Mild cataracts were identified in all participants by Wawrocka *et al.*[16] Chang *et al.,*[21] reported cataracts in 53% of individuals. Cataracts were found in 56% of the participants by Schanilec & Biernacki.[5] Han *et al.,*[2] reported on the presence of cataracts in one of the participants from their study. Thirty-eight percent of participants reviewed were found to have cataract by Jain *et al.*[40]

2.4.7 Ectopia lentis / lens subluxation

Ectopia lentis is reported as a finding in more than half (56%) of aniridics but mild cases might not be detected and lead to underestimation. Although the lens zonules seem to be normal in structure, they may have an abnormal molecular structure.[3] Ectopia lentis is reported in 56% of cases according to Angmo *et al.*[7] The association between aniridia and subluxated lenses was also studied by David, MacBeath and

Jenkins.[31] Sixty-two percent of eyes examined had subluxated lenses. Edén *et al.,*[34] reported lens luxation in 4% of eyes in aniridia patients. Park *et al.,*[13] reported 12,5% of eyes with lens subluxation and zonular weakness. Bilateral lens luxation was reported in 16,7% of participants by Gramer *et al.*[16] Wawrocka *et al.,*[17] reported lens subluxation in all of the participants. Lens subluxation was reported in one of the participants by Han *et al.*[2]

2.4.8 Retinal abnormalities

The iris epithelium and muscles, as well as the retina develop from the neuroectoderm; this explains the association between aniridia and poor retinal development.[3] Electroretinogram measurements done on aniridia patients have demonstrated retinal abnormalities while electrooculogram results were normal.[3,10,20,44]

Lipoidal deposits have been reported in the peripheral retina of 3 patients, suggesting that there is storage of an abnormal lipid compound in retinal tissue caused by an abnormality in the metabolic pathway of fat.[3,7] Associations between aniridia and tears or detachments of the retina have been described by Lee *et al.*[10] An alternative study by Lee *et al.,*[14] fundus examination revealed that 2 of the participants (18,2%) had retinal detachments. A retinal detachment was identified in only 12,5% of eyes by David, MacBeath and Jenkins.[31] The retina was examinable in 81 eyes by Edén *et al.,*[34] with 20 eyes (24,7%) of aniridia patients presenting with generalised hypopigmentation. Dilated fundoscopy showed that 2 participants presented with an unusual unilateral exudative retinopathy resembling Coats' disease, as reported by Hingorani *et al.*[12] Netland *et al.,*[15] reported retinal disease in 5% of participants and a previously repaired retinal detachment in only 1 participant. Jain *et al.,*[40] reported retinal detachments in 3% of participants.

2.4.8.1 Hypoplasia

There are 2 types of hypoplasia associated with aniridia; optic nerve and foveal or macular. Angmo *et al.,*[7] reports that approximately 75% of affected individuals present with some form of optic nerve hypoplasia however, neither type of hypoplasia is associated with in Gillespie syndrome.

Optic nerve hypoplasia was described in approximately 10% of aniridics and may occur with foveal hypoplasia.[4,44] Poor retinal and macular development is theorised to be the cause of optic nerve hypoplasia. Mild cases of hypoplasia can be detected by comparing the superior or inferior retinal arteriole to the optic disc however, it may be difficult to observe in individuals with corneal or lens abnormalities and nystagmus. True optic nerve aplasia has only been described in 1 case of aniridia.[3]

Optic nerve hypoplasia is estimated to occur in 10% of individuals and in some cases, may be associated with foveal hypoplasia.[10] Edén *et al.,*[34] reported that from 78 eyes of aniridia patients, only 9 (11,5%) had pronounced pathology; optic nerve hypoplasia in 4 eyes (5,1%) and pathological excavation in 5 eyes (6,4%). Hingorani *et al.,*[12] identified ten participants (23%) with optic nerve hypoplasia and Lee *et al.,*[14] found 4 participants (36%) with optic nerve hypoplasia. It has been described that 6,7% of participants had optic nerve hypoplasia in the study by Gramer *et al.*[16] An indirect ophthalmoscope, and where possible a 78D lens, was used to assess the optic nerve.

Foveal hypoplasia (underdevelopment of the foveal area which can be characterised by the absence of a foveal reflex) has also been reported in aniridia patients, with an estimated incidence ranging from 10,7% to 54,5%[20] or 50% to 74%, and might be the cause for photophobia.[13] Nelson *et al.,*[3] has suggested that the retina may become damaged by excessive exposure to light, resulting in secondary foveal hypoplasia postnatally in some cases. The normally avascular zone of the macula has also been reported to show blood vessels in aniridics.[3]

A classification regarding foveal hypoplasia has been proposed and may be used as a useful predictor of visual acuity[20]:

- Grade 1 - lack of expulsion of plexiform layers.
- Grade 2 - grade 1 + absent foveal pit.
- Grade 3 - grade 2 + absent outer segment lengthening.
- Grade 4 - grade 3 + absent outer nuclear layer widening.

Dilated fundus examination revealed foveal hypoplasia in the first family of participants (12) and in 5 individuals from the second family by Valenzuela and Cline.[37] Edén *et*

al.,[34] reported that of 71 eyes in aniridia patients where the macular area was examined, a foveal reflex was only found in 8 eyes (11%). Hingorani *et al.,*[12] reported that 37 (86%) of the participants with aniridia had foveal hypoplasia. Six participants (54%) were reported with foveal hypoplasia by Lee *et al.*[14] Foveal hypoplasia was found in 81,8% of eyes (36) from 44 examinable eyes by Park *et al.*[13] Gramer *et al.,*[16] reported that 3,3% of the participants presented with foveal hypoplasia. Posterior segment imaging was done with an OCT by Gregory-Evans *et al*.[38] Foveal hypoplasia was reported in 50% (2) of the participants, the retina in the remaining participants was not visible. Foveal hypoplasia was reported by Netland *et al.,*[15] in approximately 41% of participants. Wawrocka *et al.,*[17] described foveal hypoplasia in all participants. Each participant's fundus, where visible, was examined by Chang *et al.,*[21] at the initial visit with an indirect ophthalmoscope. Absence of a foveal reflex or depression was diagnosed as foveal hypoplasia. Fundus examination was done on 65% of participants (78 eyes) and from these, 91% (70 eyes) were identified to have foveal hypoplasia. Seven eyes were identified to have normal maculae. Han *et al.,*[2] reported the presence of foveal hypoplasia in the younger of the 2 participants.

2.5 Visual complications

2.5.1 Visual acuity and refractive error

Edén *et al.,*[34] reported that there was a correlation between the degree of aniridia, VA and the risk for development of glaucoma. Optic nerve or foveal (macular) hypoplasia and the development of associated complications are the biggest determining factors of VA, not iris hypoplasia.[3] Other ocular complications identified which resulted in a decrease in VA include cataract, corneal clouding and foveal hypoplasia.[34] High refractive errors and strabismus may result in secondary amblyopia.[7]

The majority (86%) of individuals affected by aniridia have a VA of 6/30 or worse in their better eye.[14] In a study where VA has mostly been preserved despite the presence of aniridia, all of the individuals have been reported to have a VA of 6/12 or better.[28] Asymmetric vision loss may also occur secondary to amblyopia or strabismus.[3] VA between the family members in the case report by David, MacBeath and Jenkins[31] ranged from no light perception to 6/18. The type of chart used was not specified.

Valenzuela and Cline[37] reported a VA of worse than 6/60 in the 12 individuals of the first family. In the second family, 5 individuals were reported to have poor vision which was associated with foveal hypoplasia and 3 had a VA of 6/24 or better. The type of chart used was not mentioned. Cycloplegic refraction was performed and myopia was found to be associated with aniridia across both families, presenting in 64% of participants.

Edén *et al.,*[34] measured VA using Snellen values or logMAR charts converted to Snellen but VA in participants who were unable to do either of these tests was not measured as it would not be comparable to Snellen tests. The visual acuity was reported in decimal form. From 85% of participants, 2 participants (4%) had a VA of 0.9 (6/7) and the remaining 80% had a VA less than 0.3 (6/18). The VA ranged between 0.04 and 0.9 (6/150 and 6/7). Edén *et al.,*[31] reported 6% of eyes having a significant reduction in VA due to corneal clouding and that 42% of cataracts identified affected VA. Forty-two percent of participants had a significant correlation between age and decreased VA.

VA reported by Hingorani *et al.,*[12] ranged from light perception to 6/9, depending on the type of genetic mutation found. Refraction was performed and it was reported that almost half of the participants (48%) had a significant refractive error with 5 participants presenting with moderate to high myopia (-3.00D to > -6.00D), however it was not reported if the refraction was objective or subjective.

Lee *et al.,*[14] reported that 9 out of 11 participants with aniridia (81,8%) achieved a VA of 6/60 or less and required visual aids. Additionally, 2 participants could function without the help of any visual aids. Park *et al.,*[13] reported that the VA could only be measured in 56 eyes and it ranged from worse than 6/60 in 60,7% of eyes with aniridia to better than 6/18 in only 1 patient. Gramer *et al.,*[16] evaluated VA based on the best corrected distance vision. Results showed that 60% of individuals achieved a VA of 6/30 or worse. VA findings ranged from light perception to 6/75, as reported by Gregory-Evans *et al.*[38] VA measurements were between 6/19 and 6/7 in research by Wawrocka *et al.*[17]

Overall, Chang *et al.,*[21] reported VA examined in 41 participants ranged from no light perception (2%) to better than 6/12 (5%), the majority falling between 6/60 and 6/120. VA of 6/6 in 2 eyes with normal maculae and 1 eye with a VA of 6/18 was reported from the 7 eyes with normal maculae. No data was recorded for the 4 remaining eyes. Refractive error was assessed over three years in children of 5 years or younger at the initial examination. Refractive errors found in the 27 children who were followed-up were mostly myopic (67%) and 70% had astigmatism.

Schanilec & Biernacki[5] reported that the VA achieved from 23 individuals with aniridia ranged between no light perception and better than 6/15, with 67% achieving 6/60 or worse. One of the participants from research by Han *et al.,*[2] was reported to have a VA of 6/40 in the right eye and 6/60 in the left eye whilst the other participant was an infant (18 months). The BCVA was taken using a Snellen acuity chart by Jain *et al.,*[40] and converted to logMAR. Only 18 participants were found with VA better than 6/60 at the final examination and 5 participants (7 eyes) had a VA better than 6/18. Using the definition of blindness according to the World Health Organisation (WHO), 57% of participants were classified as blind, 22 eyes with no light perception and 11 eyes with only light perception.

2.5.2 Nystagmus

Nystagmus has also been reported to be present as a result of macular hypoplasia[4,14] with an incidence ranging between 81,8% and 95%[9]. Nelson *et al.,*[3] has reported pendular nystagmus as a common finding in aniridics, secondary to macular hypoplasia.[3]

David, MacBeath and Jenkins[31] reported the presence of nystagmus in all 4 affected individuals. No association was made between the identified nystagmus and macular hypoplasia as the fundi were stated to appear normal.

Valenzuela and Cline[37] reported nystagmus in individuals of the first family (12) and 5 individuals of the second family. The nystagmus found in the second family was associated with their poor visual acuity.

Edén *et al.,*[34] reported marked nystagmus in 27% participants and 73% of participants were affected to a milder extent. In cases where macular hypoplasia was present, associated horizontal pendular nystagmus was detected.

Hingorani *et al.,*[12] found that 41 of their participants (95%) presented with nystagmus. Eight participants (72%) were found to have nystagmus in the study by Lee *et al.*[14] Nystagmus was reported in 53,3% of participants by Gramer *et al.*[16] Nystagmus was found in 75% of participants by Gregory-Evans *et al*.[38] Nystagmus was identified as the most prevalent ocular complication by Netland *et al.,*[15] presenting in 83% of participants. Nystagmus initially presented in 68% of individuals in the study by Chang *et al.,*[21] however the nystagmus had decreased in 5 participants (8%) at the final examination. The prevalence of nystagmus was reported to be 76% by Schanilec & Biernacki.[5] Congenital nystagmus was present in both participants, as reported by Han *et al.*[2] Nystagmus was reported in only 14% of participants by Jain *et al.*[40]

2.5.3 Strabismus

Nelson *et al.,*[3] has reported strabismus as a common finding in aniridics, with esotropia being the most common deviation. A divergent strabismus was identified by Gregory-Evans *et al.,*[38] in one of the participants in the first year of life. Strabismus was reported in 31% of participants by Netland *et al.*[15]

CHAPTER 3: METHODS

3.1 Introduction

In this chapter the methodology used to conduct the research and obtain the results will be described.

3.2 Study design

This study was a descriptive study in which the prevalence of aniridia was determined and the visual and ocular complications of aniridia among learners in visually impaired schools in central South Africa were described.

3.3 Sampling / study participants

Learners with aniridia from three visually impaired schools in central South Africa were included in this study. Convenience sampling was used.

3.3.1 Sample size

There are currently 24 schools for the visually impaired in South Africa. However, there are 3 of these schools in central South Africa namely Bartimea School for the Blind and Deaf (Free State), Thiboloha School for the Blind and Deaf (Free State) and Christiana School for the Blind (North West).

There were 140 visually impaired learners at Bartimea, 70 at Thiboloha and 175 at Christiana. All visually impaired learners in these 3 schools who consented were screened to determine the prevalence of aniridia. All those with aniridia were examined further to determine the visual and ocular characteristics.

3.3.2 Inclusion criteria

All visually impaired individuals in the three schools were screened for aniridia (grade R to grade 12, ages 4 to 24 years).

To describe the visual and ocular complications, only those with aniridia (complete and partial; congenital, genetic or traumatic) were examined.

3.4 Measuring instruments

3.4.1 Visual acuity

A logMAR visual acuity chart was used to determine the visual acuity (ETDRS Chart 1). The logMAR acuity chart was chosen over the Snellen chart due to increased reliability and accuracy.[45,46]

3.4.2 Refraction

An autorefractor (Huvitz Autorefractor / Keratometer MRK-3100) was used as a starting point to determine the approximate refractive error. Autorefraction is chosen due to the ease of the test as well as the quick testing time. This specific model of autorefractor was chosen as it was the only one available at the time.

3.4.3 Intraocular pressure

The iCare handheld tonometer (Type TA01i) was used to measure the IOP to determine the risk for the presence of glaucoma. This tonometer has been found to produce reliable results when compared to the Goldmann Applanation Tonometer.[47] It was chosen as it is a quicker, more comfortable method for measurement, especially on school children.

3.4.4 Slit lamp examination

An ophthalmoscope was used to determine if the participant had aniridia or not. A portable slit lamp biomicroscope (Haag-Streit BM 900) was used to examine the cornea and lens for pathology (AAK, cataract, lens luxation / subluxation), as well as to confirm the diagnosis of aniridia. Gonioscopy was performed with a 3-mirror gonio lens to assess the anterior chamber angle for glaucoma risks. All 4 quadrants were examined during gonioscopy (superior, nasal, inferior and temporal). A 90D lens (VOLK Double Aspheric) was used to examine the fundus, specifically the optic nerve head and fovea. This allowed a binocular, 3D view of the optic nerve and allowed for more accurate cup-to-disc ratio determination.

3.5 Pilot study

A pilot study was conducted on 2 participants with normal eyes to assess if all factors had been considered for the final study and to practise data capturing.

3.6 Procedure

The principal of each chosen school (Appendix A) was contacted to be informed about the study after permission had been obtained from the Free State (Appendix B) and North West (Appendix C) departments of Education and approval from the Health Sciences Research Ethics Committee of the University of the Free State (Appendix D). The information document (Appendix E1-4) and the consent form (Appendix F1-4) for the parent / guardian was emailed to the principal of each school. The principal then sent the learners home with these forms, which needed to be signed and returned. If no consent form had been returned from a parent / guardian, the learner was not included in the study. If consent had been obtained from the parent / guardian of the learner, the assent needed to be signed before the learner was included in the study (Appendix G1-4). Learners older than 18 years were required to give written consent after the researcher had explained the study to them (Appendix H1-4, I1-4). The date and time for each screening was then arranged.

Schools were visited in the following order:

i. Thiboloha School for the Blind and Deaf (Free State)
ii. Christiana School for the Blind (North West)
iii. Bartimea School for the Blind and Deaf (Free State)

3.6.1 Screening to determine the prevalence of aniridia

Learners were screened by grade during non-academic periods, starting with grade R and working towards grade 12. Class lists were given by the principal of each school and each learner who had returned a signed consent form was allocated a number. This number was recorded on the screening and data sheet to maintain confidentiality. A designated room for screening was used. The screening was done by the researcher, who is a qualified optometrist.

The participant was standing and the light (white light, medium illumination, largest aperture size) from an ophthalmoscope was shone into the pupil to confirm the presence of an iris. If an iris was present, aniridia was ruled out and if an iris was absent, there was aniridia. The result of each participant was recorded on the data sheet (Appendix J). Those without aniridia did not participate further in this study.

The screening took 2 minutes per participant. The prevalence was calculated by counting the number of those with aniridia divided by the total number of participants screened.

3.6.2 Ocular and visual examination

A date was arranged on which the researcher revisited the school to perform a complete visual and ocular examination on each participant with aniridia. The examination was conducted in a room at the school. Each participant was examined individually. VA measurement was done first, followed by autorefraction, tonometry and lastly slit lamp assessment.

3.6.2.1 Visual acuity procedure

Visual acuity measurement was conducted with an ETDRS logMAR acuity chart. The participant was seated at the relevant distance from the chart (4m for the ETDRS chart) under normal room illumination. The room illumination was measured using the lux meter and kept constant.

If the participant had optical correction, visual acuity was taken with the correction on. The right eye was tested first and the left eye was covered with an adjustable eye patch. The participant was instructed to keep their head straight and both eyes open while they were asked to identify the letter that was indicated on the acuity chart. The VA of the left eye was tested thereafter and finally with both eyes. If the aniridia was only in one eye, only the affected eye was tested.

The participant was asked to read the entire line, as indicated by the researcher. Letters were not individually pointed to by the researcher, only the line which should be read was indicated. If more than half of the letters on a line were correctly identified,

the participant was encouraged to keep guessing until he / she was unable to correctly identify more than 2 letters on a line. The logMAR value was read off the chart and recorded on the data sheet (Appendix I). The final logMAR value needed to be calculated according to the line score method, as described by Ferris *et al*.[48] The formula used was as follows: value – *n* (0.02). The value was the logMAR value on the last row which was read correctly and *n* was the number of individual letters read correctly after that.

The VA measurements took 5 minutes per participant.

3.6.2.2 Autorefraction

The participant was seated on a chair in front of the auto-refractor that was placed on a table. The participant was asked to place his/her chin on the chin-rest and the forehead on the forehead rest and look at the picture of a hot-air balloon inside the auto-refractor. Five measurements were taken for the right eye and then an average was displayed. The measurements were repeated for the left eye.

The data was recorded on the data sheet (Appendix I). Data was considered within the normal range if there was a spherical equivalent between -0.50 D and +1.00D.[49] If the data was abnormal (not within the range), it served as a criterion for referral to an optometrist for further refraction and management. Autorefraction took approximately 5 minutes per participant.

3.6.2.3 Intraocular pressure

Intraocular pressure was taken between 3:55pm and 4:00pm for all participants. Intraocular pressure was measured while the participant was seated and encouraged to look straight ahead at a target while keeping both their eyes open and relaxed. It was emphasised that there will be no pain, only slight discomfort at the feeling of something touching the eye as the measurements were taken. The right eye was measured first followed by the left eye and a sterile probe was used for each participant.

The iCare took 6 readings per eye and averaged them for a final reading, which was then recorded (Appendix K). The normal range for IOP is considered to range between 7mmHg and 21mmHg.[50] If the IOP was found to be higher than normal (21mmHg), it was re-measured after 15 minutes. If the IOP was still outside the acceptable range, the participant was referred to the local Ophthalmology clinic for further evaluation and management. The IOP measurements took 2 minutes per participant.

3.6.2.4 Slit lamp assessment

Slit lamp was performed on each eye while the participant was seated. If the participant was too short to reach the slit lamp while seated, he / she was asked to stand while being examined. The participant was instructed to keep his / her head straight and chin and forehead against the chin and forehead rest, however if necessary, assistance was requested to keep the participant's head in the correct position. The participant was encouraged to look at a target (a sticker behind the oculars or the examiner's ear).

Starting with the right eye, a diffuse technique (low to medium illumination, 0-degree angle, wide beam, low to medium magnification) was used and the participant was asked to close his / her eyes so that the outside of the eyelids could be examined. The participant was then instructed to open his / her eyes and the lashes, conjunctiva, punctum and pupil were examined. Thereafter, an optic section (high illumination, ± 45-degree angle, slit beam, low to medium magnification) was used to examine the cornea. The optic section was then narrowed to a lesser degree (± 30-degrees) to examine the lens. Fundoscopy was conducted with the use of a 90D lens (moderate illumination, slightly thicker than an optic section, initially low magnification which could be increased to view the optic nerve better).

Gonioscopy was performed after slit lamp on the eye affected by aniridia only. The gonioscopy is graded according to the Shaffer grading system. One drop of local anaesthetic (Tetracaine 0,5%) was instilled in the eye before gonioscopy. Corneal sensitivity was tested after 2 minutes with a cotton bud to ensure the anaesthetic was enough for the participant to not feel pain. If the cornea was not numb after 2 minutes, corneal sensitivity was repeated after an additional minute and if it was still not

numbed, another drop was instilled. The gonioscopy lens was cleaned with a hard contact lens cleaner (Sauflon Delta gas permeable lens cleaner) and rinsed with sterile water before and after each participant. Goniovisc was used as a lubricating gel on the gonioscopy lens before insertion and the participant was instructed not to move backwards during the procedure (assistance to keep younger participants in position was necessary by holding the back of the head gently against the forehead rest so that they could not move back and injure themselves). The top eyelid was held open and as the participant was asked to look up, the lower eyelid was lowered as well. The bottom part of the lens was inserted into the lower sulcus (thumbnail mirror inferiorly placed) and as the patient was asked to look forward, the rest of the lens was placed onto the cornea. The eyelids were released and the 4 angles of the anterior chamber were assessed by rotating the lens (moderate illumination, an optic section beam at 0-degrees, moderate magnification). On completion, the lens was carefully removed by asking the participant to blink. The ocular health assessment took approximately 20 minutes per participant and the results were recorded on the data sheet under the relevant section (Appendix I).

Any pathological ocular findings, such as suspected glaucoma, AAK or cataract were referred to the Ophthalmology clinic at the local hospital (Appendix L). The referral hospitals were National District Hospital in Bloemfontein, Dihlabeng Hospital in Bethlehem and Tshepong Hospital in Klerksdorp. All aniridia participants were advised to see a clinical geneticist for a systemic examination to exclude other complications, genetic syndromes and for genetic counselling.

3.7 Data analysis

The analysis was done by a biostatistician from the Department of Biostatistics (University of the Free State) using SAS Software (version 9.4). Medians and percentiles were calculated for the continuous data. Frequencies (f) and percentages (%) were calculated for the categorical data.

3.8 Strengths, validity and reliability

3.8.1 Strengths

i. The researcher is a qualified optometrist and capable of conducting this research.
ii. This study will present new data regarding aniridia in South Africa.

3.8.2 Validity and reliability

The tests, namely VA, autorefraction, IOP and slit lamp examination, to conduct this research have been scientifically validated. A pilot study was conducted to further ensure validity. The abovementioned tests were performed using standardised methods, as described under the methodology section, to ensure reliability. The researcher was the sole examiner for this study which eliminates observer variation.

3.9 Methodology and measurement errors

i. The inclusion of a participant who did not return a consent and / or minor assent form - the researcher double-checked the identity number / birth date of the participant.
ii. An uncooperative participant - the researcher explained instructions clearly. If the participant was still uncooperative, the results were excluded.
iii. The incorrect interpretation of the results - participants were examined carefully and the results recorded immediately after examination of each participant.

CHAPTER 4: RESULTS

4.1 Introduction

In this chapter, the demographics of the participants, prevalence of aniridia and ocular and visual complications of the participants will be described.

4.2 Demographics of participants

A total of 117 participants were screened from all three schools with 76 female participants (65%). The ages of all the screened participants ranged from 4 years to 21 years and the median age was 13 years. The majority of participants screened were of African descent (*n*=92, 79%) and the remainder were of Caucasian descent. Details regarding the screened participants have been reported on in Table 2 below.

Table 2: Details of all screened participants.

School	Gender	Frequency (%)	Age groups
Christiana	Female: 32 Male: 28	51%	<5: 1 5-10yr: 17 11-15yr: 26 16-20yr: 16 >20: 0
Thiboloha	Female: 28 Male: 0	24%	<5: 0 5-10yr: 12 11-15yr: 9

			16-20yr: 7 >20: 0
Bartimea	Female: 20 Male: 9	25%	<5: 0 5-10yr: 7 11-15yr: 12 16-20yr: 9 >20: 1

4.3 Prevalence of aniridia

Four participants from Christiana School for the Blind in the North West were found to have aniridia, out of a total of 117 participants screened from all 3 schools combined. The prevalence of aniridia found in this specific school was 3,4%. The ages of the participants diagnosed with aniridia ranged between 10 and 20 years. All participants were of African descent, with 50% being male. Their hometowns all varied within the same province, the North West. All aniridia was reported to be of congenital origin (Table 3).

Table 3: Participants with aniridia.

Participant No.	Age	Race	Gender	Cause of aniridia
1	17	African	Male	Congenital
2	10	African	Male	Congenital
3	13	African	Female	Congenital
4	20	African	Female	Congenital

4.4 Ocular complications for the participants with aniridia

4.4.1 IOP measurement and Gonioscopy

The average IOP measured in participants 1-3 varied between 11mmHg and 19mmHg. Participant 4 had an abnormally high IOP in 1 eye, it ranged between 43mmHg and 47mmHg, whilst the other eye had an IOP of approximately 19mmHg (Table 4).

Three of the participants (participants 1, 3 and 4) were found to have grade 4 angles in all quadrants with either iris remnants or iris processes visible however, one eye was not examinable in participant 1 due to the cornea being completely opaque. Participant 2 showed grade 2 angles with the trabecular meshwork being visible (Table 4).

Table 4: IOP and Gonioscopy results. The IOP measurements were an average of 6 readings per eye.

Participant	IOP 1		IOP 2		IOP 3		Gonioscopy (Grades)	
	OD	OS	OD	OS	OD	OS	OD	OS
1	13	11	13	12	12	12	4	Poor view
2	18	11	17	12	18	12	2	2
3	11	14	12	14	11	15	4	4
4	47	19	45	19	43	18	4	4

Table 5: Slit lamp examination results.

Participant	Cornea		AC		Lens		Fundus	
	OD	OS	OD	OS	OD	OS	OD	OS
1	Inferior pannus Vascularised Irregular	Opaque Vascularised Very irregular	Quiet	Quiet	Early cataract	Cataract	0.5 / 0.5 CD Hypoplastic macula	Poor view
2	Inferior Pannus	Superior & inferior Pannus	Small piece of iris superior	Small piece of iris superior	Residual lens Resopt Cataract	Residual lens Resopt	Vitreous opacities 0.8 / 0.8 CD Hypoplastic macula	Vitreous opacities 0.8 / 0.8 CD Hypoplastic macula
3	Superior & inferior Pannus	Superior & inferior Pannus	Quiet	Quiet	Central spot Zonules	Central spot Zonules	0.6 / 0.6 CD Hypoplastic macula	0.8 / 0.8 CD Hypoplastic macula
4	Superior & inferior Pannus	Superior & inferior Pannus	Quiet	Quiet	Subluxated Hardened No zonules inferior	Subluxated Hardened No zonules inferiorly	Thick, white membrane on retina	Thick, pigmented membrane on retina

					Partially resopt	Partially resopt		

4.4.2 Slit lamp – corneal examination

Table 5 on page 46 summarises observations made using the slit lamp techniques. Corneal pannus was present in all 4 participants (7 out of the 8 eyes). Participant 1 had a completely opaque cornea in one eye and both corneas of the same participant were vascularised and irregular.

4.4.3 Slit lamp – iris examination

A small piece of residual iris was noted superiorly in both eyes of participant 2. No visible iris remnants were noted in the other participants.

4.4.4 Slit lamp – lens examination

Early lens changes were noted centrally in 2 eyes (participant 3) and cataracts were seen in 3 eyes (participants 1 and 2). Lens resorption with the presence of a residual lens was noted in 2 participants (participants 2 and 4) and hardened lenses were present in participant 4.

In both eyes of participant 3, lens zonules were visible without subluxation of the lenses whereas the lenses of both eyes of participant 4 were subluxated upwards and lens zonules were absent inferiorly.

4.4.5 Slit lamp – retina

Participant 2 was noted to have vitreous opacities and thick membranes were obstructing the view of the fundus in participant 4. One of these membranes was white in colour and the other was pigmented.

The cup-to-disc ratio was examined in the 3 participants where a view of the fundus was obtainable (5 eyes). The cup-to-disc ratios varied between 0.5 horizontally / 0.5 vertically to 0.8 horizontally / 0.8 vertically. Foveal hypoplasia was noted in 5 eyes (participant 1-3).

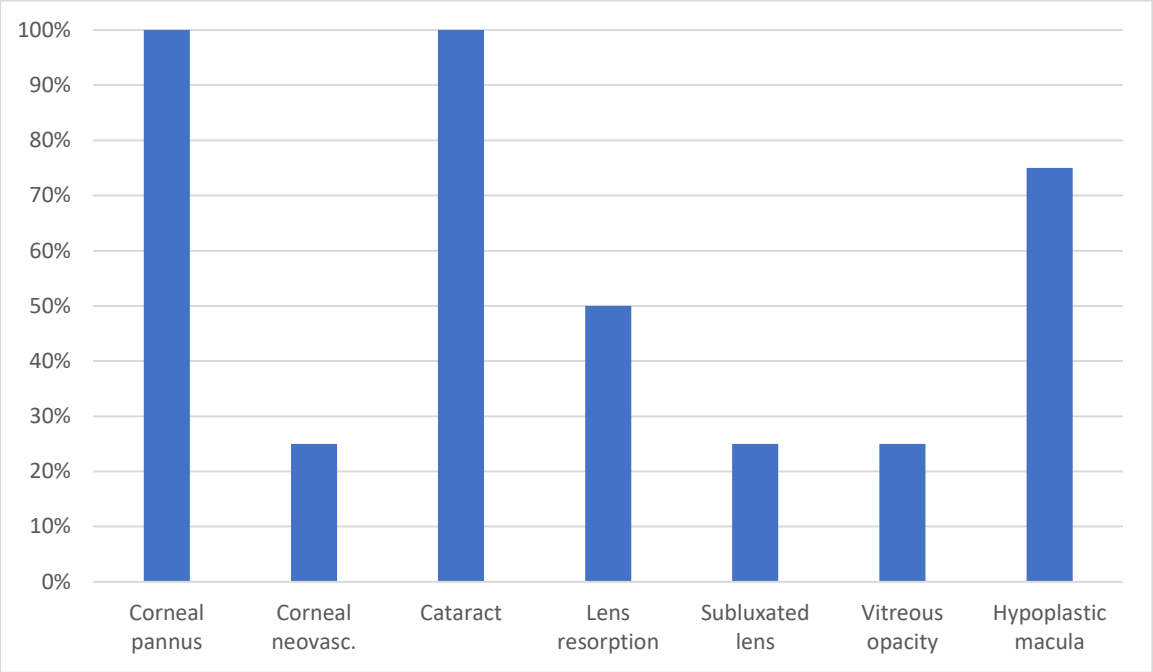

Figure 1: Distribution of ocular complications found in aniridia participants.

4.5 Visual complications

Figure 1 above summarises all the ocular complications noted in the 4 participants. The illumination in the specific area of testing was approximately 200 and was kept constant. The VA values stated are in logMAR.

Visual acuity was measurable in all 4 participants. The VA measured in each eye individually for participants 1-3 ranged from 0.68 to 0.86 and the VA with both eyes ranged from 0.62 to 0.76. Participant 4 was unable to perceive light (Figure 2 and Table 6). Nystagmus was present in participants 2 and 3.

Autorefraction was attempted in all participants however, a reading was only obtainable in 1 eye of participant 1. The reading showed a high myopic prescription of greater than 9.00D.

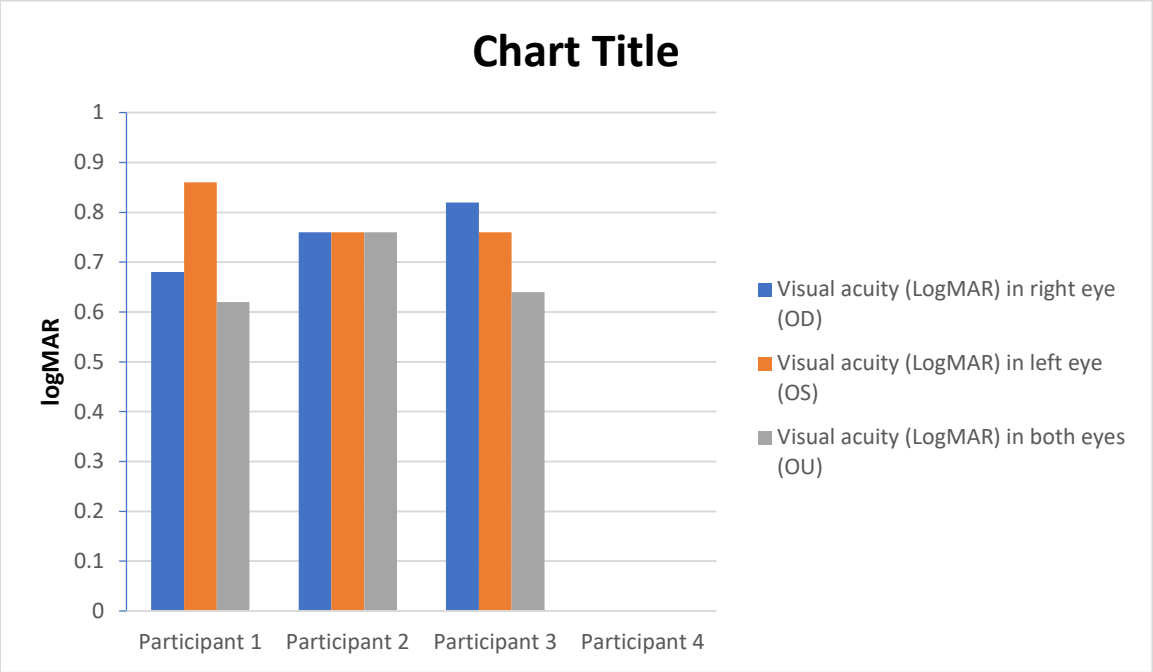

Figure 2: Visual acuity in measurable participants.

Table 6: VA examination results.

Participant	Habitual VA			Autorefraction		Autorefraction VA	
	OD	OS	OU	OD	OS	OD	OS
	logMAR			sphere / cylinder x axis		logMAR	
1	0,68	0,86	0,62	-9.50 / -3.25 x 6	No reading	0,7 -1	-
2	0,76	0,76	0,76	No reading	No reading	-	-
3	0,82	0,76	0,64	No reading	No reading	-	-
4	NLP	NLP	NLP	No reading	No reading	NLP	NLP

CHAPTER 5: DISCUSSION

5.1 Introduction

The main purpose of this quantitative study was to investigate the prevalence of aniridia, the visual and ocular complications of aniridia among learners in visually impaired schools in central South Africa (Free State and North West). The objectives were firstly to determine the number of participants living with partial and complete aniridia using an ophthalmoscope and secondly to determine the associated visual and ocular complications of these participants with aniridia. This specific research was done as there is currently no recent published research regarding the prevalence of aniridia and its ocular and visual characteristics in the central South African population. It was identified that it would be beneficial to investigate the prevalence in central South Africa and describe the visual and the ocular characteristics of individuals with aniridia.

In this chapter a summary of the results will be given as well as a discussion of the results that were found and the limitations of the study.

5.2 Comparison with the previous studies

5.2.1 Demographics and prevalence of aniridia

O'Sullivan, Gilbert and Foster[32]surveyed the prevalence of aniridia on 564 learners under the age of 16 years with blindness from South Africa. The majority of the participants with aniridia were African (8,87%), followed by Caucasian (0,53%). Participants of Indian and Coloured or other descent were equal at 0,18%. In comparison, the ages of the learners in this research were between 10 and 20 years. This study consisted of a majority of participants of African descent (*n*=92, 79%) with the 4 (3,4%) aniridia participants being of African descent and from different settlements in the same province of South Africa. The lack of diversity in the races of the affected participants of this study is most likely due to the areas around the chosen school where they were identified, which are populated mostly by African populations.

O'Sullivan, Gilbert and Foster[32]reported a prevalence of 1,77% (*n*=564) from their survey in 15 schools for the blind in South Africa, in comparison, the prevalence of aniridia among learners from visually impaired schools in central South Africa found in this study is 3,4%. The prevalence found in this study is not representative of the whole of South Africa as only a small population from one region was included in the sample. The two studies by Eden *et al.,*[33,34] reported the prevalence between Norway and Sweden combined to be 0,00139%. Participants in the research by Eden *et al.,*[33,34] were recruited from the local eye hospitals (Sweden) and the Aniridia Association (Norway), thus the population group was more specific. Wawrocka *et al.,*[17] reported a general prevalence between 0,0016% and 0,00104% in their case report. The studies by Eden *et al.,*[33,34] and Wawrocka *et al*.[17] were done on a specific population with aniridia already diagnosed whereas the population included in this study was not from an eye hospital, association for aniridia or specific aniridic population, which led to a lower number of aniridics being identified but a higher prevalence due to the smaller overall population size included.

5.2.2 Ocular complications

5.2.2.1 Cornea complications

Corneal complications were found in 100% (4) of the participants in the form of corneal pannus, which is comparable to the prevalence found by Schanilec & Biernacki[5] (89%) but higher than the prevalence reported by other literature. The incidence of corneal complications in this study is on the higher end of what has been reported on in the literature[10,15,20] (20% - 90%). One of the participants had corneal neovascularisation in both eyes along with the corneal pannus, which is a feature of AAK according to the literature.[10] According to the previously reviewed literature, the highest reported prevalence of corneal complications was from the study by Schanilec & Biernacki[5] (89% of participants), followed by Chang *et al.,*[21] (68% of participants), Valenzuela and Cline[37] (60% of participants), Lee *et al.,*[14] (54% of participants), Gregory-Evans *et al.,*[38] and Chang *et al.,*[39] (50% of participants). Four studies all reported a prevalence of under 50% for corneal complications, namely Netland *et al.,*[15] (45% of participants), Jain *et al.,*[40] (38% of participants), Hingorani *et al.,*[12] (37% of participants) and Gramer *et al.,*[16] (26,6% of participants). Three studies reported on the prevalence of corneal

complications according to the eyes instead of the participants (De La Paz *et al.,*[35] in 27% of eyes, Eden *et al.,*[34] in 64% of eyes and Park *et al.,*[13] in 71,6% of eyes). The complications mentioned in previous studies included corneal pannus, neovascularisation, keratopathy (AAK) and opacification.

5.2.2.2 Iris and anterior chamber complications

Three (75%) of the participants showed grade 4 angles with gonioscopy and iris remnants were visible in 50% (2) of the participants. The IOP ranged between the normal values for 75% (3) of the participants. The fourth participant had a consistently abnormally raised IOP in the right eye. Intraocular pressures were only reported on by three previously reviewed studies[21,31,40] but one of these studies found ocular hypertension to be a complication instead of glaucoma.[21] It can be concluded that 1 of the participants was diagnosed with glaucoma and another was considered to be at risk for glaucoma. The prevalence of glaucoma in this study (25%) was slightly lower than the value reported on by literature (50%)[41] however, it is similar to the studies by Edén *et al.,*[34] (27%) and Valenzuela and Cline[37] (30%). Higher prevalences have been reported in other studies.[5,13-16,35,38-40]

5.2.2.3 Lenticular complications

Some form of cataract was seen in all of the participants (7 out of 8 eyes), which is higher than has been reported by literature (50-85%).[3] Wawrocka *et al.,*[16] De La Paz *et al.,*[35] and Gregory-Evans *et al.,*[38] similarly reported cataracts in 100% of their participants. The majority of the reviewed studies reported a prevalence of 50% or above, more specifically Park *et al.,*[13] (82,5%), Hingorani *et al.,*[12] (79,9%), Gramer *et al.,*[16] (76,7%), Lee *et al.,*[14] (72%), Netland *et al.,*[15] (71%), Eden *et al.,*[34] (63%), Chang *et al.,*[21] (53%), Schanilec & Biernacki.[5] (56%), Valenzuela and Cline[37] (52,17%) and Han *et al.,*[2] (50%). Only two studies were reported to have identified less than 50% of the participants with cataracts (Jain *et al.,*[40] with 38% and David, MacBeath and Jenkins[31] with 25%).

Lens resorption was seen in 50% of the participants in this study. One of the participants (25%) had an upwards subluxated lens with no zonules visible inferiorly.

David, MacBeath and Jenkins.[31] reported lens luxation in 62% of eyes and Eden *et al.,*[34] in 4% of eyes. Wawrocka *et al.,*[17] had 100% with lens luxation, followed by Angmo *et al.,*[7] with 56% and Han *et al.,*[2] with 50%. Gramer *et al.,*[16] and Park *et al.,*[13] reported the lowest prevalence (16,7% and 12,5% respectively).

5.2.2.4 Vitreous complications

One of the participants had a membrane-like structure in the posterior chamber of the eye, blocking the view of the fundus. Vitreous opacities were seen in 1 participant (2 eyes).

5.2.2.5 Retinal complications

Cup-to-disc ratios varied from 0.5 to 0.8 and no signs of glaucomatous changes were noted. Optic nerve hypoplasia has been previously reported on[7] however, it was not seen in the participants included in this study. A hypoplastic macula was seen in 75% of participants where a view of the fundus was obtainable (5 eyes), which is 1% higher than the range reported by literature (10,7% to 74%[13,20]). The study with the most similar prevalence to this study was done by Valenzuela and Cline[37] (73,91%). Some of the studies previously reviewed presented a higher prevalence than the reviewed literature, specifically Wawrocka *et al.,*[17] (100%), Chang *et al.,*[21] (91%) and Hingorani *et al.,*[12] (86%). Park *et al.,*[13] reported the prevalence of macular hypoplasia as 81,8% of examined eyes in their participants. The remaining studies were within the range (Lee *et al.,*[14] with 54%, Han *et al.,*[2] and Gregory-Evans *et al.,*[38] with 50%, Netland *et al.,*[15] with 41% and Edén *et al.,*[34] with 11%) however, one study reported quite a low prevalence (Gramer *et al.,*[16] 3,3%). No optic nerve hypoplasia was noted.

5.2.3 Visual complications

Strabismus was not seen in the participants included in this study. Visual acuity ranged for each eye individually from no light perception (NLP) to 6/38 (0.86 logMAR) in this study, which was in agreement with the literature which reported that 86% of affected individuals have a VA of 6/30 or worse in the better eye. Studies which reported similar VA were David, MacBeath and Jenkins[31] (between NLP and 6/18), Jain *et al.,*[40]

(between NLP and better than 6/18), Schanilec & Biernacki[5] (NLP to better than 6/15) and Chang *et al.,*[21] (NLP to better than 6/12). Valenzuela and Cline[37] did not report on a specific VA range however, it was mentioned that the VA varied from worse than 6/60 to better than 6/24. Edén *et al.,*[34] reported a VA range between 6/150 and 6/7. Hingorani *et al.,*[12] reported VA to range between light perception and 6/9. Lee *et al.,*[14] reported VA of 6/60 or worse. Park *et al.,*[13] reported VA that ranged from worse than 6/60 to better than 6/18. Gramer *et al.,*[16] reported VA of 6/30 or worse. Gregory-Evans *et al.,*[38] found VA to range from light perception to 6/75. Wawrocka *et al.,*[17] reported VA from 6/19 to 6/7. Han *et al.,*[2] reported a VA of 6/40 in the right eye and 6/60 in the left eye in one participant, the other participant was an infant.

An association between aniridia and myopia has been observed by Biswas *et al*.[18] Autorefraction was attempted but only successively performed in 1 eye of one participant so no association can be clearly stated between refractive errors and aniridia in this study. However, the successful autorefraction that was performed on one of the participants also showed high myopia in agreement with Biswas *et al*.[18]

Literature reports the prevalence of nystagmus to range between 81,8% and 95%.[9] Nystagmus was present in 50% of cases (2 participants) in this study. Biswas *et al.,*[18] reported on two cases of familial aniridia and horizontal nystagmus was seen in both (100%). Han *et al.,*,[2] David, MacBeath and Jenkins[31] and Eden *et al.,*[34] reported a higher prevalence of nystagmus (100%). Hingorani *et al.,*[12] reported nystagmus in 95% of participants, followed by Netland *et al.,*[15] in 83%, Schanilec & Biernacki[5] in 76%, Gregory-Evans *et al.,*[38] in 75%, Valenzuela and Cline[37] in 73,91%, Lee *et al.,*[14] in 72% and Chang *et al.,*[21] in 68%. The lowest prevalences were described by Gramer *et al.,*[16] (53,3%) and Jain *et al.,*[40] (14%).

5.3 Limitations of the study

- Acquiring consent from parents / guardians had to sometimes be done over school holidays for children who lived far from the school. The data collection could also not be done during certain periods of time. This limitation sometimes set the

research back by weeks or months. Better planning could have reduced the impact of this limitation.

- Participation and parental consent were the most important limitations. Efforts were made to minimise this limitation by making sure both parents / guardians and participants knew what participation would entail and the lack of risks. Despite this, a large number of parents / guardians did not provide consent. There were a total of 385 learners in all 3 schools included at the time of the study, however only 117 gave consent to participate (30%).

- There are many other schools for the visually impaired in South Africa and including a larger sample size would have increased the accuracy of the findings. However, this was not possible due to limited time and resources.

- This study only included learners from visually impaired schools however, there might be other members in the community with aniridia that were not included. A more extensive study can be done on the community as a whole in each area, should time allow.

- The equipment necessary for this research is large and expensive. A more in-depth examination could have been performed had the facilities for tests such as OCT and fundus photography or the time for in-depth refraction been available.

- Objective retinoscopy would have been preferable over autorefraction due to it being more accurate and being able to still obtain measurements with some corneal abnormalities present. It is more time consuming however, which is why autorefraction was chosen with the limited time frame available.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

In this final chapter the conclusions of this study and recommendations for future research will be discussed.

6.2 Summary and conclusions

The main findings of this study are listed below.

6.2.1 Summary of main results

i. The prevalence of aniridia among learners from three visually impaired schools in central South Africa was found to be 3,4%. Should this study be done among a hospital population, the sample size may have been higher and the prevalence higher as well.
ii. VAs ranged between NLP and 0.86 logMAR which showed poor vision in affected individuals, not a vision-sparing form of aniridia.
iii. Corneal complications and nystagmus were present in 100% of participants which showed that these would be the most prevalent complications associated with aniridia.
iv. There is very likely an association between the foveal hypoplasia and nystagmus found in the participants.
v. No glaucomatous changes were noted at the optic nerve however, IOPs in 1 participant were abnormally high which does not make glaucoma a very prevalent complication in this study group.

6.3 Recommendations for future research

- Performing a complete low vision assessment, including objective retinoscopy, to accurately describe the associated refractive error.
- Including a larger sample size from more visually impaired schools to more accurately represent the population of aniridics in South Africa.

- Using patients from optometry and ophthalmology clinics to include the population outside of visually impaired schools.
- Genetic testing to investigate the gene associated with aniridia in the South African population.

REFERENCES

1. Churchill, A., Booth, A. 1996. Genetics of aniridia and anterior segment dysgenesis. *British Journal of Ophthalmology*, 80(7):669–673. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC505566/.

2. Han, K.H., Lee, H.J., Ha, I., Kang, H.G., Cheong, H.I. 2016. A nonsense PAX6 mutation in a family with congenital aniridia. *Korean Journal of Pediatrics*, 59(1): S1–4. DOI: 10.3345/kjp.2016.59.11.S1.

3. Nelson, L.B., Spaeth, G.L., Nowinski, T.S., Margo, C.E., Jackson, L. 1984. Aniridia. A review. *Survery of Ophthalmology*, 28(6):621-642. DOI: 10.1016/0039-6257(84)90184-X.

4. Hingorani, M., Hanson I., van Heyningen, V. 2012. Glaucoma associated with aniridia. *European Journal of Human Genetics*, 20(10):1011–1017. DOI: 10.1038/ejhg.2012.100.

5. Schanilec, P., Biernacki, R. 2014. Aniridia: A comparative overview. *American Orthoptic Journal*, 64(1):98–105.

6. Samant, M., Chauhan, B.K., Lathrop, K.L., Nischal, K.K. 2016. Congenital aniridia: etiology, manifestations and management. Expert *Review of Ophthalmology*, 11(2), 135–144. DOI:10.1586/17469899.2016.1152182.

7. Angmo, D., Jha, B., Panda, A. 2014. Congenital aniridia. *Journal of Current Glaucoma Practice*, 5(2):1–13.

8. Barber, A. 1955. Embryology of the human eye. *American Medical Association Archives of Ophthalmology*, 53(6):924. DOI: 10.1001/archopht.1955.00930010932030.

9. Beauchamp, G.R., Meisler, D.M. 1986. An alternative hypothesis for iris maldevelopment (aniridia). *Journal of Pediatric Ophthalmology and Strabismus*, 23(6):281-283.

10. Lee, H., Khan, R., O'keefe, M. 2008. Aniridia: Current pathology and management. *Acta Ophthalmologica*, 86(7):708–715. DOI: 10.1111/j.1755-3768.2008.01427.x.

11. Parekh, M., Poli, B., Ferrari, S., Teofili, C., Springer, D.P. Aniridia: Recent Developments in Scientific and Clinical Research. Switzerland: Springer; 2015. P.107. DOI: 10.1007/978-3-319-19779-1.

12. Hingorani, M., Williamson, K.A., Moore, A.T., van Heyningen, V. 2009. Detailed ophthalmologic evaluation of 43 individuals with PAX6 mutations. *Investigative Ophthalmology and Visual Science*, 50(6):2581–2590. DOI: 10.1167/iovs.08-2827.

13. Park, S.H., Park, Y.G., Lee, M.Y., Kim, M.S. 2010. Clinical features of Korean patients with congenital aniridia. *Korean Journal of Ophthalmology*, 24(5):291–6. DOI: 10.3341/kjo.2010.24.5.291.

14. Lee, H., Meyers, K., Lanigan, B., O'Keefe, M. 2010. Complications and visual prognosis in children with aniridia. *Journal of Pediatric Ophthalmology and Strabismus*, 47(4):205-10–2. DOI: 10.3928/01913913-20090818-07.

15. Netland, P.A., Scott, M.L., Boyle IV, J.W., Lauderdale, J.D. 2011. Ocular and systemic findings in a survey of aniridia subjects. *Journal of American Association for Pediatric Ophthalmology and Strabismus*, 15(6):562–566. DOI: 10.1016/j.jaapos.2011.07.009.

16. Gramer, E., Reiter, C., Gramer, G. 2011. Glaucoma and frequency of ocular and general diseases in 30 patients with Aniridia: A clinical study. *European Journal of Ophthalmology*, 22(1):104–110. DOI: 10.5301/EJO.2011.8318.

17. Wawrocka, A., Budny, B., Debicki, S., Jamsheer, A., Sowinska, A., Krawczynski, M.R. 2012. 3′ Deletion in a family with aniridia. *Ophthalmic Genetics*, 33(1):44–48. DOI: 10.3109/13816810.2011.615076.

18. Biswas, J., Chakrabarti, A., Das, D. 2014. Rare association of familial aniridia, microcornea with myopia and aphakia. *Middle East African Journal of Ophthalmology*, 21(3):268–70. DOI: 10.4103/0974-9233.134693.

19. Zhuang, J., Chen, X., Tan, Z., Zhu, Y., Zhao, K., Yang, J. 2014. A novel de novo duplication mutation of PAX6 in a Chinese family with aniridia and other ocular abnormalities. *Scientific Reports*, 4:6–10. DOI: 10.1038/srep04836.

20. Calvão-pires, P. 2014. Congenital Aniridia: Clinic, genetics, therapeutics, and prognosis. *International Scholarly Research Notices*, DOI: 10.1155/2014/305350.

21. Chang, J.W., Kim, J.H., Kim, S.-J., Yu, Y.S. 2014. Congenital aniridia: long-term clinical course, visual outcome, and prognostic factors. *Korean Journal of Ophthalmology*, 28(6):479–85. DOI: 10.3341/kjo.2014.28.6.479.

22. Tripathy, K., Salini, B. Aniridia. Florida: StatPearls; 2019.

23. Kokotas, H., Petersen, M.B. 2010. Clinical and molecular aspects of aniridia. *Clinical Genetics*, 77(5):409–420. DOI: 10.1111/j.1399-0004.2010.01372.x.

24. Nishina, S., Kohsaka, S., Yamaguchi, Y., Handa, H., Kawakami, A., Fujisawa, H., Azuma, N. 1999. PAX6 expression in the developing human eye. *British Journal of Ophthalmology*, 83(6):723-727.

25. Leiden Open Variation Database [Internet]. MRC Human Genetics Unit [updated 4 August 2018; cited 19 September 2018]. Available from: http://lsdb.hgu.mrc.ac.uk/home.php?select_db=PAX6.

26. Prosser, J., van Heyningen, V. 1998. PAX6 mutations reviewed. *Human Mutation*, 11(2):93–108. DOI: 10.1002/(SICI)1098-1004(1998)11:2<93::AID-HUMU1>3.0.CO;2-M.

27. Lauderdale, J.D., Wilensky, J.S., Oliver, E.R., Walton, D.S., Glaser, T. 2000. 3' deletions cause aniridia by preventing PAX6 gene expression. *Proceedings of the National Academy of Sciences of the United States of America*, 97(25):13755–13759. DOI: 10.1073/pnas.240398797.

28. Traboulsi, E.I., Ellison, J., Sears, J., Maumenee, I.H., Avallone, J., Mohney, B.G. 2008. Aniridia with preserved visual function: a report of four cases with no mutations in PAX6. *American Journal of Ophthalmology*, 145(4):760-764. DOI: 10.1016/j.ajo.2007.12.012.

29. Ton, C.C., Hirvonen, H., Miwa, H., Weil, M.M., Monaghan, P., Jordan, T., van Heyningen, V., Hastie, N.D., Meijers-Heijboer, H., Drechsler, M., et al., 1991. Positional cloning and characterization of a paired box- and homeobox-containing gene from the aniridia region. *Cell*, 67(6):1059-1074.

30. Miller, R.W., Fraumeni, J.F., Manning, M.D. 1964. Associations of Wilms tumour with aniridia, hemi hypertrophy and other congenital malformations. *The New England Journal of Medicine,* 270:922-927. DOI: 10.1056/NEJM196404302701802.

31. David, R., MacBeath, L., Jenkins, T. 1978. Aniridia associated with microcornea and subluxated lenses. *British Journal of Ophthalmology,* 62:118-121.

32. O'Sullivan, J., Gilbert, C., Foster, A. 1997. The causes of childhood blindness in South Africa. *The South African Medical Journal,* 87(12):1691-1695.

33. Edén, U., Iggman, I., Riise, R., Tornqvist, K. 2008. Epidemiology of aniridia in Sweden and Norway. *Acta Ophthalmologica*, 86(7):727-729. DOI: 10.1111/j.1755-3768.2008.01309.x.

34. Edén, U., Beijar, C., Riise, R., Tornqvist, K. 2008. Aniridia among children and teenagers in Sweden and Norway. *Acta Ophthalmologica*, 87(2):242. DOI: 10.1111/j.1755-3768.2008.01310.x.

35. De La Paz, M.F., Alvarez De Toledo, J., Barraquer, R.I., Barraquer, J. 2008. Long-term visual prognosis of corneal and ocular surface surgery in patients with congenital aniridia. *Acta Ophthalmologica*, 86(7):735–740. DOI: 10.1111/j.1755-3768.2008.01293.x.

36. Vicente, A., B, Lindström, M., Stenevi, U., Pedrosa Domellöf, F. 2018. Aniridia-related keratopathy: Structural changes in naïve and transplanted corneal buttons. *Public Library of Science One*, 13(6):e0198822. DOI: 10.1371/journal.pone.0198822.

37. Valenzuela, A., Cline, R.A. 2004. Ocular and nonocular findings in patients with aniridia. *Canadian Journal of Ophthalmology*, 39(6):632-638.

38. Gregory-Evans, K., Cheong-Leen, R., George, S.M., Xie, J., Moosajee, M., Colapinto, P., Gregory-Evans, C.Y. 2011. Non-invasive anterior segment and posterior segment optical coherence tomography and phenotypic characterization of aniridia. *Canadian Journal of Ophthalmology,* 46(4):337-344. DOI: 10.1016/j.jcjo.2011.06.011.

39. Chang, M.S., Han, J.C., Lee, J., Kwun, Y., Huh, R., Ki, C., Kee, C., Cho, S.Y., Jin, D. 2015. A novel splice site mutation in the *PAX6* gene in a Korean family with isolated aniridia. *Annals of Clinical and Laboratory Science*, 45(1):90-93.

40. Jain, A., Gupta, S., James, M.K., Dutta, P., Gupta, V. 2015. Aniridic Glaucoma: Long-term Visual Outcomes and Phenotypic Associations. *Journal of Glaucoma*, 24(7):539-542. DOI: 10.1097/IJG.0000000000000019.

41. Grant, W.M., Walton, D.S. 1974. Progressive changes in the angle in congenital aniridia, with development of glaucoma. *Transactions of the American Ophthalmological Society,* 72:207-228.

42. Brandt, J.D., Casuso, L.A., Budenz, D.L. 2004. Markedly increased central corneal thickness: an unrecognized finding in congenital aniridia. *American Journal of Ophthalmology,* 137(2):348-350. DOI: 10.1016/j.ajo.2003.09.038.

43. Whitson, J.T., Liang, C., Godfrey, D.G., Petroll, W.M., Cavanagh, H.D., Patel, D., Fellman, R.L., Starita, R.J. 2005. Central corneal thickness in patients with congenital aniridia. *Eye & Contact Lens,* 31(5):221-224. DOI: 10.1097/01.ICL.0000152487.16012.40.

44. McCulley, T.J., Mayer, K., Dahr, S.S., Simpson, J., Holland, E.J. 2005. Aniridia and optic nerve hypoplasia. *Eye,* 19(7):762-764. DOI: 10.1038/sj.eye.6701642.

45. Kaiser, P.K. 2009. Prospective evaluation of visual acuity assessment: a comparison of Snellen versus ETDRS charts in clinical practice. *Transactions of the American Ophthalmological Society*. 107:311–324. Available: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2814576&tool=pmcentrez&rendertype=abstract.

46. Lovie-Kitchin, J.E. 2015. Is it time to confine Snellen charts to the annals of history? *Ophthalmic & Physiological Optics,* 35(6):631–636. DOI: 10.1111/opo.12252.

47. Feng, G., Xu, L., Qing, Z., Yingzhe, P. 2017. Comparison of the iCare rebound tonometer and the Goldmann applanation tonometer. *Experimental and Therapeutic Medicine*, 13(5):1912–1916. DOI: 10.3892/etm.2017.4164.

48. Ferris, F.L., Kassoff, A., Bresnick, G.H., Bailey, I. 1982. New visual acuity charts for clinical research. *American Journal of Ophthalmology*, 94(1):91-96.

49. Goh, P.P., Abqariyah Y., Pokhare, G.P., Ellwein, L.B. 2005. Refractive error and visual impairment in schoolage children in Gombak District, Malaysia. *Ophthalmology*, 112(4):678–685.

50. Martin, X.D. 1992. Normal intraocular pressure in man. *Ophthalmologica*, 205(2):57-63. DOI: 10.1159/000310313.

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Appendix A1: Letter to the principal of Bartimea

Principal S. Mothibi (Bartimea School for the Blind and Deaf),

Application for permission to conduct research on the prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa.

I am conducting a research for a Master degree in Optometry. I would like to request permission to conduct a study. The title of my study is: The prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa. This study is important as there is currently no published research regarding this in the South African population.

The aim of this study is to determine the prevalence of aniridia and also to describe the associated visual and ocular complications of those individuals with aniridia. To achieve this aim, I will be requesting permission to conduct eye examinations on each participant from selected schools [Bartimea School for the Blind and Deaf (Free State), Thiboloha School for the Blind and Deaf (Free State) and Christiana School for the Blind (North West)] in central South Africa.

The study will involve the screening of all the learners to determine the prevalence of aniridia. Aniridia is the absence of the iris (the coloured structure of the eye). The screening will be done by shining a light into the eye and observing if the coloured part of the eye (iris) is present or absent. The screening will take 2 minutes per learner. The learners with aniridia will be examined further to determine the visual and ocular problems. The examination will comprise of visual acuity (the ability to see at distance), general eye observations, autorefraction (determining the approximate refractive error), tonometry (measuring of the pressure in the eye) and slit lamp (assessment of ocular structures, namely cornea, lens and anterior chamber and the retina). The learners with ocular and visual problems will be referred for a full eye examination at either the optometrist or ophthalmologist, depending on the problem. The examination will take approximately 1 hour.

No treatment or experiments will be conducted on the participants and there will be no risks involved for participation. A translator will accompany the researcher to help with children who do not understand English or Afrikaans.

I hereby request to conduct research in the school. I also request a room where screening and examination will take place and class lists for each grade. The research protocol has been approved by the Health Sciences Research Ethics Committee of the University of the Free State and permission has been granted by the Provincial Department of Education.

Find attached the research protocol, information documents, consent forms and assent forms. Please send the information document and consent form for the parent / guardian home with the learners so that they can obtain consent from their parent / guardian.

Yours sincerely,

Sherazadh Hatia (Student number: 2012039927)
083 793 9301

Appendix A2: Letter to the principal of Christiana

Principal M. Best (Christiana School for the Blind),

Application for permission to conduct research on the prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa.

I am conducting a research for a Master degree in Optometry. I would like to request permission to conduct a study. The title of my study is: The prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa. This study is important as there is currently no published research regarding this in the South African population.

The aim of this study is to determine the prevalence of aniridia and also to describe the associated visual and ocular complications of those individuals with aniridia. To achieve this aim, I will be requesting permission to conduct eye examinations on each participant from selected schools [Bartimea School for the Blind and Deaf (Free State), Thiboloha School for the Blind and Deaf (Free State) and Christiana School for the Blind (North West)] in central South Africa.

The study will involve the screening of all the learners to determine the prevalence of aniridia. Aniridia is the absence of the iris (the coloured structure of the eye). The screening will be done by shining a light into the eye and observing if the coloured part of the eye (iris) is present or absent. The screening will take 2 minutes per learner. The learners with aniridia will be examined further to determine the visual and ocular problems. The examination will comprise of visual acuity (the ability to see at distance), general eye observations, autorefraction (determining the approximate refractive error), tonometry (measuring of the pressure in the eye) and slit lamp (assessment of ocular structures, namely cornea, lens and anterior chamber and the retina). The learners with ocular and visual problems will be referred for a full eye examination at either the optometrist or ophthalmologist, depending on the problem. The examination will take approximately 1 hour.

No treatment or experiments will be conducted on the participants and there will be no risks involved for participation. A translator will accompany the researcher to help with children who do not understand English or Afrikaans.

I hereby request to conduct research in the school. I also request a room where screening and examination will take place and class lists for each grade. The research protocol has been approved by the Health Sciences Research Ethics Committee of the University of the Free State and permission has been granted by the Provincial Department of Education.

Find attached the research protocol, information documents, consent forms and assent forms. Please send the information document and consent form for the parent / guardian home with the learners so that they can obtain consent from their parent / guardian.

Yours sincerely,

Sherazadh Hatia (Student number: 2012039927)
083 793 9301

Appendix A3: Letter to the principal of Thiboloha

Principal L. S. Khooa (Thiboloha School for the Blind and Deaf),

Application for permission to conduct research on the prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa.

I am conducting a research for a Master degree in Optometry. I would like to request permission to conduct a study. The title of my study is: The prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa. This study is important as there is currently no published research regarding this in the South African population.

The aim of this study is to determine the prevalence of aniridia and also to describe the associated visual and ocular complications of those individuals with aniridia. To achieve this aim, I will be requesting permission to conduct eye examinations on each participant from selected schools [Bartimea School for the Blind and Deaf (Free State), Thiboloha School for the Blind and Deaf (Free State) and Christiana School for the Blind (North West)] in central South Africa.

The study will involve the screening of all the learners to determine the prevalence of aniridia. Aniridia is the absence of the iris (the coloured structure of the eye). The screening will be done by shining a light into the eye and observing if the coloured part of the eye (iris) is present or absent. The screening will take 2 minutes per learner. The learners with aniridia will be examined further to determine the visual and ocular problems. The examination will comprise of visual acuity (the ability to see at distance), general eye observations, autorefraction (determining the approximate refractive error), tonometry (measuring of the pressure in the eye) and slit lamp (assessment of ocular structures, namely cornea, lens and anterior chamber and the retina). The learners with ocular and visual problems will be referred for a full eye examination at either the optometrist or ophthalmologist, depending on the problem. The examination will take approximately 1 hour.

No treatment or experiments will be conducted on the participants and there will be no risks involved for participation. A translator will accompany the researcher to help with children who do not understand English or Afrikaans.

I hereby request to conduct research in the school. I also request a room where screening and examination will take place and class lists for each grade. The research protocol has been approved by the Health Sciences Research Ethics Committee of the University of the Free State and permission has been granted by the Provincial Department of Education.

Find attached the research protocol, information documents, consent forms and assent forms. Please send the information document and consent form for the parent / guardian home with the learners so that they can obtain consent from their parent / guardian.

Yours sincerely,

Sherazadh Hatia (Student number: 2012039927)
083 793 9301

Appendix B: Letter to the Free State Department of Education

Mrs B Kitching
The Director
Strategic Planning, Policy and Research
Free State Department of Education
Private Bag x20565
Bloemfontein 9300

Application for permission to conduct research on the prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa.

I am conducting a research for a Master degree in Optometry. I would like to request permission to conduct a study. The title of my study is: The prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa. This study is important as there is currently no published research regarding this in the South African population.

The aim of this study is to determine the prevalence of aniridia and also to describe the associated visual and ocular complications of those individuals with aniridia. To achieve this aim, I will be requesting permission to conduct eye examinations on each participant from selected schools [Bartimea School for the Blind and Deaf (Free State), Thiboloha School for the Blind and Deaf (Free State) and Christiana School for the Blind (North West)] in central South Africa.

The study will involve the screening of all the learners to determine the prevalence of aniridia. Aniridia is the absence of the iris (the coloured structure of the eye). The screening will be done by shining a light into the eye and observing if the coloured part of the eye (iris) is present or absent. The learners with aniridia will be examined further to determine the visual and ocular problems. The examination will comprise of visual acuity (the ability to see at distance), general eye observations, autorefraction (determining the approximate refractive error), tonometry (measuring of the pressure

in the eye) and slit lamp (assessment of ocular structures, namely cornea, lens and anterior chamber and the retina). The learners with ocular and visual problems will be referred for a full eye examination at either the optometrist or ophthalmologist, depending on the problem.

No treatment or experiments will be conducted on the participants and there will be no risks involved for participation. A translator will accompany the researcher to help with children who do not understand English or Afrikaans.

I hereby request to conduct research at the schools in the Free State. The research protocol has been approved by the Health Sciences Research Ethics Committee of the University of the Free State.

Yours sincerely,

Sherazadh Hatia 083 793 9301 (Student number: 2012039927)

Appendix C: Letter to the North West Department of Education

Dr I. S. Molale,

Application for permission to conduct research on the prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa.

I am conducting a research for a Master degree in Optometry. I would like to request permission to conduct a study. The title of my study is: The prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa. This study is important as there is currently no published research regarding this in the South African population.

The aim of this study is to determine the prevalence of aniridia and also to describe the associated visual and ocular complications of those individuals with aniridia. To achieve this aim, I will be requesting permission to conduct eye examinations on each participant from selected schools [Bartimea School for the Blind and Deaf (Free State), Thiboloha School for the Blind and Deaf (Free State) and Christiana School for the Blind (North West)] in central South Africa.

The study will involve the screening of all the learners to determine the prevalence of aniridia. Aniridia is the absence of the iris (the coloured structure of the eye). The screening will be done by shining a light into the eye and observing if the coloured part of the eye (iris) is present or absent. The learners with aniridia will be examined further to determine the visual and ocular problems. The examination will comprise of visual acuity (the ability to see at distance), general eye observations, autorefraction (determining the approximate refractive error), tonometry (measuring of the pressure in the eye) and slit lamp (assessment of ocular structures, namely cornea, lens and anterior chamber and the retina). The learners with ocular and visual problems will be referred for a full eye examination at either the optometrist or ophthalmologist, depending on the problem.

No treatment or experiments will be conducted on the participants and there will be no risks involved for participation. A translator will accompany the researcher to help with children who do not understand English or Afrikaans.

I hereby request to conduct research at the school in the North West. The research protocol has been approved by the Health Sciences Research Ethics Committee of the University of the Free State.

Yours sincerely,

Sherazadh Hatia (Student number: 2012039927)
083 793 9301

Appendix D: Letter to the Ethics Committee

July 18, 2018

Chair
Health Sciences Research Ethics Administration
Faculty of Health Sciences
P. O Box 339
Bloemfontein 9300

Dear Dr Le Grange

RE: STUDENT S HATIA: 2012039927

Student S Hatia (student number 2012039927) is registered as Master of Optometry (M.Optom) student at the University of the Free State. She is currently tasked to conduct a research project for the fulfillment of the M. Optometry degree requirements under the supervision of Prof TA Rasengane and co-supervision of Dr BD Henderson

For more information, do not hesitate to contact me.

Sincerely,

Tuwani A. Rasengane, PhD
Head of Department : Optometry

Appendix E1: Information document - Parent / Guardian (English)

Title of study: The prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa

Researcher: Sherazadh Hatia

Your child is being invited to take part in a research study. Before your child participates in this study, it is important that you understand why the research is being done and what it will involve. Please take the time to read the following information carefully.

The purpose of this study is to determine the prevalence of aniridia and the associated visual and ocular complications among learners seen in schools for the visually impaired in central South Africa.

The study will involve the screening of all the learners at this school to determine the prevalence of aniridia. Aniridia is the absence of the iris (the coloured structure of the eye). The screening will be done by shining a light into the eye and observing if the coloured part of the eye (iris) is present or absent. The screening will take 2 minutes. If your child has aniridia, he / she will be examined further to determine the visual and ocular problems. The examination will comprise of visual acuity (the ability to see at distance), general eye observations, autorefraction (determining the approximate refractive error), tonometry (measuring of the pressure in the eye) and slit lamp (assessment of ocular structures, namely cornea, lens and anterior chamber and the retina). If your child is found to have ocular and visual problems, he/she will be referred for a full eye examination at either the optometrist or ophthalmologist, depending on the problem. This examination will take approximately 1 hour.

There will be no cost or remuneration for participation in this study. No treatment or experiments will be conducted on your child and there are no risks involved for participating in this study, however there might be slight discomfort with the instillation

of anaesthetic eye drops (to make the eye numb) and some of the tests conducted. Your child's information will be kept confidential however, an identity number / date of birth will be required to ensure there is no duplication of data. Your child may withdraw from this study at any time without penalty and there is no penalty for declining to participate.

Whom do I call or contact if I have questions or problems

Should you have any questions about the research or any related matters, please contact the researcher at 083 793 9301 during regular business hours. For questions about the rights of the research participant or for reporting of complaints, contact the Secretariat of the Health Sciences Research Ethics Committee, University of the Free State at 051 401 7795.

Appendix E2: Information document - Parent / Guardian (Afrikaans)

Titel van studie: Die prevalensie van aniridia en geassosieerde visuele en okulêre komplikasies onder leerders in skole vir die visuele benadeeldes in sentrale-Suid-Afrika

Navorser: Sherazadh Hatia

U kind word genooi om aan 'n navorsingsstudie deel te neem. Voor u kind aan hierdie studie deelneem, is dit belangrik dat u verstaan waarom die navorsing gedoen word en wat dit sal behels. Neem asseblief die tyd om die volgende inligting noukeurig te lees. Vra asseblief vir die navorser as daar iets is wat nie duidelik is nie of as u meer inligting benodig.

Die doel van hierdie studie is om die prevalensie van aniridia (dit is die afwesigheid van die gekleurde deel van die oog) en die geassosieerde visuele en oog komplikasies onder leerders met aniridia.

Die studie sal die sifting van al die leerders in hierdie skool behels om die prevalensie van aniridia te bepaal. Aniridia is die afwesigheid van die iris (die gekleurde deel van die oog). Die sifting word gedoen deur 'n lig in u oog te skuin om te kyk of die gekleurde deel van die oog (iris) teenwoordig of afwesig is. Hierdie sifting sal 2 minute vat. As u kind aniridia het, sal hy / sy verder ondersoek word om visuele en oog- probleme te bepaal. Die ondersoek sal uit visuele skerpheid (die vermoë om ‘n afstand te sien), algemene oog waarnemings, outorefraksie (bepaling van die naastenbye refraksiefout), tonometrie (meting van die druk in die oog) en slit-lamp (assessering van okulêre strukture, naamlik die kornea, lens en voorkamer en die retina) bestaan. Die leerders met oog- en visuele probleme sal vir 'n volledige oogondersoek by die oogkundige of oogarts verwys word, afhangend aan die probleem. Die oog ondersoek sal ongeveer 1 uur neem.

Daar sal geen koste of vergoeding wees vir deelname aan hierdie studie nie. Daar is geen risiko's betrokke met deelname aan hierdie studie nie, maar daar kan dalk 'n

bietjie ongemak wees met die toediening van verdowingsoogdruppels (druppels om die oog te verdoof) en sommige van die toetse wat uitgevoer word op diegene met aniridia. U kind se inligting sal vertroulik gehou word, maar 'n identiteitsnommer / geboortedatum sal nodig wees om te verseker dat daar geen duplisering van data is nie. U kind mag op enige tyd, sonder enige boete uit hierdie studie onttrek en daar is geen straf as u weier om om deel te neem.

Wie bel of kontak ek as ek vrae of probleme het

Indien u enige vrae oor die navorsing of enige verwante sake het, kontak die navorser by 083 793 9301 gedurende gewone werksure. Vir vrae oor die regte van die navorsingsdeelnemer of vir die rapportering van klagtes, kontak die Sekretariaat van die Gesondheidswetenskappe Navorsings Etiekkomitee, Universiteit van die Vrystaat by 051 401 7795.

Appendix E3: Information document - Parent / Guardian (Sesotho)

Sehlooho sa phuputso: Hoata ha mathata a pono ho batho banang le aniridia, bohareng ba Afrika Borwa

Mofuputsi: Sherazadh Hatia

Ngwana wa hao o memelwa ho nka karolo phuputsong. Pele ga ngwana wa hao a ka etsa qeto ya ho nka karolo phuputsong ena, ho bohlokwa ho utlwisisa hore na ke hobaneng ha e etsuwa, le hore na e kenyelleditse eng. Nka nako ya hao ho bala tlhahiso-leseding eo o e fuweng. O ka kopa mofuputsi hore a o hlalosetse se sa hlakang tlhahiso-leseding.

Morero wa phuputso ena ke ho batlisisa hore na mathata a hlahiswang ke aniridia a atile ha kae mahlong a batho ba tswang bohareng ba Afrika Borwa.

Thuto e tla kenyeletsa ho hlahlojoa ha baithuti bohle ba sekolo sena ho fumana hore na ho ata ha aniridia ho kae. Aniridia ke ho ba siyo ha iris (sebopeho sa mebala ea leihlo). Ho hlahloba ho tla etsoa ka ho khantša leseli le ka leihlo ebe o sheba hore na karolo e mebala ea leihlo (iris) e teng kapa ha eyo. Ha ngwana wa hao a na le aniridia o tla hlahlojoa ka ho eketsehileng ho fumana hore na mathata a ho bona le a mang a mahlo ke afe. Tlhahlobo e tla ba le mahlo a bonono (bokhoni ba ho bonela hole), hlahlobo ya leihlo e akaretsang, di-autorefraction (ho lekanya phoso ea refractive e batlang e le joalo), tonometry (ho lekanya khatello mahlong) le ho khanya lebone (tlhahlobo ea mehaho ea mahlo, e leng cornea, lens le kamore e ka pele le retina). Ha ngwana wa hao a fumanwa a na le bothata ba ho bala le ho bona o tla romelloa tlhahlobong ea mahlo ka botlalo ho mohlahlobo wa mahlo kapa ngaka ya mahlo, ho itšetlehile ka bothata. Tlhahlobo ena ya leihlo e tla nka hora.

Ho ke ke ha eba le litšenyehelo kapa meputso ea ho kopanela thutong ena. Ha hona kotsi etla o hlahela ha o nka karolo phuputsong ena, empa o tla utlwa makukuno a seng makae ha o tshelwa marothodi a mahlo (a mang a marothodi a ka etsa mahlo a shwe bohatsu) hape tse ding tsa diteko di etswetswa batho ba kopanang le tshwaetso

ena ya aniridia. Dintlha tsa ngwana wa hao tsa teko di tla behwa sephiring, empa ho tla hlokahala bukana ya boitsebiso ho qoba phethaphetho ya dintlha. Ngwana wa hao a ka nka qeto ya ho se nke karolo phuphutsong ena nako efe kapa efe kantle ho kotlo.

Nka letsetsa mang kapa ka ikopanya le mang ha ke na le dipotso

Ha o ka ba le potso mabapi le phuphutso kapa maemo a amanang le tsona, o ka letsetsa mofuputsi nomorong ena: 0837939301 dihoreng tsa mosebetsi tse tlwaelehileng. Dipotso mabapi le ditokelo tsa monka-karolo phuphutsong, kapa tletlebo efe kapa efe, o ka ikopanya le Secretariat ya Ethics Committee ya Faculty of Health Sciences, University of the Free State, mohaleng ona, 051 401 7795.

Appendix E4: Information document - Parent / Guardian (Setswana)

Setlhogo sa go ithuta: Go nna teng ga aniridia le tse di amanang pono le mathata a matlho a baithuti mo dikolong tsa baithuti ba ba nang le bokowa jwa matlho mo bogareng jwa Aforikaborwa

Mmatlisisi: Sherazadh Hatia

Ngwana wa gago o laletswa go tsaya karolo mo dithuto-patlisisong. Pele o ka tsaya tshwetso ya gore a nne le seabe mo patlisisong eno, go botlhokwa gore o tlhaloganye goreng dipatlisiso di dirilwe le goreng dile teng. Tsweetswee, tsaya nako go buisa tshedimosetso e e latelang ka kelotlhoko. Tsweetswee kopa mmatlisisi fa go na le sengwe se se sa tlhamalala kgotsa fa o tlhoka tshedimosetso e nngwe.

Boikaelelo jwa patlisiso eno ke go tlhomamisa gore go nna teng ga aniridia (Seno ke go sa nne teng ga karolo ya leitlho e re fang mmala wa matlho) le tse di amanang le pono le mathata a baithuti ba ba nang le aniridia mo bogareng jwa Aforikaborwa.

Patlisiso eno e tla akaretsa go tlhatlhoba baithuti botlhe kwa sekolong se go tlhomamisa go nna teng ga Aniridia. Aniridia ke go sa nne teng ga karolo ya leitlho e e refang mmala wa leitlho. Ditlhatlobo tseno di tla dirwa ka go botsha lebone mo leitlhong la ngwana go bona fa karolo e no ya leitlho e leng, (iris) gore a e teng kgotsa e se teng. Go bontsha lebone mo leitlhong go tla tsaya metsotso e le 2. Fa a na le aniridia, o tla tlhatlhobiwa go bona ga a na le mathata mangwe a pono mo matlhong a gagwe. Ditlhatlhobo di tla akaretsa go sheba acuity ya matlho a gagwe (e leng bokgoni jwa matlho a gagwe go bona kwa kgakala), ka kakaretso, re lebelele matlho a gagwe, go tla dirwa le autorefraction (go lebella ga a na le bothata jwa go bona jwa matlho gore a o tlhoka diborele), tonometry (go bona fa poresha ka fa matlhong e itekanetse) le slit lamp (go tlhatlhoba ka mechine go bona fa bogare jwa matlho bo itekanetse , go dira jalo go bonwa lense ya matlho le dikarolo tsotlhe go fitlha ka fa morago ga matlho). Fa ngwana wa gago a fitlhelwa a na le mathata a pono, o tla romelwa go etsa ditlhatlhobo tse di felletseng tsa matlho kwa ngakeng ya matlho kgotsa sepeshalisiting sa matlho go tswa gore bothata jwa matlho a gagwe ke eng.

Tlhatlhobo e no ya matlho e ka nnang ura e le 1.

Ga go kitla go nna le tuelo e e tla tlhokagalang kgotsa e etla fiwang motsayakarolo go nna le seabe mo patlisisong eno. Ga go na dikotsi tse di tla nna teng fa o nna le seabe mo patlisisong eno, le fa go ntse jalo go ka nna le go tsipanyana fa re tshela setlhare sa go bolaya botlhoko / bogatsu mo tedikong tse di tla dirwang go botlhe baba nang le aniridia. Bana ba gago tshedimosetso ya gago e tla bolokwa e le khupamarama le fa go ntse jalo, nomoro ya boitshupo / Letlha la botsalo e tlhokega go netefatsa gore ga go na poeletso ya tshedimosetso. Ngwana wa gago o ka kopa go tswa mo patlisisong eno ka nako nngwe le nngwe kwa ntle ga kotlo, ga go na go nna le kotlhao ya go sa tseye karolo mo dipatlisisong tseno.

Ke mang yo o bitsa kgotsa ikgolaganye le fa ke na le dipotso kgotsa mathata

Fa o na le dipotso ka ga patlisiso kgotsa mabaka a a jalo, tsweetswee ikgolaganye le Mmatlisisi kwa 083 793 9301 ka nako ya diura tsa tiro ya ka gale. Ya dipotso ka ga ditshwanelo tsa gago jaaka motsayakarolo kgotsa patlisiso ya pego ya dingongorego, ikgolaganye le Mokwaledi wa Disaense tsa Pholo Komiti ya maitsholo, Yunibesiti ya Foreisetata kwa 051 401 7795.

Appendix F1: Consent Form - Parent / Guardian (English)

The prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa

By signing this consent form, I (parent / guardian) confirm that I have read and understood the information. I understand that my child's participation is voluntary and that he/she is free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form.

_____	_____	_____
Name of Parent / Guardian	Signature	Date
_____	_____	_____
Researcher's name	Signature	Date

Questions for parent / guardian:

- Did the child get injured in their eyes or were they born with an eye problem?

_____

- Where is the child from? (hometown)

_____

Appendix F2: Consent Form - Parent / Guardian (Afrikaans)

Die prevalensie van aniridia en geassosieerde visuele en okulêre komplikasies onder leerders in skole vir die visuele benadeeldes in sentrale-Suid-Afrika

Deur hierdie toestemmingsvorm te teken, bevestig ek (ouer / voog) dat ek die inligting gelees en verstaan het en die geleentheid gehad het om vrae te vra. Ek verstaan dat my kind se deelname vrywillig is en dat ek enige tyd kan onttrek sonder om 'n rede te gee en sonder koste. Ek verstaan dat ek 'n afskrif van hierdie toestemmingsvorm sal ontvang. Ek aanvaar vrywillig om aan hierdie studie deel te neem.

_____	_____	_____
Naam van Ouer / Voog	Handtekening	Datum

_____	_____	_____
Navorser se naam	Handtekening	Datum

<u>Vrae vir ouer / voog:</u>

- Is die kind in die oë beseer of is hulle met ‘n oog problem gebore?

_____

- Van waaraf kom die kind? (dorp)

_____

Appendix F3: Consent Form - Parent / Guardian (Sesotho)

Sehlooho sa phuputso: Hoata ha mathata a pono ho batho banang le aniridia, bohareng ba Afrika Borwa

Ho saena pampithana ena, ke bopaki hore ke (motswadi/mohlokomedi) badile le ho utlwisisa tlhahiso-lesedi. Ho nka karolo ha ngwana wa ka phuputsong ena ke ka boithaupi mme o dumelletswe ho ikhula nako efe kapa efe ka ntle le ho lebaka kapa ho fuwa kotlo.

_____	_____	_____
Lebitso la Motswadi/Mohlokomedi	Tshaeno	Letsatsi

_____	_____	_____
Lebitso la Mofuputsi	Tshaeno	Letsatsi

<u>Lipotso bakeng sa motsoali / mohlokomeli:</u>

- Ngwana o fumane kotsi mahlong kapa o hlahile a le jwalo na?

_____

- Ngwana o hlahetse kae? (sebaka)

_____

Appendix F4: Consent Form - Parent / Guardian (Setswana)

Go nna teng ga aniridia le tse di amanang pono le mathata a matlho a baithuti mo dikolong tsa baithuti ba ba nang le bokowa jwa matlho mo bogareng jwa Aforikaborwa

Ka go saena foromo eno ya tumelelo, ke (motsadi / motlhokomedi) go tlhomamisa gore ke buisitse le go tlhaloganya tshedimosetso le go nna le tšhono ya go botsa dipotso. Ke tlhaloganya gore botsayakarolo jwa ngwana wame ke boithaopo le gore o gololesega go ka ntsha nako nngwe le nngwe, kwa ntle ga go naya lebaka le le kwa ntle ga tuelo. Ke tlhaloganya gore ke tla newa khopi ya foromo eno ya tumelelo.

_____	_____	_____
Leina la Motsadi / Motlhokomedi	Tshaeno	Letlha

_____	_____	_____
Leina la mmatlisisi ' di	Tshaeno	Letlha

<u>Dipotso tsa motsadi kgotsa motlhokomedi wa ngwana wa semolao:</u>

- A ngwana o kile a gobala ka fa matlhong kgotsa o belegwe ka bothata jo jwa matlho?

_____

- Kwa ga bo ngwana ke kae? (Legae)

_____

Appendix G1: Assent Form (English)

The prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa

You are being asked to take part in a research study being done by the University of the Free State. In this study, I am interested to know more about your eyes. I have requested that your parent or caregiver gives permission for you to participate, but now I want to see if you agree to take part.

If you decide to take part in this study, I will have a look at your eyes to see if you have the coloured part of the eye or not. If you do not have the coloured part of the eye (aniridia), I will have another look into your eye, and this will take about 1 hour to do. All the information I collect will be kept secret and you don't have to share any of the answers with anybody else. I will not use your name so everything will remain private.

By signing this you are showing that you understand what is going to be happening and have asked any questions you may have about the research. You can also ask questions later if you cannot think of them now. Signing this form does not mean that you have to finish the study - you can pull out from the study at any time without explaining why.

The information about this study has been explained to me.

I understand that I will be asked to name shapes and light will be shone into my eyes in order to check if my vision is good or not.

I have not been forced into agreeing to participate in this study.

I have been told that I will not be harmed, and I may withdraw or say that I do not want to participate anymore from the study at any point in time.

I confirm that I have agreed to participate freely and on my own.

☺ ☹

_____ _____

Child's name Date

I have accurately read or witnessed the accurate reading of the assent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given assent freely.

_____

Name of researcher

_____ _____

Signature of researcher Date

Appendix G2: Assent Form (Afrikaans)

Die prevalensie van aniridia en geassosieerde visuele en okulêre komplikasies onder leerders in skole vir die visuele benadeeldes in sentrale-Suid-Afrika

Jy word gevra om deel te neem aan 'n navorsingsstudie wat deur die Universiteit van die Vrystaat gedoen word. In hierdie studie wil ek meer oor jou oë weet. Ek het gevra dat jou ouer of versorger toestemming gee vir jou om deel te neem, maar nou wil ek sien of jy instem om deel te neem.

As jy besluit om aan hierdie studie deel te neem, sal ek na jou oë kyk om te kyk of die gekleurde deel teenwoordig is of nie. As die gekleurde deel van jou oog afwesig is (aniridia), sal ek weer in jou oog kyk en dit sal ongeveer 1 uur vat. Al die inligting wat ek versamel, sal geheim wees en jy hoef nie enige van die antwoorde met iemand anders te deel nie. Ek sal nie jou naam gebruik nie, so alles bly privaat.

Deur dit te teken, wys jy dat jy verstaan wat gaan gebeur en vrae oor die navorsing wat jy gehad het, gevra het. Jy kan ook later vrae vra as jy nie nou aan hulle kan dink nie. Die teken van hierdie vorm beteken nie dat jy die studie moet voltooi nie - jy kan enige tyd, sonder verduideliking uit die studie onttrek.

Die inligting oor hierdie studie is aan my verduidelik.

Ek verstaan dat ek gevra sal word om vorms te noem en lig sal in my oë geskyn word om te kyk of my visie goed is of nie.

Ek is nie gedwing om in te stem om aan hierdie studie deel te neem nie.

Ek is meegedeel dat ek nie benadeel sal word nie, en ek kan onttrek of sê dat ek nie meer aan die studie wil deelneem nie.

Ek bevestig dat ek ingestem het om vrylik en op my eie deel te neem.

☺ ☹

_____ _____

Kind se handtekening Datum

Ek het akkuraat gelees of die akkurate lees van die instemmingsvorm gesien aan die potensiële deelnemer, en die individu het die geleentheid gehad om vrae te vra. Ek bevestig dat die individu vrywillig instemming gegee het.

_____

Naam van navorser

_____ _____

Handtekening van navorser Datum

Appendix G3: Assent Form (Sesotho)

Sehlooho sa phuputso: Hoata ha mathata a pono ho batho banang le aniridia, bohareng ba Afrika Borwa

O memelwa ho nka karolo phuputsong e etswuwang ke Universithi ya Freistata. phuputsong ena, ke labalabela ho tseba haholwanyana ka mahlo a hao. Ke kopile tumello hotswa ho motswadi/mohlokomedi wa hao hore o nke karolo phuputsong, empa nka thabela ho tseba haeba o ka rata ho nka karolo na.

Ha o ka dumela ho nka karolo phuputsong ena, ke tlo hlahloba mahlo a hao ho bona hore ona bothata ba tshwaetso ya bohareng ba Afrika Borwa kappa tjhehe,ke tla tlameha ho sheba mahlong a hao, empa hona ho tla nka hora e le nngwe. Dintlha tsohle tseo ke di fumaneng ka mahlo a hao di tla behwa sephiring. Lebitso la hao le keke la sebediswa phuputsong ena.

Ho saena pampitshana ena, ke bopaki ba hore ke badile le ho utlwisisa tlhahiso-lesedi e ke e fuweng, le ho fuwa monyetla wa ho botsa diposto. Ho nka karolo phuputsong ena ke ka boithaopi mme ke dumelletswe ho ikhula nako efe kapa efe ka ntle ho lebaka kapa ho fuwa kotlo. Ke dumela hore ke tlo fuwa pampitshana ena, mme ke dumela ho nka karolo phuputsong ena.

Dintlha tsa thuto ena ya diphuputso ke di hlalositswe hantle ka nepo.

Ke utlwisisa hore mahlo a ka a tla lekolwa.

Ke tiisa hore ha ke a qobellwa ho fana ka tumello, ha ho na dikotsi mme ke dumeletswe ho ka sebe dithutong tsena ha eba kena le mabaka.

Ke tiisa hore tumello e fanwe ka bolokolohi le ka boithaopo.

☺ ☹

_____ _____

Tshaeno ya monka karolo Letsatsi

Ke badile ka nepo kapa ka ba le bopaki ho balwa ka nepo ha foromo ya kananelo ho motho eo e ka bang monkakarolo, mme motho eo o bile le monyetla wa ho botsa dipotso. Ke tiisa hore motho eo o fane ka tumello ka bolokolohi.

_____

Lebitso la mofuputsi

_____ _____

Tshaeno ya mofuputsi Letsatsi

Appendix G4: Assent Form (Setswana)

Go nna teng ga aniridia le tse di amanang pono le mathata a matlho a baithuti mo dikolong tsa baithuti ba ba nang le bokowa jwa matlho mo bogareng jwa Aforikaborwa

O kopiwa go tsaya karolo mo patlisisong ya patlisiso e e dirwang ke Yunibesiti ya Foreisetata. Mo patlisisong eno, ke na le kgatlhego ya go itse go le gontsi ka matlho a gago. Ke kopile gore motsadi kgotsa motlhokomedi wa gago go go naya tetla ya go nna le seabe, mme jaanong ke batla go bona gore a o dumela go tsaya karolo.

Fa o dumela go nna le seabe mo patlisisong eno, ke tla lebelela matlho a gago, go bona a o na le karalo e ya mmala ka fo leitlhong la gago kgotsa nnya. Mme ga o sena karolo e ya mmala mo leitlhong (aniridia), ke tla dira diteko tse dingwe tse di tla tsayang ura e le nngwe. Tshedimosetso yotlhe e e tla tsholwa sephiri mme ga o na o kupiwa go abelana dikarabo tsa gago le mongwe. Ga ke ye go dirisa leina la gago gope, mme sengwe le sengwe se re tlang go se dira se tla nna poraefete.

Ka go saena o bontsha gore o tlhaloganya gore ke eng se se tlile go direga mme o boditse dipotso dipe tse o ka be o na le tsone ka patlisiso. Gape o ka botsa dipotso morago fa o sa kgone go akanya ka ga tsona jaanong. Gosaena foromo eno ga go reye gore o tshwanetse go fetsa dipatlisiso tseno - o ka tswa mo patlisisong ka nako nngwe le nngwe kwa ntle ga go tlhalosa gore ke ka ntlha ya eng.

Tshedimosetso ka ga thuto eno e setse e tlhalositswe mo go nna.

Ke tlhaloganya gore ke tla kopiwa go umaka maina a dipopego mme le lebone le tla bontshiwa ka fa gare ga matlho a me go kgona go bona gore a pono ya me e siameng kgotsa nnyaa.

Ga ke a gapeletswa go dumela go nna le seabe mo patlisisong eno.

Ke boleletswe gore ga ke na ke utlwisiwa botlhoko, mme nka tlogela go nna le seabe le gore nka bua go ka tswa mo patlisisong ka nako nngwe le nngwe.

Ke dumela go tseya seabe ke sa pateletswa.

☺ ☹

_____ _____

Leina la ngwana Letlha

Ke na le nako e e nepagetseng ya go buisa le go netefatsa go balwa sentle ga foromo e no go motsayakarolo, le motsayakarolo o nnile le tšhono ya go botsa dipotso. Ke tlhomamisa gore motseyakarolo o dumetse go tseya karolo ka kgololosego.

_____

Leina la mmatlisisi

_____ _____

Tshaeno ya mmatlisisi Letlha

Appendix H1: Information document - Participant over 18 years (English)

Title of study: The prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa

Researcher: Sherazadh Hatia

You are being invited to take part in a research study. Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. Please take the time to read the following information carefully. Please ask the researcher if there is anything that is not clear or if you need more information.

The purpose of this study is to determine the prevalence of aniridia and the associated visual and ocular complications among learners seen in schools for the visually impaired in central South Africa.

The study will involve the screening of all the learners at this school to determine the prevalence of aniridia. Aniridia is the absence of the iris (the coloured structure of the eye). The screening will be done by shining a light into your eye and observing if the coloured part of the eye (iris) is present or absent. This screening will take 2 minutes. If you have aniridia, you will be examined further to determine the visual and ocular problems. The examination will comprise of visual acuity (the ability to see at distance), general eye observations, autorefraction (determining the approximate refractive error), tonometry (measuring of the pressure in the eye) and slit lamp (assessment of ocular structures, namely cornea, lens and anterior chamber and the retina). If you are found to have ocular and visual problems, you will be referred for a full eye examination at either the optometrist or ophthalmologist, depending on the problem. This eye examination which will take approximately 1 hour.

There will be no cost or remuneration for participation in this study. No treatment or experiments will be conducted on you. There are no risks involved for participating in

this study, however there might be slight discomfort with the instillation of anaesthetic eye drops (to make your eye numb) and some of the tests conducted. Your information will be kept confidential however, an identity number / date of birth will be required to ensure there is no duplication of data. You may withdraw from this study at any time without penalty and there is no penalty for declining to participate.

Whom do I call or contact if I have questions or problems

Should you have any questions about the research or any related matters, please contact the researcher at 083 793 9301 during regular business hours. For questions about your rights as a research participant or for reporting of complaints, contact the Secretariat of the Health Sciences Research Ethics Committee, University of the Free State at 051 401 7795.

Appendix H2: Information document - Participant over 18 years (Afrikaans)

Titel van studie: Die prevalensie van aniridia en geassosieerde visuele en okulêre komplikasies onder leerders in skole vir die visuele benadeeldes in sentrale-Suid-Afrika

Navorser: Sherazadh Hatia

U word genooi om aan 'n navorsingsstudie deel te neem. Voordat u besluit om aan hierdie studie deel te neem, is dit belangrik dat u verstaan waarom die navorsing gedoen word en wat dit sal behels. Neem asseblief die tyd om die volgende inligting noukeurig te lees. Vra asseblief vir die navorser as daar iets is wat nie duidelik is nie of as u meer inligting benodig.

Die doel van hierdie studie is om die prevalensie van aniridia (dit is die afwesigheid van die gekleurde deel van die oog) en die geassosieerde visuele en oog komplikasies onder leerders met aniridia.

Die studie sal die sifting van al die leerders in hierdie skool behels om die prevalensie van aniridia te bepaal. Aniridia is die afwesigheid van die iris (die gekleurde deel van die oog). Die sifting word gedoen deur 'n lig in u oog te skuin om te kyk of die gekleurde deel van die oog (iris) teenwoordig of afwesig is. Hierdie sifting sal 2 minute vat. As u aniridia het, sal u verder ondersoek word om visuele en oog- probleme te bepaal. Die ondersoek sal uit visuele skerpheid (die vermoë om ‘n afstand te sien), algemene oog waarnemings, outorefraksie (bepaling van die naastenbye refraksiefout), tonometrie (meting van die druk in die oog) en slit-lamp (assessering van okulêre strukture, naamlik die kornea, lens en voorkamer en die retina) bestaan. Die leerders met oog- en visuele probleme sal vir 'n volledige oogondersoek by die oogkundige of oogarts verwys word, afhangend aan die probleem. Die oog ondersoek sal ongeveer 1 uur neem.

Daar sal geen koste of vergoeding wees vir deelname aan hierdie studie nie. Daar is geen risiko's betrokke met deelname aan hierdie studie nie, maar daar kan dalk 'n

bietjie ongemak wees met die toediening van verdowingsoogdruppels (druppels om die oog te verdoof) en sommige van die toetse wat uitgevoer word op diegene met aniridia. U inligting sal vertroulik gehou word, maar 'n identiteitsnommer / geboortedatum sal nodig wees om te verseker dat daar geen duplisering van data is nie. U mag op enige tyd, sonder enige boete uit hierdie studie onttrek en daar is geen straf as u weier om om deel te neem.

Wie bel of kontak ek as ek vrae of probleme het

Indien u enige vrae oor die navorsing of enige verwante sake het, kontak die navorser by 083 793 9301 gedurende gewone werksure. Vir vrae oor u regte as navorsingsdeelnemer of vir die rapportering van klagtes, kontak die Sekretariaat van die Gesondheidswetenskappe Navorsings Etiekkomitee, Universiteit van die Vrystaat by 051 401 7795.

Appendix H3: Information document - Participant over 18 years (Sesotho)

Sehlooho sa phuputso: Hoata ha mathata a pono ho batho banang le aniridia, bohareng ba Afrika Borwa

Mofuputsi: Sherazadh Hatia

O memelwa ho nka karolo phuputsong. Pele o ka etsa qeto ya ho nka karolo phuputsong ena, ho bohlokwa ho utlwisisa hore na ke hobaneng ha e etsuwa, le hore na e kenyelleditse eng. Nka nako ya hao ho bala tlhahiso-leseding eo o e fuweng. O ka kopa mofuputsi hore a o hlalosetse se sa hlakang tlhahiso-leseding.

Morero wa phuputso ena ke ho batlisisa hore na mathata a hlahiswang ke aniridia a atile ha kae mahlong a batho ba tswang bohareng ba Afrika Borwa. O tla etswa teko ya mahlo e tla nka hora.

Thuto e tla kenyeletsa ho hlahlojoa ha baithuti bohle ba sekolo sena ho fumana hore na ho ata ha aniridia ho kae. Aniridia ke ho ba siyo ha iris (sebopeho sa mebala ea leihlo). Ho hlahloba ho tla etsoa ka ho khantša leseli ka leihlong ebe o sheba hore na karolo e mebala ea leihlo (iris) e teng kapa ha eyo. Tlhahlobo e tla nka metsotso e 2. Ha ona le aniridia o tla hlahlojoa ka ho eketsehileng ho fumana hore na mathata a ho bona le a mang a mahlo ke afe. Tlhahlobo e tla ba le mahlo a bonono (bokhoni ba ho bonela hole), hlahlobo ya leihlo e akaretsang, di-autorefraction (ho lekanya phoso ya refractive e batlang e le joalo), tonometry (ho lekanya khatello mahlong) le ho khanya lebone (tlhahlobo ea mehaho ea mahlo, e leng cornea, lens le kamore e ka pele le retina). Ha o fumanwa o na le bothata ba ho bala le ho bona o tla romelloa tlhahlobong ea mahlo ka botlalo ho mohlahlobi wa mahlo kapa ngaka ya mahlo, ho itšetlehile ka bothata. Tlhahlobo ena ya leihlo e tla nka hora.

Ho ke ke ha eba le litšenyehelo kapa meputso ea ho nka karolo thutong ena. Haho phokolo kapa teko etla etswa ho wena. Ha hona kotsi etla o hlahela ha o nka karolo phuputsong ena, empa o tla utlwa makukuno a seng makae ha o tshelwa marothodi a mahlo (a mang a marothodi a ka etsa mahlo a shwe bohatsu) hape tse ding tsa

diteko di etswetswa batho ba kopanang le tshwaetso ena ya aniridia. Dintlha tsa hao tsa teko di tla behwa sephiring, empa ho tla hlokahala bukana ya hao ya boitsebiso ho qoba phethaphetho ya dintlha. O ka nka qeto ya ho se nke karolo phuphutsong ena nako efe kapa efe kantle ho kotlo.

Nka letsetsa mang kapa ka ikopanya le mang ha ke na le dipotso

Ha o ka ba le potso mabapi le phuphutso kapa maemo a amanang le tsona, o ka letsetsa mofuputsi nomorong ena: 0837939301 dihoreng tsa mosebetsi tse tlwaelehileng. Dipotso mabapi le ditokelo tsa hao jwalo ka monka-karolo phuphutsong, kapa tletlebo efe kapa efe, o ka ikopanya le Secretariat ya Ethics Committee ya Faculty of Health Sciences, University of the Free State, mohaleng ona, 051 401 7795.

Appendix H4: Information document - Participant over 18 years (Setswana)

Setlhogo sa go ithuta: Go nna teng ga aniridia le tse di amanang pono le mathata a matlho a baithuti mo dikolong tsa baithuti ba ba nang le bokowa jwa matlho mo bogareng jwa Aforikaborwa

Mmatlisisi: Sherazadh Hatia

O laletswa go tsaya karolo mo dithuto-patlisisong. Pele o ka tsaya tshwetso ya go nna le seabe mo patlisisong eno, go botlhokwa gore o tlhaloganye patlisiso e e dirwang mme se se tla e akaretsang. Tsweetswee, tsaya nako go buisa tshedimosetso e e latelang ka kelotlhoko. Tsweetswee kopa mmatlisisi fa go na le sengwe se se sa tlhamalala kgotsa fa o tlhoka tshedimosetso e nngwe.

Boikaelelo jwa patlisiso eno ke go tlhomamisa gore go nna teng ga aniridia (Seno ke go sa nne teng ga karolo ya leitlho e re fang mmala wa matlho) le tse di amanang le pono le mathata a baithuti ba ba nang le aniridia ba nang le one.

Patlisiso eno e tla akaretsa go tlhatlhoba baithuti botlhe kwa sekolong se go tlhomamisa go nna teng ga Aniridia. Aniridia ke go sa nne teng ga karolo ya leitlho e e refang mmala wa leitlho. Ditlhatlobo tseno di tla dirwa ka go botsha lebone mo leitlhong la gago go bona fa karolo e no ya leitlho e leng, (iris) gore a e teng kgotsa e se teng. Go bontsha lebone mo leitlhong go tla tsaya metsotso e le 2. Fa o na le aniridia, o tla tlhatlhobiwa go bona ga o na le mathata mangwe a pono mo matlhong a gago. Ditlhatlhobo di tla akaretsa go sheba acuity ya matlho a gago (e leng bokgoni jwa matlho a gago go bona kwa kgakala), ka kakaretso, re lebelele matlho a gago, go tla dirwa le autorefraction (go lebella ga o na le bothata jwa go bona jwa matlho gore a o tlhoka diborele), tonometry (go bona fa poresha ka fa matlhong e itekanetse) le slit lamp (go tlhatlhoba ka mechine go bona fa bogare jwa matlho bo itekanetse , go dira jalo go bonwa lense ya matlho le dikarolo tsotlhe go fitlha ka fa morago ga matlho). Fa o fitlhelwa o na le mathata a pono, o tla romelwa go etsa ditlhatlhobo tse di felletseng tsa matlho kwa ngakeng ya matlho kgotsa sepeshalisiting sa matlho go tswa gore bothata ke eng. Tlhatlhobo e no ya matlho e ka nnang ura e le 1.

Ga go kitla go nna le tuelo e e tla tlhokagalang kgotsa e etla fiwang motsayakarolo go nna le seabe mo patlisisong eno. Ga go na dikotsi tse di tla nna teng fa o nna le seabe mo patlisisong eno, le fa go ntse jalo go ka nna le go tsipanyana fa re tshela setlhare sa go bolaya botlhoko / bogatsu mo tedikong tse di tla dirwang go botlhe baba nang le aniridia. Tshedimosetso ya gago e tla bolokwa e le khupamarama le fa go ntse jalo, nomoro ya boitshupo / Letlha la botsalo e tlhokega go netefatsa gore ga go na poeletso ya tshedimosetso. O ka kopa go tswa mo patlisisong eno ka nako nngwe le nngwe kwa ntle ga kotlo, ga go na go nna le kotlhao ya go sa tseye karolo mo dipatlisisong tseno.

Ke mang yo o bitsa kgotsa ikgolaganye le fa ke na le dipotso kgotsa mathata

Fa o na le dipotso ka ga patlisiso kgotsa mabaka a a jalo, tsweetswee ikgolaganye le Mmatlisisi kwa 083 793 9301 ka nako ya diura tsa tiro ya ka gale. Ya dipotso ka ga ditshwanelo tsa gago jaaka motsayakarolo kgotsa patlisiso ya pego ya dingongorego, ikgolaganye le Mokwaledi wa Disaense tsa Pholo Komiti ya maitsholo, Yunibesiti ya Foreisetata kwa 051 401 7795.

Appendix I1: Consent Form - Participant over 18 years (English)

The prevalence of aniridia and associated visual and ocular complications among learners in schools for the visually impaired in central South Africa

By signing this consent form, I (participant) confirm that I have read / or the information was read and explained to me and I understood the information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form. I voluntarily agree to take part in this study.

_____	_____	_____
Name of Participant	Signature	Date
_____	_____	_____
Researcher's name	Signature	Date

Appendix I2: Consent Form - Participant over 18 years (Afrikaans)

Die prevalensie van aniridia en geassosieerde visuele en okulêre komplikasies onder leerders in skole vir die visuele benadeeldes in sentrale-Suid-Afrika

Deur hierdie toestemmingsvorm te teken, ek (deelnemer) bevestig ek dat ek die inligting gelees het / die inligting was aan my gelees en verduidelik, en dat ek die inligting verstaan en die geleentheid gehad het om vrae te vra. Ek verstaan dat my deelname vrywillig is en dat ek enige tyd kan onttrek sonder om 'n rede te gee en sonder koste. Ek verstaan dat ek 'n afskrif van hierdie toestemmingsvorm sal ontvang. Ek aanvaar vrywillig om aan hierdie studie deel te neem.

_____	_____	_____
Naam van Deelnemer	Handtekening	Datum
_____	_____	_____
Navorser se naam	Handtekening	Datum

Appendix I3: Consent Form - Participant over 18 years (Sesotho)

Sehlooho sa phuputso: Hoata ha mathata a pono ho batho banang le aniridia, bohareng ba Afrika Borwa

Ho saena pampithana ena, ke bopaki hore ke (monka-karolo) badile / balletswe le ho hlalosetswa tlhahiso-lesedi mme ka e utlwisisa le ho fuwa monyetla wa ho botsa dipotso. Ho nka karolo phuputsong ena ke ka boithaupi mme ke dumelletswe ho ikhula nako efe kapa efe ka ntle le ho lebaka kapa ho fuwa kotlo. Ke dumela hore ke tla fuwa pampitshana ena, mme ke dumela ho nka karolo phuputsing ena.

_____	_____	_____
Lebitso la Monka-karolo	Tshaeno	Letsatsi

_____	_____	_____
Lebitso la Mofuputsi	Tshaeno	Letsatsi

Appendix I4: Consent Form - Participant over 18 years (Setswana)

Go nna teng ga aniridia le tse di amanang pono le mathata a matlho a baithuti mo dikolong tsa baithuti ba ba nang le bokowa jwa matlho mo bogareng jwa Aforikaborwa

Ka go saena foromo eno ya tumelelo, ke (tsayakarolo) go tlhomamisa gore ke buisitse / le go tlhaloganya tshedimosetso le go nna le tšhono ya go botsa dipotso. Ke tlhaloganya gore botsayakarolo jwa me ke boithaopo le gore ke gololesega go ntsha ka nako nngwe le nngwe, kwa ntle ga go naya lebaka le le kwa ntle ga tuelo. Ke tlhaloganya gore ke tla newa khopi ya foromo eno ya tumelelo. Ke ka dumela go nna le seabe mo patlisiso eno.

_____	_____	_____
Leina la Motsayakarolo	Tshaeno	Letlha
_____	_____	_____
Leina la mmatlisisi ’ di	Tshaeno	Letlha

Appendix J: Data sheet 1

Participant No									
D.o.B.	Y	Y	Y	Y	M	M	D	D	
Age				**Race**			**Gender**		
Aniridia present?	Y			N					

Participant No									
D.o.B.	Y	Y	Y	Y	M	M	D	D	
Age				**Race**			**Gender**		
Aniridia present?	Y			N					

Participant No									
D.o.B.	Y	Y	Y	Y	M	M	D	D	
Age				**Race**			**Gender**		
Aniridia present?	Y			N					

Participant No									
D.o.B.	Y	Y	Y	Y	M	M	D	D	
Age				**Race**			**Gender**		
Aniridia present?	Y			N					

Participant No									
D.o.B.	Y	Y	Y	Y	M	M	D	D	
Age				**Race**			**Gender**		
Aniridia present?	Y			N					

Participant No									
D.o.B.	Y	Y	Y	Y	M	M	D	D	
Age				**Race**			**Gender**		
Aniridia present?	Y			N					

Participant No									
D.o.B.	Y	Y	Y	Y	M	M	D	D	
Age				**Race**			**Gender**		
Aniridia present?	Y			N					

Appendix K: Data sheet 2

Participant No										
D.o.B.	Y	Y	Y	Y	M	M	D	D		
Age			**Race**			**Gender**				
Hometown						**Cause**				
1. VA (logmar)				Calculated (ETDRS) = 0.7±n(0.02)						
	OD			OD						
	OS			OS						
	OU			OU						
2. Autorefraction	OD								VA	
	OS								VA	
3. Intraocular Pressure	OD									
	OS									
4. Slitlamp	OD								OS	
	Cornea									
	Anterior chamber									
	Lens									
	Retina									
	Optic nerve									
	Fovea									
5. Gonioscopy	OD								OS	

Appendix L: Referral letter to local Ophthalmologist / Optometrist

Referral Letter

Dear colleague,

Date: _____

Patient: _____

School: _____

I am currently conducting research for my Masters in Optometry. The aim of my study is to determine the ocular and visual complications in individuals with aniridia, seen in schools for the visually impaired in central South Africa. Ocular examinations were conducted on participants with aniridia from selected schools. The above mentioned patient was included in my study.

Reason for referral: _____

_____

_____

_____

_____

_____

Please evaluate and manage accordingly.

Regards

Sherazadh Hatia
083 793 9301

Appendix M: Screening results

Participant Nr	Date of Birth	Date of Exam	Age	Race	Gender	Presence of aniridia
CH001	2012-11-15	2019-02-22	6	African	Male	No
CH002	2012-11-03	2019-02-22	6	African	Female	No
CH003	2014-01-08	2019-02-22	5	African	Male	No
CH004	2014-10-11	2019-02-22	4	African	Male	No
CH005	2007-09-21	2019-02-22	11	African	Female	No
CH006	2008-08-26	2019-02-22	10	African	Female	No
CH007	2010-08-29	2019-02-22	8	African	Female	No
CH008	2010-05-24	2019-02-22	8	African	Male	No
CH009	2012-07-17	2019-02-22	6	African	Male	No
CH010	2000-10-29	2019-02-22	18	African	Male	No
CH011	2001-01-12	2019-02-22	18	African	Male	No
CH012	2002-01-04	2019-02-22	17	African	Male	No
CH013	2001-03-24	2019-02-22	17	African	Male	No
CH014	2004-08-24	2019-02-22	14	African	Female	No

CH015	2004-07-06	2019-02-22	14	Caucasian	Male	No
CH016	2002-01-16	2019-02-22	17	African	Female	No
CH017	2003-01-24	2019-02-22	16	African	Female	No
CH018	2001-11-01	2019-02-22	17	African	Male	Yes
CH019	2009-02-21	2019-02-22	10	Caucasian	Female	No
CH020	2007-05-17	2019-02-22	11	African	Female	No
CH021	2010-02-06	2019-02-22	9	African	Male	No
CH022	2009-01-08	2019-02-22	10	African	Male	Yes
CH023	2005-01-15	2019-02-22	14	African	Male	No
CH024	2001-06-25	2019-02-22	17	African	Female	No
CH025	2005-05-05	2019-02-22	13	African	Female	No
CH026	2003-09-06	2019-02-22	15	African	Female	No
CH027	2002-12-01	2019-02-22	16	African	Female	No
CH028	2002-10-26	2019-02-22	16	African	Male	No
CH029	2005-09-18	2019-02-22	13	African	Female	No
CH030	2003-05-02	2019-02-22	15	African	Male	No

CH031	2011-12-15	2019-02-22	7	African	Male	No
CH032	2010-08-12	2019-02-22	8	African	Male	No
CH033	2004-04-14	2019-02-22	14	African	Male	No
CH034	2007-11-16	2019-02-22	11	African	Male	No
CH035	2005-09-15	2019-02-22	13	African	Female	No
CH036	2004-11-15	2019-02-22	14	African	Female	No
CH037	2011-04-30	2019-02-22	7	African	Male	No
CH038	2005-05-16	2019-02-22	13	African	Female	Yes
CH039	2002-12-03	2019-02-22	16	African	Male	No
CH040	2007-08-29	2019-02-22	11	African	Female	No
CH041	2004-08-05	2019-02-22	14	African	Male	No
CH042	2006-01-01	2019-02-22	13	African	Female	No
CH043	2006-02-17	2019-02-22	13	African	Male	No
CH044	2003-12-07	2019-02-22	15	Caucasian	Female	No
CH045	2007-11-28	2019-02-22	11	African	Male	No
CH046	2006-10-22	2019-02-22	12	African	Male	No

CH047	2003-11-22	2019-02-22	15	African	Male	No
CH048	2006-09-29	2019-02-22	12	African	Female	No
CH049	2002-09-10	2019-02-22	16	African	Male	No
CH050	2004-09-14	2019-02-22	14	African	Male	No
CH051	2001-12-16	2019-02-22	17	Caucasian	Male	No
CH052	2009-04-19	2019-02-22	9	African	Female	No
CH053	2001-03-28	2019-02-22	17	African	Female	No
CH054	2001-06-25	2019-02-22	17	African	Female	No
CH055	1998-09-04	2019-02-22	20	African	Female	Yes
CH056	2010-11-03	2019-02-22	8	African	Female	No
CH057	2010-04-30	2019-02-22	8	African	Male	No
CH058	2007-06-18	2019-02-22	11	African	Male	No
CH059	2009-01-15	2019-02-22	10	African	Female	No
CH060	2004-11-30	2019-02-22	14	African	Female	No
TH001	2010-02-23	2019-04-26	9	Caucasian	Female	No
TH002	2011-01-16	2019-04-26	8	Caucasian	Female	No

TH003	2006-11-10	2019-04-26	12	African	Female	No
TH004	2009-06-02	2019-04-26	9	Caucasian	Female	No
TH005	2010-01-11	2019-04-26	9	Caucasian	Female	No
TH006	1999-07-05	2019-04-26	19	Caucasian	Female	No
TH007	2000-10-12	2019-04-26	18	Caucasian	Female	No
TH008	2011-10-11	2019-04-26	7	African	Female	No
TH009	2008-05-28	2019-04-26	10	African	Female	No
TH010	2001-11-19	2019-04-26	17	Caucasian	Female	No
TH011	2001-10-27	2019-04-26	17	Caucasian	Female	No
TH012	2009-03-09	2019-04-26	10	African	Female	No
TH013	2003-01-09	2019-04-26	16	Caucasian	Female	No
TH014	2008-09-24	2019-04-26	10	Caucasian	Female	No
TH015	2007-02-09	2019-04-26	12	Caucasian	Female	No
TH016	2005-03-23	2019-04-26	14	Caucasian	Female	No
TH017	2008-04-07	2019-04-26	11	Caucasian	Female	No
TH018	2010-12-14	2019-04-26	8	African	Female	No

TH019	2008-03-12	2019-04-26	11	Caucasian	Female	No
TH020	2007-10-15	2019-04-26	11	Caucasian	Female	No
TH021	2004-08-23	2019-04-26	14	Caucasian	Female	No
TH022	2000-03-02	2019-04-26	19	Caucasian	Female	No
TH023	2002-05-18	2019-04-26	16	Caucasian	Female	No
TH024	2006-10-02	2019-04-26	12	African	Female	No
TH025	2011-06-22	2019-04-26	7	Caucasian	Female	No
TH026	2009-03-05	2019-04-26	10	African	Female	No
TH027	2009-08-22	2019-04-26	9	Caucasian	Female	No
TH028	2006-10-21	2019-04-26	12	Caucasian	Female	No
BT001	2001-01-07	2019-07-19	18	African	Male	No
BT002	1998-05-15	2019-07-19	21	African	Female	No
BT003	2001-07-12	2019-07-19	18	African	Female	No
BT004	2003-05-27	2019-07-19	16	African	Female	No
BT005	2004-10-21	2019-07-19	14	African	Female	No
BT006	2005-03-10	2019-07-19	14	African	Male	No

BT007	2005-11-26	2019-07-19	13	African	Male	No
BT008	2006-12-01	2019-07-19	12	African	Female	No
BT009	2005-05-14	2019-07-19	14	African	Male	No
BT010	2007-11-10	2019-07-19	11	African	Female	No
BT011	2000-03-09	2019-07-19	19	African	Female	No
BT012	2001-11-27	2019-07-19	17	African	Female	No
BT013	2002-05-04	2019-07-19	17	African	Female	No
BT014	1999-08-23	2019-07-19	19	African	Female	No
BT015	2003-11-27	2019-07-19	15	African	Female	No
BT016	2000-03-30	2019-07-19	19	African	Female	No
BT017	2008-02-29	2019-07-19	11	African	Male	No
BT018	2009-02-21	2019-07-19	10	African	Male	No
BT019	2007-02-07	2019-07-19	12	African	Female	No
BT020	2001-05-12	2019-07-19	18	African	Female	No
BT021	2005-03-22	2019-07-19	14	African	Male	No
BT022	2011-08-04	2019-07-19	7	African	Male	No

BT023	2007-01-05	2019-07-19	12	African	Female	No
BT024	2008-05-31	2019-07-19	11	African	Female	No
BT025	2008-12-13	2019-07-19	10	African	Female	No
BT026	2008-09-26	2019-07-19	10	African	Female	No
BT027	2010-09-27	2019-07-19	8	African	Female	No
BT028	2009-03-05	2019-07-19	10	African	Female	No
BT029	2010-12-07	2019-07-19	8	African	Male	No