Patterns of Contact Lens Prescribing in KwaZulu-Natal

By

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DECLARATION

STUDENTS DECLARATION

I, Veni Moodley, hereby declare that the dissertation submitted for the degree Master in Optometry to the University of KwaZulu-Natal has not been submitted before for consideration for a degree at this University or any other University previously.

MS VENI MOODLEY

SUPERVISORS DECLARATION

I hereby declare that the preparation of this project was supervised in accordance with the guidelines of research supervision laid down by the University of KwaZulu-Natal.

MS NAIMAH EBRAHIM KHAN

DEDICATION

This dissertation is dedicated to my daughter Avani for her patience and providing me with the inspiration to undertake this academic endeavour alongside her own.

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The writing of this dissertation has been a significant academic challenge. I owe my deepest gratitude to the following people:

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ABSTRACT

Introduction: The prescribing of contact lenses to correct common refractive errors is a growing trend in the optical industry. This can be attributed to the on-going research and development in contact lens designs and material. This research will provide information to assist the contact lens practitioner keep abreast of prescribing trends in KwaZulu-Natal.

Aim: To determine the contact lens prescribing trends in KwaZulu-Natal for the correction of common refractive errors.

Method: A quantitative research method was employed in this study. A self-administered questionnaire was used. Probability sampling technique was used for the two stage sampling procedure. Random sampling strategy was used to determine the primary population (*n*=40) which included all optometrists, registered with the Health Professions Council of South Africa (HPCSA). A cluster sampling strategy was used to select the secondary population (*n*=400) which included all contact lens wearers in KwaZulu-Natal. The data collected was processed and analysed using the Statistical Package of Social Sciences (SPSS).

Results: The results were presented in two sections: Regarding the optometrist profile, the participants consisted of 35% male and 65% female of which 60% were Indian, 25% were White, 7% were Coloured and 5% were African. The results of the survey indicated that 75% of contact lens practitioners prescribe only disposable contact lenses. Regarding the contact lens wearer, the gender distribution was 68% females and 32% males and the age ranged from 7 years to 91 years with a mean of 34.61 (± 13.72) years and mode of 30 years. Furthermore, the racial profile showed that Indians and Whites represented 41% and 43% of all contact lens wearers. The majority of contact lens wearers (72%) are existing wearers. Spherical lens design was mostly prescribed with silicone hydrogel being the preferred material. Furthermore, silicone hydrogel material was most common prescription for both the new fit and re-fitting of contact lenses ($p = 0.029$). Monthly replacement contact lenses were most widely prescribed at 82% with 96% of contact lenses worn on a daily wear modality.

Conclusion: The contact lens prescribing trends in KwaZulu-Natal for the correction of common refractive errors is comparative to international trends of contact lens prescribing.

Key words: Contact lens, Contact lens wearer, prescribing trends, questionnaire, survey

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LIST OF ACRONYMS

CPD:	Continuing professional developement
HSSREC:	Humanities and Social Sciences Research Ethics Committee
HPCSA:	Health Professions Council of South Africa
KZN:	Kwa-Zulu Natal
RGP:	Rigid gas permeable
SPSS:	Statistical Package of Social Sciences

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CHAPTER 1. INTRODUCTION

1.1. INTRODUCTION

The study describes the patterns of contact lens prescribing in KwaZulu-Natal, South Africa. This chapter outlines the background information as well as the motivation for the study. Furthermore, the problem statement, research question as well as the aims and objectives of this study are presented. The significance and the type of study and study method will be discussed. This chapter will conclude with an outline of the study.

1.2. BACKGROUND

Refractive errors such as myopia, hyperopia, astigmatism and presbyopia affect visual acuity. The use of contact lenses for the correction of these errors has increased tremendously over the years (Morgan *et al*, 2013). This marked increase in contact lens use can be attributed to the continuous development of the contact lens material, designs, wearing modalities and replacement schedules (Kading and Brujic, 2013). The wide range of contact lenses available influences the prescribing trends of contact lenses. In addition to the correction of common refractive errors the use of contact lenses for cosmetic purposes as well as a therapeutic modality for corneal pathologies has given a multi-dimensional aspect to this optometric tool.

Contact lenses can be used as an alternative to spectacle prescription and also offers many advantages. Despite the advances in spectacle lens technology, the use of contact lenses as a form of vision correction is increasing around the world (Nichols, 2013). Pseudovs *et al* (2006) demonstrated with the aid of the Quality of Life Impact of Refractive Correction (QIRC) questionnaire for comparing the quality of life of pre-presbyopic individuals with refractive surgery, contact lenses or spectacles. The study revealed that the QIRC score for contact lens wearers was significantly better than for the spectacle wearers. Furthermore, contact lenses allow an unrestricted field of vision and the distortions which occur through the periphery of the spectacle lens are eliminated (Bhattacharyya, 2009). Contact lenses may also offer better visual acuity in keratoconic patients. Kastl *et al* (1987) reported that contact lenses were successfully fitted in 95% of patients with keratoconus. In addition, results indicated that contact lenses should be the initial treatment of choice for keratoconus.

Estimates of the size of the contact lens population worldwide range from 125 million in 2004 to 140 million in 2010 (Swanson, 2012). There were approximately 38 million contact lenses wearers in the United States in 2012 (Nichols, 2012). Also, Asian countries such as China, Malaysia, South Korea Taiwan, Hong Kong and Singapore showed a growth of 7.4%, while the United States and Europe showed a growth of 4.8% and 3.2%, respectively (Nichols, 2012). This report was based on the contact lens sales in 2011 as compared to the contact lens sales in 2010. In South Africa, contact lens wear is gaining popularity; however there is limited research to compare South African contact lens trends to international trends.

Reviews of contact lens prescribing in twenty seven countries such as Australia, Canada, United Kingdom, United States of America, Germany and Norway have been conducted annually to understand the patterns of contact lens prescribing and factors that influence this trend (Morgan *et al.*, 2001-2014). This study will aim to fill the information void in this regard.

The PEAR Study by Oduntan *et al* (2007) revealed that 26.6% of optometry students completing their undergraduate studies in 2006 at the four universities in South Africa were least prepared in the field of contact lenses, while only 28% of students felt that it was the area that they were most prepared.

The technological progress of contact lens materials and designs is on-going. The method of incorporating the latest advances in soft lens materials into practice in the United States has been demonstrated by Kading and Brujic (2013). Furthermore, Papas (2013) reported that the use of contact lens is expanding to include drug delivery, disease monitoring as well low vision devices. A recent study of international contact lens prescribing by Morgan *et al* (2013) demonstrates the direct effect of advanced lens materials and designs on prescribing trends. Soft contact lenses are available in a wide range of materials, designs, and replacement frequencies and make up a greater proportion of new fits. This significant increase, from 4.86% at the beginning of the study to 5.16% at the end of the study, in the annual growth rate of soft contact lens prescribing in Australia has been demonstrated by Edwards *et al* (2009).

The most popular soft lens designs include spherical, toric, cosmetic, bifocal and multifocal lenses. Spherical soft lenses are used to correct myopia, hyperopia, monovision correction for presbyopia and also able to mask small degrees of astigmatism. The use of cosmetic colour contact lenses, both prescription and purely for cosmetic purpose, make up a significant percentage of the soft contact lens market in the United States (Kading and Brujic, 2013).

The introduction of silicone hydrogel contact lens materials allow healthier options in contact lens wear. An important property of the silicone hydrogel lenses is that more oxygen passes through the lens to the cornea and thus significantly reduces hypoxia related problems (Papas, 2013). Silicone hydrogel material prescription has continued to increase and now represents 59% of the soft lenses prescribed (Morgan *et al*, 2013).

Toric contact lenses are essential for the correction of astigmatism. The improvement of toric lens design indicates an upward prescribing trend. South Africa is included as one of only six nations that meet the minimum prescribing rate for astigmatism (Morgan *et al*, 2013). Furthermore, a constant increase in toric lens prescribing was noted from 1996.

Bifocal and multifocal contact lenses offer exceptional alternatives for the correction of presbyopia. If multifocal lenses are not comfortable or do not offer adequate, comfortable distant and near vision, then monovision correction can be used as an alternative prescription. Monovision correction can be obtained using single vision spherical and toric lens design. Furthermore, modified monovision can be obtained by prescribing a single vision distant contact lens in the one eye and prescribing a multifocal contact lens in the other eye to accommodate a specific visual need that cannot be met with another presbyopic contact lens system (Corey, 2014). The preference of multifocal contact lenses has increased yearly from 2008 (Nichols, 2013).

According to Efron *et al* (2013) rigid gas permeable lenses are in decline but still represent approximately 10% of all contact lenses fitted worldwide. Gill *et al* (2010) reported that the more experienced contact lens practitioners in the United Kingdom continued to fit gas permeable lenses and also recommended gas permeable lenses to contact lens wearers.

Rigid gas permeable lenses have been restricted to more specialist applications such as the correction of keratoconus, high levels of astigmatism, post-surgery and for orthokeratology. Advanced keratoconus can also be corrected with scleral lenses. Carrasquillo and Barnett (2014) mentioned that scleral contact lenses represent an area of major growth in the gas permeable lens industry. Scleral lenses are also an excellent option for patients who have aphakia, corneal irregularity, or intolerance to corneal gas permeable lenses. In a more recent review, scleral lenses can successfully serve as a prosthetic device for cases involving paediatric patients with damage to the ocular surface as well as patients with irregular corneas due to glaucoma surgery (Carrasquillo and Barnett, 2014).

Nichols (2013) found that when practitioners, in the Unites States of America, were asked about the development of speciality lens options in 2014, most indicated custom soft lenses (47%) followed by hybrids (26%), scleral lenses (20%) and orthokeratology lenses (7%) showed the most progress. Furthermore, practitioners indicated a preference for multifocal (69%) contact lenses as compared with monovision (19%) correction for presbyopia. It was also reported that silicone hydrogel material, including multifocal and toric contact lenses, would be increasing in practice (Nichols, 2013).

A number of factors affect patterns of contact lens prescribing in different countries, such as differences in population demographics, prevalence of different refractive errors, availability of specific lens designs and also the preference and experience of contact lens practitioners. Efron *et al* (2011), over a nine year survey of international trends in contact lens prescribing, reported that an increase in patient age may indicate a growing confidence in prescribing bifocal and multifocal contact lenses. Furthermore, an increase of new fits among minors and younger age groups indicates an upward trend in contact lens prescribing for teenagers (Efron *et al,* 2011). According to Thite *et al* (2011) the difference in the mean age of contact lens wearers in different countries could be attributed to the level of optometric education and expertise in developing countries.

Although contact lens materials continue to evolve, long term use of contact lenses can affect the physiology of the cornea (Holden *et al*, 1985). Changes in the corneal epithelium have been associated with all types of contact lens wear. The epithelium presenting with signs of increased permeability have been reported with hard lenses whereas thinning of the cornea due to epithelial cell loss has been associated with soft lenses (Millis, 2005). The stroma, or substantia propia, which comprises the majority of the corneal thickness, consists mainly of collagen fibrils. Contact lenses may also cause different degrees of stromal edema: least with RGP daily-wear lens and greatest with extended wear contact lenses (Millis, 2005). Furthermore, decreased oxygen supply to the cornea can cause hypoxia and may be an indication for contact lens refitting (Hom and Bruce, 2006).

Petricek *et al (*2013) noted that the majority of contact lens wearers in Croatia are non-compliant. Furthermore, Kuzman *et al* (2014) reported that contamination of contact lens cases was prevalent in 42% of cases. McMonnies (2011) reported that contact-lens wearers do not understand the consequences of non-compliant behaviour and therefore should be given detailed instructions which will help reduce contact lens failure and sustain better contact lens performance.

The primary reasons for discontinuing contact lens use are discomfort, dryness and red eyes (Pritchard *et al*, 1999). Dry eyes are a common reason for discontinuation of contact lens wear, although with correct contact lens materials and appropriate management of contact lens wearing schedules, contact lens wear can be successfully achieved (Sindt and Longmuir, 2007). Sengor *et al* (2012) demonstrated significant changes of the tear film and ocular surface with long term use of contact lenses. Ocular surface signs such as limbal and bulbar hyperemia and corneal staining were also prevalent among soft contact lens wearers (Riley *et al*, 2006). Riley *et al* (2006) demonstrated that common contact lens related problems can be prevented by refitting with new-generation silicone hydrogel contact lenses.

Medical conditions are known to affect the eye and will therefore impact contact lens use. The literature on diabetes and contact lens use suggests that diabetic contact lens wearers have decreased corneal sensitivity, functional and structural changes to the corneal epithelium as well as altered tear chemistry (O'Leary and Millodot, 2009). A study by O'Donnell and Efron (2012) revealed that there is an increased prevalence of blepharitis, burning and discomfort experienced by diabetic contact lens wearers. Blepharitis is a general term for eczema of the eyelid (Hom and Bruce, 2006). Patel and McGhee (2013) reported that asthma, allergy and eczema were commonly found among keratoconic subjects as compared to the general population in New Zealand and Aotearoa.

Lee *et al* (2012) found that Asian contact lens wearers with rheumatoid arthritis tend to experience dry eyes and more severe ocular surface damage in the superior cornea. Similarly, Ismailova *et al* (2013) revealed that 65.2% of patients with Thyroid disease experienced dry eye syndrome and histological changes in the conjunctiva. Thyroid disease is also associated with exophthalmos and upper lid retraction. Keay *et al* (2009) reported poor health and thyroid conditions were common in cases of contact lens-related microbial inflammations in Australia and New Zealand. Furthermore, flexibility in wearing schedules should be recommended to contact lens wearers with thyroid disease to manage symptoms associated with this systemic disease (Keay *et al*, 2009).

In summary, it is clear that the incorporation of evidence-based contact lens fitting, and management of common problems encountered by contact lens wearers, can provide a variety of benefits for contact lens practitioners.

1.3. PROBLEM STATEMENT

Reviews of contact lens prescribing in various countries have been conducted annually to understand the patterns of contact lens prescribing as well as the factors that influence this trend (Morgan *et al*, 2001-2014). While international contact lens practicing trends are well documented, there has been limited research to suggest that contact lens prescribing in South Africa mirrors international trends. This study will aim to fill the information void in this regard.

1.4. HYPOTHESIS/RESEARCH QUESTION

1. How does the demographic characteristics of contact lens wearers in KZN compare with international information?

2. What are the commonly prescribed contact lens materials and designs?

3. What are the common contact lens related problems experienced by contact lens wearers in KZN?

1.5. AIM AND OBJECTIVES

The aim of the study was to determine the contact lens prescribing trends in KwaZulu-Natal for the correction of common refractive errors.

The study objectives were:

1. To describe the demographic profile of contact lens practitioners in KZN.

2. To describe the contact lens practitioners trends in KZN.

3. To describe the demographic characteristics of contact lens wearers in KZN.

4. To determine the contact lens designs and materials prescribed to correct common refractive errors.

5. To establish common problems encountered by contact lens wearers and the methods of management of these problems.

1.6. TYPE OF STUDY AND METHOD

A quantitative research method was used in this study. Probability sampling technique was used for the two stage sampling procedure. The primary population in this study are optometrists, registered with the Health Professions Council of South Africa (HPCSA), practicing in KwaZulu-Natal. A simple random sampling technique was used to select the primary population in this study. The secondary population in this study included all contact lens wearers in KZN. A cluster sampling technique was used to select the secondary population. A self-administered questionnaire was used as the data collection instrument.

1.7. SIGNIFICANCE OF THE STUDY

Optometry is continually evolving, and a study of this nature will help enable practitioners keep abreast of international trends in contact lens practice. Furthermore, this study will assist contact lens practitioners in the diagnosis and management of common problems encountered by contact lens wearers. This study will also assist contact lens suppliers to promote and market products based on the prescribing patterns of contact lens practitioners in KwaZulu-Natal.

CHAPTER 2. LITERATURE REVIEW

2.1. INTRODUCTION

This chapter discusses the anatomy and physiology of the eye related to contact lens wear, common refractive errors, contact lens designs and materials, problems experienced by contact lens wearers and methods of management of the problems. Finally, medical conditions that affect the eye and how these impacts on contact lens wear will be discussed.

2.2. ANATOMY AND PHYSIOLOGY OF THE EYE

The structures of the ocular surface must work in unison with each other to allow an ideal ocular environment for successful contact lens wear (Brujic and Kading, 2015). These structures include the eyelids, the lipid and aqueous layer of the tear film, limbus, mucin and goblet layers of the cornea and conjunctiva, and the corneal and conjunctival epithelial layers.

2.2.1. The Eyelids

The eyelids have a significant role in contact lens wear. The lid anatomy consists of muscles, skin, lashes, nerves connective tissue and glands. The closure of the eyelid is performed by the palpebral and orbital muscles. The levator muscle is responsible for elevating the upper eyelid. Muller's muscle also helps to elevate the upper eyelid. The innermost layer of the lid, that provides the surface against the eye, is called the palpebral conjunctiva. The palpebral conjunctiva is continuous with the bulbar conjunctiva which covers the sclera (Figure 2.1). The fold of the conjunctiva from the eyelids to the eye prevents any foreign bodies, including contact lenses, from getting behind the eye.

An important function of the eyelids in relation to contact lenses is the blink action. The blinking action of the eyelids causes the tears to spread over the cornea keeping the eyes moist. For contact lens wearers, blinking is essential for exchange of tears beneath the contact lens. The eyelids are also responsible for contact lens positioning, orientation and movement (Hom, 2000).

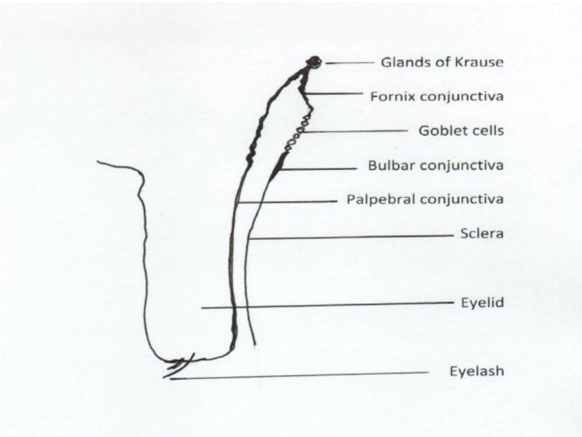

Figure 2.1. A schematic representation of the upper eyelid and conjunctiva

2.2.2. Tear Film Physiology

The tear film provides the necessary optical surface for vision, protects the eye and provides wettability for contact lenses. The tear film is comprised of three basic layers. The outermost layer is the lipid or oily layer. The lipid layer is secreted by the meibomian glands and this layer slows the evaporation of the tear film. The lipid layer also increases surface tension and supports the vertical stability of the tear film, hence preventing tears from overflowing onto the lower lid margin (Agarwal *et* al, 2005). The middle layer is called the aqueous or lacrimal layer. This layer makes up the thickness of the tear film and is secreted by the Glands of Krause and Wolfring which is situated in the palpebral conjunctiva. The aqueous layer is responsible for oxygen supply to the corneal epithelium. The innermost layer situated against the cornea and the conjunctiva is the mucoid layer. This layer is formed by goblet cells in the conjunctiva. The mucoid layer is spread over the cornea and conjunctiva by the blinking action of the lids.

According to Foulks (2003), the instability in the quantity and quality of the tear film results in intolerance to contact lens wear and damage to the ocular surface. Nichols and Sinnott (2006) suggest that dry eye caused by contact lens wear may be explained by an increase in the tear film thinning due to evaporation of the tear film.

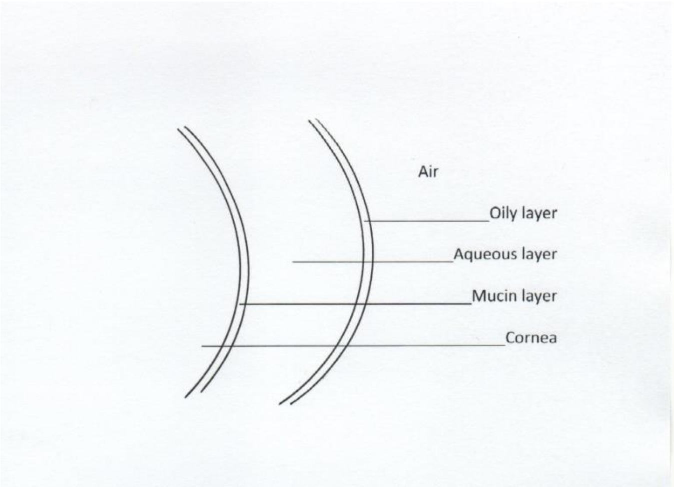

Figure 2.2 A schematic representation of the layers of tear film

2.2.3. The Cornea

The cornea presents as the main refracting surface of the eye (Hom and Bruce, 2006). The cornea is responsible for two-third of the optical power of the eye (Kanski, 2011). This avascular tissue receives oxygen from the tear film. The cornea is made up of multi-layered transparent tissue and makes up the outermost part of the eye.

The outermost layer of the cornea is the epithelium. The epithelium comprises of five or six layers of epithelial cells (Hamano and Kaufman, 1997; Bhattacharya, 2009). The superficial cells of the epithelium have microvilli along the surface extending into the tear film (Agarwal *et al*, 2005). The microvilli help stabilize the tear film (Hom and Bruce, 2006). According to Liesegang (2002) changes in the cornea as a result of contact lenses occurs at the epithelium. The corneal epithelium can become edematous and lose the normal tight adherence between cells as well as the basement membrane. The intercellular spaces which develop fill with fluid that scatters light. Hence, this causes loss of transparency to the epithelium and is referred to as epithelial edema (Bennett and Weismann, 2005).

Bowman's membrane lies beneath the epithelium and above the stroma. This layer is made up of a fine meshwork of collagen fibrils. The Bowman's layer does not regenerate if it is damaged and hence scarring can occur at this layer (Lowther and Snyder, 1992).

The stroma or substantia propia consists of 90% of the corneal thickness and this layer gives the cornea its strength (Philips and Stone, 1989). The stroma is made up of regularly spaced collagen fibrils and the layer does not have blood vessels (Philips and Stone, 1989). The absence of blood vessels and regular structure contributes to the transparency of the cornea.

According to Dua *et al* (2013) there exists a previously undetected layer of the cornea. This layer, referred to as the Dua's Layer, lies between the stromal layer of the cornea and the Descemet's membrane. The Dua's layer is a well-defined, acellular strong layer (Dua *et al*, 2013). However, further research is required to determine origin and function of this layer.

The inner curve of the cornea is lined by the corneal endothelium and the basement membrane. The basement membrane, also called the Descemet's membrane, is secreted by the endothelial cells (Hamano and Kaufman, 1997).

The endothelium is the innermost layer of the cornea and can be described as a single layer of hexagonal cells which present a smooth surface to the anterior chamber. This layer is responsible for maintaining the water content of the stroma and the endothelium is also a metabolically active layer (Lowther and Snyder, 1992). The endothelium can be affected by contact lens wear. Changes in cell size, shape and number can occur as well as carbon dioxide accumulation which can be seen as black spots (Hom and Bruce, 2006).

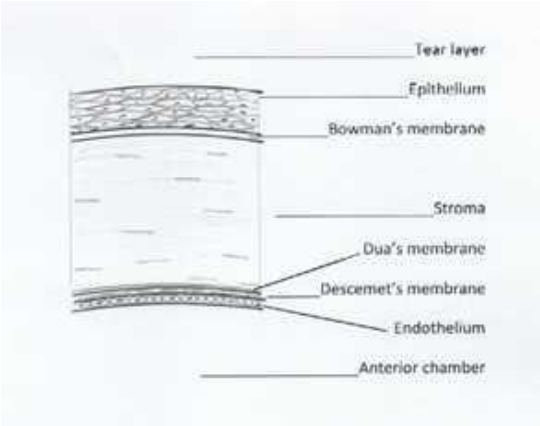

Figure 2.3. A schematic representation of the cornea

2.2.4. The Limbus

The limbus may be described as the transition area between the cornea, sclera and the bulbar conjunctiva. Bowman's layer and Descemet's membrane end at the limbus. The epithelium thickens and the stroma appears cloudy as a result of the loosening of the collagen fibers (Lowther and Snyder, 1992). According to Bennett and Weismann (2005), current research suggests that regeneration of the corneal epithelium depends on the stem cells located deep in the limbus. Blood vessels and corneal nerves can be seen at the limbal zone. Ocular irritation resulting from allergies, foreign bodies, infection and contact lenses can cause blood vessels to dilate and this is called limbal engorgement. Corneal oedema or corneal disease can cause new blood vessels from the limbal area to grow into the cornea resulting in neovascularization (Lowther and Snyder, 1992).

2.2.5. The Conjunctiva

The conjunctiva is a membrane lining the inside of the eyelids and the sclera. This mucous membrane is made up of connective tissue and epithelium (Hom, 2000). The conjunctiva has an abundant supply of blood vessels. The blood supply is through the ophthalmic artery by way of the arcades and anterior ciliary arteries.

The conjunctiva consists of three sections. This is the bulbar, fornix and palpebral conjunctiva as illustrated in Figure 2.1. The bulbar conjunctiva covers the sclera on the anterior surface and the corneal epithelium at the limbal area. The conjunctival stroma becomes the palisades of Vogt at the limbus. The blood vessels of the bulbar conjunctiva form a radial arrangement. At the fornix, the conjunctiva is loose and redundant and may be thrown into folds (Kanski, 2011). The palpebral conjunctiva lines the inside of the eyelids. The blood vessels that supply the tarsal plate pass vertically from the lid margin and the fornix.

2.3. REFRACTIVE ERROR

Refractive error is a term used to describe an error in the focusing of light by the eye which can result in reduced visual acuity. When parallel rays of light from a distant object are focussed on the retina, the eye is said to be emmetropic. An eye which is not emmetropic is said to be ametropic or to possess a refractive error (Ogle, 1961). The common refractive errors include myopia (short-sightedness), hyperopia (far-sightedness), astigmatism and presbyopia.

2.3.1. Myopia

Myopia, the most common refractive error, is also referred to as short sightedness or near sightedness (Pan *et al*, 2012). Myopia occurs when incident parallel rays of light are brought to a focal point in front of the retina. Hence this results in a blurred image. A clear image is possible by increasing the divergence of the rays of light.

Myopia can be corrected by placing a concave lens or a contact lens in front of the eye. Contact lenses offer a wider field of vision as compared to spectacles. The image size may be larger as it is worn closer to the eyes than glasses. The image distortion through the peripheral part of the spectacles is also eliminated (Bhattacharyya, 2009).

2.3.1.1. Prevalence of Myopia

Numerous studies have presented the information regarding the pattern and prevalence of myopia. Murthy *et al* (2002) reported that the prevalence of myopia in 6 year old children and 15 year old children was 5.8% and 10.5% respectively. This study was a population-based study in New Delhi, India and included 6447 participants.

Pan *et al* (2012) outlined the prevalence of myopia in adults in worldwide population studies. According to Pan *et al* (2012) the prevalence of myopia in India, in 40 year and older adults, was reported to be 34.6% in the Indian state of Andre Pradesh. In Bangladesh and Pakistan, the prevalence of myopia in adults over 40 years has been reported to be 23.8% and 36.5% respectively (Pan *et al*, 2012). In the Baltimore eye study (*n*=5028), the prevalence of myopia was 28.1% among the Caucasian and 19.4% among the African American participants.

Naidoo *et al* (2003) found that the prevalence of myopia in 6 year old children was 4.6% and increased to 9.6% in 15 year olds in a population based study of 4890 children in South Africa.

2.3.2. Hyperopia

Hyperopia is also referred to as long sightedness (Bhattacharyya, 2009). Hyperopia occurs when incident parallel rays of light are brought to a focal point behind the retina. Total hyperopia is made up of latent and manifest hyperopia. Latent hyperopia can be corrected by accommodation of the eye. Accommodation can be described as the phenomenon to focus near objects clearly on the retina by increasing the convergence power of the eye (Bhattacharyya, 2009). Young children present with latent hyperopia and as age progresses the elasticity of the crystalline lens decreases and it changes towards manifest hyperopia. This results in a blurred image. A clear image is possible by decreasing the divergence of light. This can be achieved by placing a convex spectacle lens or contact lens in front of the eye. Contact lenses are suitable for high degrees of hyperopia (Bhattacharyya, 2009).

2.3.2.1 Prevalence of Hyperopia

Information regarding the patterns and prevalence of hyperopia is not as well documented in literature as with myopia. Naidoo *el al* (2003) found that the prevalence of hyperopia (+2.00 D or more) measured with retinoscopy in at least one eye was 1.8% of 6 year old children and in 2.6% measured with autorefraction. Ip *et al* (2008) reported the prevalence of hyperopia was found to be 13.2% and 5.0% among children ages 6 (*n* = 1765) and 12 (*n* = 2353) respectively.

2.3.3. Astigmatism

Astigmatism is a common refractive error caused by the irregular curve of the cornea or the crystalline lens. Astigmatism can occur in one or both eyes with different intensities in each eye (www.eyehealthweb.com/astigmatism). Therefore, for the purpose of this study, astigmatism was measured in both eyes. Astigmatism occurs when incident parallel rays of light are refracted off two different meridians resulting in two images formed in different planes of the eye. Astigmatism may occur in varying degrees in each eye, and often accompanies myopia or hyperopia (Bhattacharyya, 2009; www.eyehealthweb.com/astigmatism).

In simple myopic astigmatism, one image is located on the retina and the second image is located in front of the retina whereas in simple hyperopic astigmatism, one image is located on the retina and the second image is located behind the retina. In compound myopic astigmatism, both images are located in front of the retina, whereas in compound hyperopic astigmatism both images are located behind the retina. In mixed astigmatism, one image is formed in front of the retina and the other image is located behind the retina.

Based on the orientation or maximum curvature of the cornea, astigmatism can be classified as with-the-rule, against-the-rule or oblique (Bhattacharyya, 2009). The vertical corneal meridian is more curved than the horizontal corneal meridian in with-the-rule astigmatism (90 degrees), whereas, in against-the-rule astigmatism (180 degrees) the horizontal meridian of the cornea is more curved than the vertical meridian. In oblique astigmatism, the radius of maximum and minimum curvature is aligned at ninety degrees and is neither horizontal nor vertical. Furthermore, the maximum curvature of the cornea in oblique astigmatism lies between 120 and 150 degrees and 30 and 60 degrees (Bhattacharyya, 2009).

Astigmatism can be corrected with a spectacle lens as well as contact lenses. Soft toric contact lenses are available to correct many types of astigmatism. Corneal astigmatism occurs on the surface of the cornea and can be fitted by either a back surface toric contact lens or a bitoric contact lens (Goughary, 2006). Furthermore, astigmatism located on the inside of the eye can be corrected by a front surface toric contact lens (Goughary, 2006).

Rigid gas permeable contact lenses maintain the normal shape when placed on the cornea and the RGP lenses are able to correct vision in irregular astigmatism (Bennett and Weismann, 2005). The advantages of gas permeable contact lenses as compared to conventional and disposable hydrogel toric contact lenses include more stable vision, higher oxygen transmissibility as well as greater durability (Hom and Bruce, 2006).

2.3.3.1. Prevalence of Astigmatism

The prevalence of astigmatism (defined as < or = -0.75) was 13.3% of all children with significant variation across ethnic groups. This ranged from 27% of Hispanic, 17.2% of Chinese, 12.2% of Malay, 8.22% of Indian to 8.81% of African (Wang *et al*, 2014).

2.3.4. Presbyopia

Presbyopia is defined as the slow, gradual, age related and irreversible decline in the physiological process of amplitude of accommodation, i.e. recession of the near point beyond comfortable near work and reading distance (Bhattacharyya, 2009). The onset of presbyopia usually occurs between the ages of 38 to 45 years and is usually reported between 40 and 48 years.

There are numerous soft and gas permeable contact lens options available for the correction of presbyopia. Contact lenses for distant vision correction can be worn with a pair of reading glasses for near or intermediate distance. Bifocal contact lenses are described as contact lenses that provide visual correction at distant and near whereas, multifocal contact lenses provide visual correction for more than two distances. Monovision contact lens correction pertains to prescribing contact lens in one eye that optimally corrects distant vision and prescribing a contact lens in the other eye that optimally corrects near vision (Bennett and Weismann, 2005).

Rajagopal *et al* (2006) assessed the visual performance of a sample population of 32 participants ranging in age from 42 and 65 years wearing gas permeable, bifocal and monovision contact lenses. It was concluded that participants prescribed with gas permeable multifocal contact lenses provided improved binocular contrast acuity. Furthermore, bifocal and monovision contact lens participants demonstrated a reduction in binocular contrast sensitivity at all special frequencies.

2.3.4.1. Prevalence of Presbyopia

A cross-sectional community based survey was conducted to determine the prevalence of presbyopia in Durban, South Africa. According to He *et al* (2014), the prevalence of presbyopia was 77% (95% confidence interval), significantly higher in those 50 - 60 years old and 65 – 79 years old. Similarly, the prevalence of presbyopia was found to be 63,4% in a population-based, cross sectional study in a rural African community in Nigeria (Uche *et al,* 2014).

A population-based, cross sectional study was carried out in Durban (South Africa), Shunyi (China), Kaski (Nepal), Madurai (India), Dosso (Niger), Guangzhou (China) and Los Angeles (United States of America). The purpose of the study was to assess the prevalence of presbyopia and the use of prescription spectacles among middle aged and older adults. He *et al* (2012) reported that the prevalence of near vision impairment ranged from 49% in Dosso to 60% in Shunyi and Guangzhou, 65% in Kaski and Los Angeles and 83% in Madurai and Durban.

Kading and Brujic (2013) reported that according to the U.S. Department of Commerce, Bureau of the Census. Intercensal Estimates of the Resident Population by Sex and Age for the United States: April 1, 2000 to July 1 2010, it was estimated that there are 122 million Americans who have presbyopia. This accounts for nearly one in every three persons in the United States.

2.4. CONTACT LENSES

A contact lens can be defined as a transparent optical device with dioptric power that is applied directly to the surface of the eye for the purpose of correcting deficiencies in vision (Efron, 2002). The history and the benefits of contact lenses will be discussed. For the purpose of this study, contact lenses are classified in terms of design, material, and wearing modalities.

2.4.1. History of Contact Lenses

Correcting refractive errors by placing a lens on the eye was first introduced by Leonardo da Vinci in his 1508 *Codex of the Eye, Manual D* (Lowther and Snyder, 1992). However, his concept of altering corneal power is illustrated by a large glass sphere with water and a face immersed in the water.

Frederick A. Muller, a Weisbaden glass blower, made the first scleral, non-optical contact lens in 1887 (Bennett and Weisman, 2005). This contact lens was manufactured for eyes with lagophthalmos and an eyelid deformed by cancer.

However, the first contact lens to correct vision was invented in 1888 by Adolf Eugene Fick, a Zurich physician and Eugene Kalt, A French physician (Hamano and Kaufman, 1997; Bennett and Weismann, 2005). All early contact lenses were made of glass and this material made the contact lenses heavy and impermeable to oxygen, hence wearing time was reduced (Hamano and Kaufman, 1997).

Polymethyl methacrylate (PMMA) contact lens was invented in 1936 by Dr William Feinbloom. PMMA lenses, referred to as hard lenses, were more popular due to reduced weight and improvement in patient comfort (Hamano and Kaufman, 1997). According to MacRae *et al* (1994) the prolonged use of PMMA contact lenses on the corneal epithelium resulted in polymegethism and decreased cell densities. Furthermore, a recent study by Tyagi *et al* (2012) revealed significant corneal swelling and reduced optical performance of the cornea with short term use of PMMA contact lenses.

The next development of contact lens material was the introduction of hydrogel materials in 1954 by Professor Otto Wichterle and Dr Drahoslav Lim in Prague. Finally in March 1971, the first hydrogel soft contact lens was developed and manufactured by Bausch and Lomb (Lowther and Snyder, 1992). According to Bennett and Weismann (2005), problems with this first hydrogel lenses include decentration, hypoxia and “tight lens syndrome”. Polse (1979) stated that the tear volume replenishment rates under hydrogel lenses were significantly low. According to Mutti and Seger (1989), hydrogel contact lenses transmitted insufficient oxygen which resulted in corneal hypoxia. Wheeler *et al* (1996) stated that the hydrogel contact lenses were successfully developed for use as soft contact lenses and drug delivery systems. Also in mid-1982, Ciba Vision was the first company to have developed a hydrogel bifocal soft lens.

The rigid gas permeable (RGP) lens was developed in 1978 (Lowther and Snyder, 1992). To increase oxygen permeability of PMMA lenses, silicone was added to produce a more commercially successful RGP lens. An advantage of RGP lenses is that better vision can be achieved as compared to soft lenses (Agarwal *et al*, 2005). According to Leung (2010) RGP lenses are the choice of correction for most keratoconic patients.

The soft silicone contact lens has the highest oxygen permeability of all known materials available (Lowther and Snyder, 1992). In the late 1970s, silicone lenses were marketed in Japan and Germany. According to Stapleton *et al* (2006), silicone hydrogel lenses have eliminated lens-induced hypoxia and also have a decreased effect on tear film structure as well as corneal physiology. Oxygen permeability, wettability, material strength and stability are few of the benefits of silicone hydrogel materials (Sweeney, 2004).

Nichols (2014) reported that the majority of contact lenses prescribed in the United States were those with silicone hydrogel materials. Furthermore, Morgan *et al* (2015) stated that prescribing silicone hydrogel contact lenses varied considerably, from more than 80% of soft lens materials in Bulgaria and France to less than 10% in Taiwan and Nepal.

2.4.2. Benefits of Contact Lenses

Contact lenses offer various benefits when compared to spectacles. Contact lenses allow an unrestricted field of vision and the distortions which occur through the periphery of the spectacle lens are eliminated (Bhattacharyya, 2009). Contact lenses may also offer better visual acuity in keratoconic patients. According to Kastl *et al* (1987) contact lenses were successfully fitted in 95% of patients with keratoconus. Also, results indicated that contact lenses should be the initial treatment of choice for keratoconus. Gonzalez-Meijome *et al* (2013) demonstrated that both Soft-K silicone hydrogel contact lens and gas permeable contact lens produces a statistically significant improvement in contrast sensitivity function and visual acuity and over spectacle correction.

Furthermore, contact lenses move with the cornea as the eyes rotate whereas spectacle lenses remain fixed in orientation to the head. Therefore, wearing of contact lenses reduces prismatic effects common to spectacle lens wear (Bennett and Weismann, 2005). Another good reason motivating contact lens wear include a desire to improve cosmesis and the inconvenience of spectacles.

The British Contact Lens Association (2014), described contact lens wear as a safe, effective, stable and reversible alternative to refractive surgery. Also, contact lenses have many advantages for sporting activities as well as leisure activities. Contact lenses can improve most visual problems and are suitable for all age groups.

McMonnies (2013) reported that the decision to be fitted with contact lenses is made on the basis of wanting to be able to see without wearing glasses. There are also visual and practical, non-cosmetic advantages to wearing contact lenses. Optical and visual advantages increase for higher prescriptions, anisometropia as well as irregular astigmatism. Contact lenses provide protection from ultra-violet (UV) radiation. Furthermore, contact lenses do not make the eyes appear larger with thicker lenses for hyperopia and smaller with stronger lenses for myopia (McMonnies, 2013).

2.5. CLASSIFICATION OF CONTACT LENSES

Contact lenses can be classified into different categories. In this study, contact lenses will be described by material, design, replacement frequency and modality of wear.

2.5.1. Contact Lens Material

There are three types of contact lenses according to the material properties. This includes rigid gas permeable contact lenses and soft contact lenses. Soft contact lenses can be further classified, by material properties, as conventional hydrogel lenses and silicone hydrogel lenses.

The raw material for contact lenses is manufactured from a plastic polymer. The molecules of different chemical substances are blended together to create a polymer which is made up of blend of different materials. Hard contact lenses are composed of variants of polymethyl methacrylate (PMMA). Soft contact lenses are made of a polymer such as poly hydroxyethyl methcrylate (pHEMA).

2.5.1.1. Rigid Gas Permeable Contact Lens

Rigid contact lens is made from a rigid or inflexible material that is incapable of being folded so that opposite edges can touch (Efron, 2002). The diameter of such lenses is smaller than the diameter of the cornea. The benefits of RGP contact lenses include good quality of vision, significant amount of astigmatism can be corrected, bifocal designs, irregular corneal management and the control of myopia (Bhattacharyya, 2009). Furthermore, comparative studies suggest that the risk of microbial keratitis is reduced for RGP contact lenses as compared to daily wear soft lenses and extended wear soft lenses (Liesegang, 2002).

Although there are many benefits of wearing RGP contact lenses, the following complications may occur (Eye Health Web):

- Eyes may become dry at the end of the day
- Adjustment period is necessary
- Abrasions may develop if foreign particles enter the eye
- Lenses may get lost due to the smaller size

The use of rigid gas permeable lenses offer superior vision, long term comfort, durability for more specialist applications such as the correction of keratoconus, high levels of astigmatism, post-surgery and for orthokeratology (Hom and Bruce, 2006).

The selection of gas permeable lens material commonly used today is fluoro-silicone/acrylate (Bennett and Hom, 2004). The addition of fluorine to silicone/acrylate increases deposit resistance of the lens material. Furthermore, fluorine promotes tear film interaction with the lens surface which increases tear film break-up time. Fluorine also assists with oxygen transmission through the lens material and this allows for the reduction in the silicone component in the lens material (Bennett and Hom, 2004).

Carrasquillo and Barnett (2014) stated that scleral contact lenses represent an area of major growth in the gas permeable lens industry. Advanced keratoconus can also be corrected with scleral lenses. Scleral lenses are also an excellent option for patients who have aphakia, corneal irregularity, or intolerance to corneal gas permeable lenses. Furthermore, scleral lenses can successfully serve as a prosthetic device for cases involving paediatric patients with damage to the ocular surface as well as patients with irregular corneas due to glaucoma surgery (Carrasquillo and Barnett, 2014). Scleral contact lenses are larger compared to corneal gas permeable contact lenses and this allows for better centration and comfort (Messer *et al*, 2015).

2.5.1.2. Conventional Hydrogel Contact Lenses

The first soft contact lenses, developed in 1954, were made of hydrogel materials (Lowther and Snyder, 1992). Conventional hydrogel materials are made of polymers that are composed of several monomers connected in chains which are joined by cross-linking agents to form a polymer network. Cross-linking of the polymeric chains is necessary to make the entire lens matrix stable and insoluble in an aqueous environment (Bennett and Weisman, 2005). The primary function of the chemical group in hydrogel contact lenses is to attract and bind water within the material (Efron, 2002). Hydrogel contact lenses differ from RGP lenses in their ability to bind substantial amounts of water (Bennett and Weismann, 2005).

According to Maldonado-Codina and Efron (2002), a hydrogel polymer suitable for contact lens material must possess suitable properties. These include:

- Optical transparency
- Have a refractive index comparable to that of the cornea, approximately 1.37
- Having adequate oxygen-permeability
- Having the appropriate hydraulic permeability
- Having adequate dimensional stability
- Having sufficient mechanical properties
- Having biocompatible properties in the ocular environment

Hydrogel lens materials can be further classified into two groups: firstly conventional or long term hydrogel materials and disposable hydrogel materials. The long term hydrogel materials are replaced every year or two years. Hypoxia related problems with conventional hydrogel contact lenses were eliminated by decreasing the thickness of the lenses as well as employing more hydrophilic monomers (Maldonado-Codina and Efron, 2002). However, the conventional hydrogel materials do not meet the requirements needed for safe continuous wear.

2.5.1.3. Silicone Hydrogel Contact Lenses

Contact lens materials have evolved considerably in recent years, particularly with materials providing greater levels of oxygen to the cornea. These materials, referred to generically as silicone hydrogels, were initially developed to overcome the complication of hypoxia in extended wear contact lenses (Bhattacharyya, 2009). The thicker lens design allows adequate oxygen transmission and the contact lens is less prone to on-eye dehydration (Hom and Bruce, 2006).

In soft silicone hydrogel contact lens material, silicone rubber is combined with hydrogel monomers (Sweeney, 2004; Efron, 2002). The process of combining these monomers is similar to the method of combining oil and water, while maintaining optical clarity (Sweeney, 2004). The silicone-rubber based material allows the lenses to be flexible and durable with exceptional oxygen transmission. However, the material elasticity of silicone hydrogel contact lenses remains “stiffer” than conventional hydrogel contact lenses (Efron, 2002; Maldonado-Codina and Efron, 2002). The increased rigidity or stiffness allows better handling of the contact lenses.

Contact lens materials in the silicone hydrogel categories increased slightly from 2013 to 2014 and currently stand at 68% of materials prescribed in the United States of America (Nichols, 2014). Furthermore, the 2014 annual report in contact lens prescribing in 32 countries worldwide suggests the rapid increase of silicone hydrogel materials, from more than 80% in Bulgaria and France to less than 10% in Taiwan and Nepal with an average of 49% worldwide (Morgan *et al*, 2014).

2.5.1.4. Cosmetic Contact Lenses

Cosmetic contact lenses are designed to enhance or alter eye colour. The coloured contact lenses have a valuable role as prosthetics for diseased and traumatised eyes (Hom and Bruce, 2006). Translucent tints are used to aid in contact lens handling or to enhance the natural eye colour. McMonnies (2013) reported that custom coloured contact lenses can reduce glare and photophobia in the case of damage to the iris or cornea. In incidents of abrupt diplopia or in cases of neurologically uncorrected diplopia, coloured cosmetic lenses can be prescribed to occlude the eye (McMonnies, 2013).

The coloured lenses are available in either hydrogel or silicone hydrogel lens material. According to Lam (2015), cosmetic contact lenses in silicone hydrogel material are new to the contact lens market and this material offers increased oxygen transmissibility to the cornea. Furthermore, cosmetic contact lenses are also manufactured in prescription to correct myopia as well as astigmatism.

In South Africa, cosmetic contact lenses are purchased over the counter as well as on the internet. The absence of a clinical consultation on the use and contact lens maintenance increases the risk of ocular complications. Moodley (2009) stated that current available cosmetic contact lenses in South Africa do not meet the design, parameter and fitting characteristics to provide optimum fits for a large proportion of the population. Zaslow *et al* (2014) further demonstrated by means of a retrospective chart review of all cases of microbial keratitis in minors secondary to cosmetic contact lens wear. Microbial keratitis, central ulcers as well as culture negative peripheral ulcers were reported in contact lens wearers that obtained cosmetic contact lenses over the counter by illegal sales (Zaslow *et al*, 2014).

Nichols (2015) reported using data obtained from GfK Retail and Technology and the ABB Optical Group, a decline of 2.5% of cosmetic contact lenses in the United States in 2014 as compared to 2009. However, Kading and Brujic (2013) stated that the use of colour contact lenses, both prescription and for cosmetic purposes is of significant value in the United States. Globally, soft lenses account for 91% of all contact lens fits of which 8% represent cosmetic lenses (Morgan *et al*, 2015).

2.5.2. Contact Lens Design

There are a wide range of contact lens designs available to correct a variety of vision problems. Contact lenses are composed of curved surfaces that are either spherical or non-spherical. For most contact lenses, the posterior central curve radius, commonly referred to as the base curve, is spherical (Lowther and Snyder, 1992). An aspheric contact lens is a gradual lengthening of the radius from the centre of the back surface to toward the edge of the lens (Lowther and Snyder, 1992). The popular contact lens designs include aspheric, spherical, toric, bifocal and multifocal contact lenses. For the purpose of this study, the bifocal, multifocal, monovision, spherical and toric contact lens design will be discussed.

2.5.2.1. Spherical Contact lenses

A sphere can be defined as a round geometrical object in three-dimensional space that forms the surface of a ball. A spherical base contact lens can be made to fit over the cornea in a manner that reduces instability and improves lens-cornea bearing relationship (Bennett and Weissmann, 2002). Spherical or aspheric contact lenses can be prescribed to correct common refractive errors such as myopia, hyperopia and presbyopia.

Spherical lenses are the most widely fitted contact lens design (Morgan *et al*, 2015; Thite *et al*, 2013; Mahadevan *et al*, 2015). Furthermore, soft contact lenses account for 91% of all contact lens fits of which 61% are made up of spherical soft lens design (Morgan *et al*, 2015). GfK Retail and Technology and the ABB Optical Group demonstrated a similar pattern in the U.S. market in 2014, with 62% and 63% respectively (Nichols, 2015).

2.5.2.2. Bifocal Contact Lens

Bifocal contact lenses are prescribed to correct presbyopia as well as common refractive errors such as hyperopia, myopia and astigmatism. Bifocal contact lenses are defined as lenses that provide two corrections: distant and near correction.

Bifocal contact lenses are available in a wide range of designs. The concentric ring design is made with distant prescription in the centre and is surrounded by alternating near and distant prescription. In this bifocal lens design, the contact lens must move up so that the near portion covers the pupil. This is also referred to as an alternating lens design because the contact lens moves between the distant and near portion (Lowther and Snyder, 1992).

In the aspheric design, the near and distant prescriptions are both found in front of the pupil. Both the concentric ring design and aspheric design gain additional near power by the slight shifting or translating of the lens upward by the downward gaze for reading. This is also referred to as the simultaneous lens design (Lowther and Snyder, 1992).

However, due to improvement in multifocal contact lens design, there has been a decrease in bifocal contact lens wear (Morgan *et al* (2014); Nichols, 2015).

2.5.2.3. Monovision Correction for Presbyopia

Monovision is a clinical approach to correcting presbyopia with contact lenses whereby one eye is given the required distant refractive power and the other eye is given the required near refractive power. This principle is based on the theory that the visual system can alternate central suppression between the two eyes when alternating between near and distant targets (Efron, 2002). All forms of soft contact lenses, both spherical and toric, and rigid contact lenses can be used for monovision correction. The usual fitting approach is to fit the dominant eye with the distant vision correcting lens and the near vision correcting lens is fitted onto the non-dominant eye.

The anisometropic contact lens correction, monovision, is one of the most successful methods of visual correction and this form of correction allows presbyopic patients to have clear vision at both distant and near (Bennett and Weissman, 2005). However, prescribing less minus power in the non-dominant eye provides the convenience of not requiring reading spectacles, but it can also disrupt binocularity (Brujic and Kading, 2015). Despite the technological advancements of multifocal contact lens designs, monovision correction of presbyopia continues to remain popular and successful. According to a recent annual survey of contact lens prescribing habits, 22% of practitioners prefer to fit monovision correction for presbyopic contact lens wearers (Nichols, 2015). Furthermore, monovision continues to be a popular option with a success rate of 70% or greater (Messer *et al*, 2015).

2.5.2.4. Multifocal Contact Lenses

Multifocal contact lenses can be defined as contact lenses that provide a visual correction in more than two distances, often in a progressive manner. Multifocal contact lenses are prescribed to correct presbyopia as well as hyperopia, myopia and astigmatism. The presbyopia market is growing yearly and every presbyopic patient should be given the option to wear contact lenses (Brujic and Kading, 2015). Multifocal contact lenses provide better stereo-acuity and clear vision at near, resulting in a better balance of real-world visual function because binocularity is less disrupted as compared to the monovision correction (Gupta *et al*, 2009).

Multifocal contact lenses are available in a number of designs and modalities (Brujic and Kading, 2015). These include:

- New-Centre Aspheric Optical Design. The near optics of this simultaneous lens design is located in the centre of the contact lens and slowly progress to distant optics in the periphery of the contact lens.

- Distant-Centre Alternating Design. The distant optics is located in the centre of the contact lens and alternates between near and distant toward the periphery of the contact lens.

- Distance-Centre Lens. The distant optics is located centrally in the contact lens, progressing to near optics at the periphery of the contact lens.

- Gas-Permeable Contact Lens Design. This aspheric design has the distant optics located centrally in the contact lens and progressing to near optics near the periphery of the contact lens.

- Scleral Contact Lens Design. The near optics is located in the centre of the contact lenses, progressing to distant optics in the periphery of the contact lens.

Improvements in multifocal contact lens technology resulting in higher add powers, better optics, and availability in hybrid and scleral designs are on-going. According to the Reader Profile survey in 2014 in the United States, soft spherical lenses made up of 51% of all contact lenses (Nichols, 2015). Furthermore, soft multifocal and soft gas permeable multifocal contact lens made up 14% and 2% respectively (Nichols, 2015). According to the 2014 report of current trends in contact lens practicing in 32 countries worldwide, 11% of contact lenses fitted included multifocal and monovision designs (Morgan *et al*, 2015).

2.5.2.5. Toric Contact Lenses

Toric contact lenses are specially designed to correct astigmatism. Most toric contact lenses are made of conventional hydrogel, silicone hydrogel as well as rigid gas permeable contact lens materials. Toric contact lenses have sphero-cylindrical powers in different meridians of the lens.

According to the GP Lens Institute (2015), there are three types of toric contact lens designs:

- Bi-toric Lens Design: This is a type of contact lens with two different curves. One curve is on the front surface and the other curve is on the posterior surface of the contact lens. This design of toric contact lens is indicated when the corneal cylinder is greater than or equal to -2.50 dioptres.

- Back-surface Toric Lens design: This contact lens is similar to bi-toric design. However the back toric use is restricted, as all back-toric designs create a residual astigmatism equal from one-third to one-half of the back-surface toricity of the contact lens.

- Front-surface Toric Lens Design: This contact lens design is specified for the correction of residual astigmatism.

Corneas with higher degrees of toricity utilise back-toric designs to align the meridians for greater consistency and stability of the contact lens (Bennett and Weissmann, 2002). Front-toric designs are contact lenses that are spherical on the back surface and toric on the front surface and these contact lenses are used to prescribe astigmatism present inside the eye (Goughary, 2006). Corneal astigmatism exceeding 3.00DC with-the-rule or 2.00DC against-the-rule can be corrected with a bitoric contact lens design (Goughary, 2006).

Regular astigmatism is defined by the major meridians of the refractive curvatures 90 degrees away from each other and irregular astigmatism is when the major astigmatic meridians are not 90 degrees apart (Bennett and Weissmann, 2002).

Toric contact lenses are essential for the correction of astigmatism. The improvement of toric lens designs has resulted in an upward prescription trend, with South Africa included as one of only six nations that meets the minimum prescribing rate for astigmatism (Morgan *et al*, 2013). Furthermore, there has been a constant increase in toric lens prescribing from 1996. According to Morgan *et al* (2015), toric contact lenses account for 20% of all soft lenses fitted worldwide. The proportion of toric lenses fitted including 1.00DC and 0.75DC of astigmatism is expected to increase to 35% and 45% respectively. Mahadevan *et al* (2015) reported that astigmatism with a cylinder error less than 0.75 were fitted with spherical contact lenses and a cylinder error greater than or equal to 0.75 were fitted with a toric lens.

2.5.3. Contact Lenses: Modality of Wear

Modality of contact lens wear refers to the duration that a contact lens is worn. The common contact lens wearing modalities include daily wear and extended wear. Daily wear contact lenses are removed at the end of each day whereas extended wear contact lenses can be worn constantly without removal for days, weeks or even a month. Nichols (2010) reported that the majority of contact lens wearers, in the United States of America, are wearing lenses on a daily wear modality. Furthermore, the modality of choice amongst participants in a hospital based study in India was daily wear (Mahadevan *et al*, 2015). A recent survey indicated that contact lenses for extended wear remain rarely prescribed with an average of only 8% of both new fits and refits in 32 countries worldwide (Morgan *et al*, 2015).

2.5.4. Contact Lenses: Frequency of Replacement

Frequency of replacement refers to how often contact lenses are discarded and replaced. The ideal contact lens replacement frequency would be one that is selected on the basis of the rate of lens spoilage of each patient, and would be such that comfort and vision does not deteriorate throughout the life of the contact lens (Efron, 2002). This rate of replacement is dependent on contact lens material and the tear film quality of the contact lens wearer. Contact lenses can be replaced daily, bi-weekly, monthly and yearly.

Mahadevan *et al* (2015) reported that the lens replacement schedule in a hospital based study in India was monthly followed by bi-weekly. Contact lens practitioners in the United States, participating in the Contact Lens Spectrum readers survey indicated that the mostly prescribed monthly replacement lenses (45%), and the daily disposable category increased from 20% in 2013 to 23% in 2014 (Nichols, 2015).

2.6. SYSTEMIC DISEASE CONSIDERATIONS FOR CONTACT LENS WEAR

Medical conditions are known to affect the eye and will therefore impact contact lens wear. Knowledge of presenting eye problems associated with common systemic diseases, atopic conditions as well as autoimmune disorders will facilitate diagnosis and management of common problems experienced by contact lens wearers.

2.6.1. Diabetes Mellitus

Diabetes mellitus can be described as a chronic condition in which the pancreas no longer produces sufficient insulin or the cells stop responding to the insulin.

Hence, cells of the body cannot absorb the glucose in the blood. Diabetes mellitus has diverse genetic, environmental, and pathological origins. This will be further discussed in terms of classification, ocular manifestations, prevalence and diabetes and contact lens wear.

2.6.1.1. Classification of Diabetes Mellitus

Insulin-dependent diabetes mellitus (IDDM, type 1 diabetes mellitus), is also referred to as juvenile-onset diabetes and occurs commonly in childhood or adolescence. In this form of diabetes, the body produces little or no insulin. Autoimmune destruction of pancreatic islet cells is hypothesized as instrumental in pathogenesis. IDDM is clinically characterized by hyperglycaemia and a tendency to diabetic ketoacidosis. Common symptoms include polydipsia, polyuria and weight loss (Kanski, 2011). Type 1 diabetes mellitus can be treated by keeping the blood sugar level within a normal range with several injections daily of different types of insulin.

Non-insulin –dependent diabetes mellitus (NIDDM, type 11 diabetes mellitus) is also referred to as age-onset or adult–onset diabetes. NIDDM is a heterogeneous group of disorders in which hyperglycaemia results from both reduced insulin secretory response to glucose and impaired insulin effectiveness. Common symptoms include polydipsia, polyuria, fatigue, increased hunger and weight gain. This form of diabetes is a slow-onset condition and can be controlled with nutrition and oral medication.

2.6.1.2. Ocular Manifestations of Diabetes Mellitus

Diabetes mellitus has important effects on the structure of the cornea. Corneal epithelial cells in diabetic patients exhibit a number of morphological changes. This include changes to a varying number of epithelial cell layers, a decrease in the number of cells, sectorial thinning, bullae, polymorphism, polymegethism as well as the presence of superficial debris (Sanchez-Thorin, 1998).

More common ocular manifestations include diabetic retinopathy and third and sixth nerve palsies (Lenake and Du Toit, 2014). Visual symptoms include blurred vision (Kanski, 2011). Uncommon ocular complications include accelerated senile cataract, rubeosis iridis and asteroid hyalosis (Kanski, 2011). Furthermore, decrease of visual acuity in diabetes is most commonly caused by vitreous haemorrhage, maculopathy, tractional retinal detachment, cataracts or neovascular glaucoma (Viswanath and Murray, 2003).

2.6.1.3. Prevalence of Diabetes Mellitus

Diabetes mellitus presents as one of the common chronic diseases in most countries. According to Motala *et al* (2008), the prevalence of diabetes in a rural South African community is 3.9%. The prevalence of diabetes among adults from 29 to 79 years for the years 2010 and the predicted value in 2030 in South Africa is 4.5% and 5.6% respectively (Shaw *et al*, 2009). Furthermore, Shaw *et* al (2009) reported that the prevalence of diabetes in the United Kingdom and in the United States of America is 4.9% and 12.3% respectively. The increase in the prevalence of diabetes worldwide predicted from 2010 to 2030 is 54%, at an annual growth of 2.2% (Shaw *et al*, 2009).

2.6.1.4. Diabetes and Contact Lens Wear

The literature on diabetes and contact lens use suggests that diabetic patients have decreased corneal sensitivity, physical and functional changes to the corneal epithelium as well as altered tear chemistry (O'Leary and Millodot, 2009). Furthermore, diabetic contact lens wearers are more inclined to develop eye infections (O'Donnell and Efron, 2012). There is an increased prevalence of blepharitis, burning and discomfort experienced by diabetic contact lens wearers

(O'Donnell and Efron, 2012). Blepharitis is a general term for eczema of the eyelid (Hom and Bruce, 2006).

2.6.2. Asthma and Eczema

Eczema and asthma are atopic conditions associated with allergic conjunctivitis, cataracts, keratoconus and reduced resistance to herpes simplex infection (Lenake and Du Toit, 2014).

2.6.2.1. Asthma

Asthma is a lung disease characterised by airway obstruction that is reversible, either spontaneously or with treatment. The airway obstruction is as a result of a combination of factors that include the spasm of smooth muscle, increased mucous secretion, edema of the airway mucosa, cellular infiltration of the airway walls as well as injury of the airway epithelium (Berkow *et al*, 1992). The symptoms experienced by asthmatics vary in frequency and degree. Common symptoms include coughing, wheezing, shortness of breath and respiratory distress. Furthermore, asthma is frequently associated with atopic dermatitis or eczema (Berkow *et al*, 1992).

2.6.2.2. Eczema

Eczema of dermatitis is an acute or chronic inflammation of the skin characterised by redness, edema, crusting, scaling and itching. Facial eczema is typically seen in infants and consists of dry, itchy and erythematous papules. Flexural eczema usually progresses in later stages with symmetrical involvement of the elbow and knee flexures, wrists and ankles by dry, lichenified or excoriated skin (Kanski, 2011). An allergen or irritant should be suspected as the cause in any form of dermatitis (Berkow *et al*, 1992). Eczema can be treated with ointments to hydrate the skin and the use of mild topical steroids (Kanski, 2011).

2.6.2.3. Ocular Manifestations of Asthma and Eczema

More common ocular manifestations of eczema include madarosis and staphylococcal blepharitis (Kanski, 2011). Keratoconjunctivitis, cataracts and keratoconus are also associated with eczema (Lenake and Du Toit, 2014. Asthma, allergy and eczema were commonly found among keratoconic subjects as compared to the general population in New Zealand and Aotearoa (Patel and McGhee, 2013). According to Vehof *et al* (2014), the risk factors that were significantly associated with dry eye disease were asthma, eczema, the presence of any allergy, cataract surgery, rheumatoid arthritis, migraine and stroke.

2.6.2.4. Prevalence of Asthma and Eczema

The prevalence of asthma in a study population of school children in Ireland increased from 21.7% in 2002 to 23.5% in 2007 (Duggen *et al*, 2012). Furthermore, Duggen *et al* (2012) reported an increase in the prevalence of eczema from 8.9% in 2002 to 13.5% in 2007. Similarly, Khor *et al* (2011) concluded that the prevalence of asthma and eczema, in a hospital-based population study of Asian patients with keratoconus, was 26.3% and 18.4% respectively.

2.6.2.5. Asthma, Eczema and Contact Lens Wear

Contact lens wearers that have asthma and/or eczema experience dry eye symptoms (Verhof *et al*, 2014). In severe cases of dry eye, contact lens wearers are encouraged to discontinue contact lens or decrease wearing time until symptoms improve. A higher water content daily disposable lens is recommended for contact lens wearers with symptoms of dry eyes (Townsend, 2012).

2.6.3. Rheumatoid Arthritis

Rheumatoid arthritis is a chronic autoimmune disease characterized by nonspecific, usually symmetric inflammation of the joints which results in progressive destruction of articular and periarticular structures (Berkow *et al*, 1992). Onset is of any age, but it most often occurs between the ages of twenty five and fifty years. Rheumatoid arthritis may occur occasionally in childhood (juvenile rheumatoid arthritis). It affects females more commonly than males (Kanski, 2011). Onset may be sudden, with simultaneous inflammation in multiple joints. Furthermore, stiffness in joints as well as early afternoon fatigue and malaise may occur.

Conservative treatment results in approximately 75% of patients improving during the first year of the disease and 10% are eventually fully disabled despite full treatment (Berkow *et al*, 1992). Treatment options include nonsteroidal anti-inflammatory drugs (NSAIDs), gold salts, penicillamine, hydroxychloroquine, sulphasalazine, corticosteroids and cytotoxic agents. According to Lenake and Du Toit (2014), ocular side effects with administering corticosteroids include glaucoma, cataracts and worsening of herpetic keratitis.

2.6.3.1. Ocular Manifestations of Rheumatoid Arthritis

Diseases such as rheumatoid arthritis can cause various forms of ocular inflammation. Ophthalmic feature of rheumatoid arthritis include keratoconjunctivitis sicca (secondary Sjogren syndrome). More common ocular manifestations include scleritis, episcleritis and keratitis (Lenake and Du Toit, 2014). Management of rheumatoid arthritis includes treating the systemic condition and referral for immunosuppressive therapy for the ocular condition.

2.6.3.2. Prevalence of Rheumatoid Arthritis

The incidence and prevalence of rheumatoid arthritis differ among populations, statistical methods and disease definitions. The prevalence of rheumatoid arthritis in a Swedish study population of 58102 individuals yielded a prevalence of 0.77% (Neovius *et al*, 2010). Similarly, the prevalence in North America is estimated at 20-50 cases per 100 000 population and the prevalence range from 0.5 to 1.1% (Tobon *et al*, 2010).

2.6.3.3. Rheumatoid Arthritis and Contact Lens Wear

Lee *et al* (2012) found that Asian contact lens wearers with rheumatoid arthritis tend to experience dry eyes and more severe ocular surface damage in the superior cornea. Contact lens wear may also cause an inflammatory reaction to the cornea (Markoulli *et al*, 2012). Refitting with silicone hydrogel or daily wear lenses may help to reduce contact lens-related adverse conditions (Markoulli *et al*, 2012).

2.6.4. Thyroid Disease

In order to understand thyroid disease and the ocular manifestations, a basic knowledge of the physiology, anatomy and pathology of the thyroid gland is required. The thyroid gland is composed of two vertically shaped lobes, connected by an isthmus and is located anterior to the oesophagus, just beneath the larynx. The thyroid gland is vascularised and absorbs iodine from the circulation. The thyroid hormones are released to the rest of the body once the hormones bind to the circulating blood proteins. The thyroid hormones are responsible for increased fat and carbohydrate metabolism, increased oxygen consumption in most part of the body as well as reducing cholesterol levels. Any condition that can affect the balance in the thyroid hormones can affect the overall physical health.

Thyrotoxicosis (hyperthyroidism) is a clinical condition involving secretion of thyroid hormones (Kanski, 2011). Graves' disease, the most common type of hyperthyroidism, is an autoimmune disorder. This is characterized by IgG antibodies binding to thyroid-stimulating hormone (TSH) receptors in the thyroid gland which in turn causes the release of thyroid hormones. The most common cause of hyperthyroidism results from inflammation and infiltration of CD3 T lymphocytes. Enlargement of the thyroid is also a common sign of hyperthyroidism.

Many symptoms and signs are associated with hyperthyroidism. Presentation is usually in the third or fourth decade with weight loss, increased bowel frequency, palpitations, weakness, sweating, irritability, and fatigue. External signs include diffuse thyroid enlargement, fine hand tremor, finger clubbing, alopecia and vitiligo (Kanski, 2011). Treatment options may include carbimazole, propranolol, radioactive iodine as well as partial thyroidectomy.

Patients with hypothyroidism can be asymptomatic or may report muscle or joint stiffness and pain, weight gain, dry skin, constipation and reduced tolerance to cold. According to Townsend (2008) 27% of patients with hypothyroidism showed signs of Sjogren's syndrome. Treatment options include synthetic preparation of thyroxine, liothyronine, combination of synthetic hormones or desiccated animal thyroid (Berkow, 1992).

2.6.4.1. Ocular Manifestations of Thyroid Disease

The more common ocular manifestations include thyroid eye disease. This is characterized by proptosis, lid retraction, optic neuropathy, restrictive myopathies and soft tissue swelling (Lenake and Du Toit, 2014). Furthermore, uncommon ophthalmic features include superior limbic keratoconjunctivitis sicca and diplopia (Kanski, 2011). Similarly, Ismailova *et al* (2013) revealed that that 65.2% of patients with Thyroid disease experienced dry eye syndrome and histological changes in the conjunctiva. The changes in the eyes are due to excessive adrenergic stimulation and remit upon treatment of thyrotoxicosis (Berkow *et al*, 1992). Radioactive iodine, which is recommended in the treatment of hyperthyroidism, can impair thyroid disease (Kanski, 2011).

The European Group on Graves' Ophthalmopathy (Lenake and Du Toit, 2014) classified the severity of thyroid eye disease follows:

Mild disease: This stage of thyroid eye disease is not sufficient to warrant immunosuppressive or surgical treatment. Mild thyroid eye disease is characterised by mild soft tissue involvement, mild lid retraction of less than 2mm, proptosis is less than 3mm and there are no signs of optic neuropathy or corneal exposure. Treatment of mild thyroid disease is with the use of lubricant and an antioxidant.

Moderate to severe disease: This stage of thyroid disease does not affect the vision, but has sufficient impact to warrant immunosuppressive therapy. Moderate thyroid disease is characterised by moderate to severe soft tissue involvement, lid retraction of more than 2mm, proptosis of more than 3mm and diplopia. Treatment of moderate disease is by immunosuppressive therapy and with the use of a systemic steroid for six to twelve weeks.

Severe disease: This stage of thyroid eye disease includes optic neuropathy and/or corneal breakdown. Treatment of this stage of thyroid disease is with a systemic steroid. Orbital decompression is required if treatment with steroids does not improve the condition.

2.6.4.2. Prevalence of Thyroid Disease

The prevalence of subclinical hypothyroidism was found to be 0.9% in a sample population of 563 participants at the Kalafong Hospital Diabetics Clinic in Gauteng, South Africa (Ueckermann and Van Zyl, 2013). Furthermore, the prevalence of subclinical hypothyroidism was found to be 1.6% in a subgroup of participants with type 2 diabetes mellitus (Ueckermann and Van Zyl, 2013). The prevalence of hypothyroidism was significantly higher in an Indian population of 5376 adult males and females, eighteen years of age and older. This was founfd to be 10.95% (Umnikrishnan, 2013).

2.6.4.3. Thyroid Disease and Contact Lens Wear

Keay *et al* (2009) reported poor health and thyroid disease were common in cases of contact lens-related microbial keratitis in Australia and New Zealand. Furthermore, flexibility in wearing schedules should be recommended to contact lens wearers with thyroid disease to manage symptoms associated with this systemic disease (Keay *et al*, 2009). According to Rakow (2012), there is an increased prevalence of thyroid disease in the presbyopic age group and this in turn may be responsible for dry eyes. Gas permeable (GP) multifocal lenses will increase wettability and increase wearing time (Rakow, 2012). Townsend (2012) recommended wetting agents or a lens lubricant to alleviate symptoms of ocular dryness resulting from contact lens wear.

2.7. CONTACT LENS COMPLICATIONS

Although contact lens materials continue to evolve, long term use of contact lenses can affect the physiology of the cornea (Holden *et al*, 1985). Furthermore, incorrect use of contact lenses can cause various complications, which are manifested in several clinical signs and symptoms. This study will review common complications associated with contact lens wear and the appropriate management. Blepharitis, dry eyes, hyperaemia, hypoxia and neovascularisation will be further discussed.

2.7.1. Blepharitis

Blepharitis is an inflammation that affects the part of the eyelids where the eyelashes grow. It is a chronic condition that is often difficult to treat. Blepharitis affecting the external eyelids, lid margin, conjunctiva and cornea can introduce bacterial by-products into the tear film thus affecting the quantity and quality of tear film lipids. The result for contact lens wearers can be discomfort and reduced visual acuity (Brujic, 2014).

Due to the constant lid contact with the surface of the eye, chronic blepharitis could result in secondary changes in the conjunctiva and the cornea (Kanski, 2003). According to Brubaker *et al* (2013) blepharitis is associated with a variety of symptoms ranging from mild irritation to persistent irritation, burning, itching, redness, pain, vision disturbances and ocular fatigue.

Chronic blepharitis can be classified into two subgroups, anterior and posterior blepharitis (Kanski, 2003). Anterior blepharitis is the inflammation of the eyelash follicles, while posterior blepharitis affects the Meibomian glands. Anterior blepharitis can include both staphylococcal infection as well as seborrhoea. Staphylococcal blepharitis is indicated by hyperaemia and telangiectasia on the anterior lid margins. Hard scales are found largely near the base of the eyelashes.

Seborrhoeic blepharitis is usually associated with seborrhoeic dermatitis which may involve the scalp, nasolabial folds, retroauricular areas and sternum (Kanski, 2003). It is characterized by hyperaemic and greasy anterior lid margins. The lashes stick together and the soft scales are and situated on the lid margin and lashes.

Posterior blepharitis is manifest by excessive meibomian gland secretion. Small oil globules accumulate on the meibomian gland orifices. The tear film appears oily and foamy and collects on the lid margins or inner canthi (Kanski, 2003). Posterior blepharitis may also result in complications such as chalazion formation, tear instability and inferior corneal epithelial erosions.

2.7.1.1. Prevalence of Blepharitis

According to Lemp and Nichols (2009) ophthalmologists and optometrists report that blepharitis is frequently seen in clinical practice in 37% and 47% respectively. Furthermore, the data suggested that symptoms associated with blepharitis were very common in the United States, with the younger population experiencing more recurrent symptoms than the older population (Lemp and Nichols, 2009).

2.7.1.2. Management of Blepharitis

Blepharitis does not have a permanent cure but the control of symptoms can be successfully achieved (Kanski, 2003). Treatment of anterior blepharitis is preceded by simple lid hygiene. The scales or crusts, depending on severity, can be hard or soft and are located around the base of the lash and the lid margin. This can be removed by daily scrubbing of the eyelid margins with a weak solution of sodium bicarbonate or a weak solution of baby shampoo (Kanski, 2003). Following lid hygiene, a weak antibiotic ointment such as sodium fusidate can be used. Weak topical steroids, such as fluoromethalone, can also be administered for secondary papillary conjunctivitis as well as marginal keratitis. Tear substitutes are also recommended for related tear film instability (Kanski, 2003).

Posterior blepharitis can be treated with the use of systemic tetracyclines. Erythromycin or azithromycin may be used when treatment with tetracyclines are contraindicated. Warm compresses are applied to eyelid margins to melt and expel solidified sebum as well as to reduce lipids within the meibomian glands (Kanski, 2003).

According to Brujic (2014), the best option for contact lens wearers experiencing mild symptoms of blepharitis is daily disposable contact lenses which are discarded at the end of each day. In severe cases of blepharitis, it is often recommended to reduce or suspend lens wear (Brujic, 2014).

2.7.2. Dry Eye Syndrome

Keraoconjuntivitis sicca (KCS) refers to any eye with some degree of dryness (Kanski, 2011). Dry eyes occur when insufficient tear volume or function results in an unbalanced tear film and ocular surface disease (Kanski, 2011). The tear film is mechanically spread over the ocular surface by the blinking action of the eyelids.

The tear film consists of three layers, each of which has distinct functions. The outer lipid layer is secreted by the meibomian glands. Dysfunction of this layer may result in an evaporative dry eye. The middle layer or aqueous layer is secreted by the lacrimal glands, Glands of Krause and Glands of Wolfring. The main lacrimal glands produce 95% of the aqueous component of the tears. Deficiency of the aqueous layer results in hyposecretive dry eye (Kanski, 2003). The innermost layer situated against the cornea and conjunctiva is the mucin layer. The mucin layer is secreted by the conjunctival goblet cells, the crypts of Henle and the glands of Manz. Deficiency of this layer may be of both hyposecretive and evaporative state of dry eye. Contact lens wear as well as air condititioning can cause KCS (Kanski, 2011).

The two main categories of dry eye are hyposecretive and evaporative.

2.7.2.1. Hyposecretive Dry Eye Syndrome

Hyposecretive may be classified as Sjogren Syndrome and Non-Sjogren Syndrome.

Sjogren hyposecretive KCS: Sjogren syndrome is an inflammatory process that affects the lacrimal glands and ducts resulting in abnormalities in the tear film with ocular surface disease. Primary Sjogren syndrome is characterised by the presence of antibodies indicative of autoimmune pathogenesis. Secondary Sjogren syndrome is characterised by a systemic autoimmune connective tissue disorder such as arthritis, lupus erythematous as well as mixed connective tissue disease (Kanski, 2003).

Non-Sjogren KCS: The most common form of Non-Sjogren syndrome is primary age-related dry eye. Destruction of the lacrimal tissue as well as absence of the lacrimal gland may also result is Non-Sjogren syndrome. Furthermore, obstruction of the lacrimal gland as a result of conjunctival scarring may cause dry eyes (Kanski, 2003).

2.7.2.2. Evaporative Dry Eye Syndrome

The most common causes of evaporative KCS are oil deficiency and obstructive meibomian gland dysfunction. Abnormal or incomplete blinking may result in defects in the tear film surface resulting in symptoms of dry eye. Furthermore, environmental factors such as air conditioning as well as contact lens wear may result in evaporative dry eyes (Kanski, 2011).

2.7.2.3. Prevalence of Dry Eye Syndrome

Dry eye syndrome is estimated to be one of the most common ocular problems in the United States particularly among older women (Schaumberg *et al*, 2003). The prevalence of dry eye syndrome increases with age, from 5.7% among women 50 years and older to 9.8% among women aged 75 years and older (Schaumberg *et al*, 2009). A similar study by Schaumberg *et al* (2009) measured the prevalence of dry eye syndrome among men in the United States. The results of the study yielded a prevalence of 3.9% among men aged 50 years and older to 7.67% among men aged 80 years and older. Hence, it was concluded by Schaumberg *et al* (2009) that aging is associated with the development of meibomian gland dysfunction, which results in tear film instability and evaporative dry eye.

The prevalence of dry eye symptoms in a study population of students studying optometry at the University of Johannesburg show that 64% of the sample have at least mild dry eye symptoms (Gillian, 2009). According to Gillian (2009), the high incidence of dry eye symptoms could be due to the high attitude and relatively lower humidity in Johannesburg, South Africa.

Nichols and Sinnott (2006) investigated dry eye symptoms in contact lens wearers. Contact lens wearers (N = 415) were tested and 55.3% were classified as having contact lens-related dry eye using a self-administered questionnaire. It was found that contact lens-related dry eye may be described by an increase tear film thinning resulting in increased tear film osmolality. Similarly, Begley *et al* (2000) administered a dry eye questionnaire randomly to contact lens wearers at a private practice in Toronto, Canada. Results showed that ocular dryness and discomfort were reported among contact lens wearers.

2.7.2.4. Management of Dry Eye Syndrome

The main aim of treatment of dry eye is to relieve discomfort, prevent structural damage to the cornea and provide a smooth optical surface (Kanski, 2003). The method of treatment depends on the severity of the dry eye problem. This can be achieved with the use of tear substitutes, reduction of tear drainage by punctal occlusion and the administration of anti-inflammatories. Low water content HEMA lenses may be successfully fitted to moderately dry eyes (Kanski, 2011). Silicone hydrogel lenses that contain no water and readily transmit oxygen are effective in protecting the cornea in extreme tear film deficiency (Kanski, 2011). Kok and Visser (1992) fitted large diameter scleral lenses for contact lens wearers that experienced corneal surface disorders and dry eye conditions. A significant improvement of visual acuity and an improvement in lens tolerance were found. Bennet *et al* (2014) confirmed the benefits of scleral lenses for contact lens wearers that experience dry eyes.

2.7.3. Hyperaemia

Hyperaemia is defined as an excessive amount of blood in an organ or part thereof. Contact Lens-Induced Acute Red Eye (CLARE) presents as an acute inflammatory reaction of the anterior segment characterised by severe conjunctival and limbal hyperaemia. Corneal staining, when present, is usually scattered and superficial. Symptoms present as an acute onset of tearing, pain, photophobia and injection.

Evidence indicates that inflammatory mediators such as endotoxins released from gram-negative bacteria on the lenses or in the solutions and cases are responsible for this immune reaction (Holden *et al*, 1996). Furthermore, contact lenses fitted tightly and worn overnight, together with gram-negative bacteria is associated with the onset of CLARE (Morris, 2006).

2.7.3.1. Prevalence of Hyperaemia

Holden *et al* (1985) reported that the contamination of hydrogel contact lenses worn overnight resulted in CLARE reactions in 33% of the participants and infiltrates was found in 44% of the study participants.

2.7.3.2. Management of Hyperaemia

Hyperaemia or CLARE can be treated by removing the stimulus to inflammation. Discontinuation of contact lenses is recommended. General management of CLARE requires lid hygiene, a looser fitting lens as well as switching to daily wear contact lenses (Morris, 2006). Antibiotic and corticosteroid treatment can be used when the inflammation is severe and faster resolution is required (Szczotka-Flynn, 2011). According to Morris (2006), approximately one third of all cases of CLARE will recur especially as a higher incidence of this reaction is seen in contact lens wearers suffering from an upper respiratory infection.

2.7.4. Hypoxia

Hypoxia is a condition in which the body or a part thereof is deprived of adequate oxygen supply. A frequent cause of hypoxia is a contact lens that is very thick and/or lens manufactured in a low oxygen-transmissible material (Laurent and Lee, 2013). This condition is commonly referred to as corneal oedema.

Microcyst formation is a distinctive indicator of contact lens-induced hypoxia (Morris, 2006). The microcysts present as minute, irregular shaped inclusions usually found in the central to mid-peripheral zones of the cornea. Striae can be seen in the stromal layer of the cornea. The striae appear when the cornea swells. It has been suggested that the striae are due to fluid separation of the vertically orientated collagen fibrils within the cornea (Morris, 2006). Vision is generally unaffected except in very severe cases of hypoxia. Another sign of corneal hypoxia is neovascularisation.

Contact lenses with a tight fit may also cause corneal oedema. The blinking action allows tears to circulate across the surface of the eye. A tight lens prevents tear circulation and hence decreases oxygen transmission to the cornea. This leads to swelling of the cornea as well as further drying of the contact lens. Symptoms may include redness, eye irritation, blurred vision, burning or a dry sensation of the eye.

2.7.4.1. Prevalence of Hypoxia

The prevalence of corneal oedema was less than 5% in nine hundred and fifty-three contact-related complication recorded in a hospital setting in Singapore (Teo *et al*, 2011). According to Sapkota *et al* (2013), corneal neovascularisation as a result of hypoxia was prevalent in 3.5% of the 4.9% of soft contact lens wearers presenting with complications as a result of contact lens use in a tertiary eye care centre Nepal.

2.7.4.2. Management of Hypoxia

Kading and Brujic (2013) reported a reduction in contact lens-related hypoxia with the introduction of latheable silicone hydrogel lenses. Michaud *et al* (2012) suggested further research to refine scleral lens fitting with regard to corneal physiology. To minimise hypoxia-induced corneal swelling it is recommended that scleral lenses be manufactured with the highest oxygen transmissibility available and a maximum central thickness of 250 micrometres (Michaud *et al,* 2012). Furthermore, it is recommended to discontinue overnight wear of contact lenses. Contact lens wearers experiencing corneal oedema as a result of tight lens syndrome can be refitted with a smaller diameter and larger base curve contact lens.

2.7.5. Neovascularisation

Neovascularisation is the in-growth of blood vessels into the avascular corneal tissue. The cornea acquires oxygen from the atmosphere. Neovascularization may occur as a result of chronic hypoxia, inflammation, trauma as well as interstitial keratitis (Kanski, 2003). Blood vessels may extend 2mm to 4mm into the cornea around the entire limbus. According to Josephson and Caffrey (2000), vascularisation can also occur when soft hydrogel contact lenses fit tightly. This would result in infringement and compression of the limbal conjunctiva and associated vessels (Josephson and Caffrey, 2000). A poorly fitted contact lens may result in a decrease in the oxygen supply (Josephson and Caffrey, 2000).

Neovascularisation can be classified as deep and superficial. Superficial neovascularisation is more common with contact lens wear. Contact lens wearers may be asymptomatic although blood vessels may be seen proliferating into the limbal area. In more severe cases, contact lens wearers may experience pain, tearing, photophobia, injection and contact lens intolerance.

Liesegang (2002) summarised the severity of limbal neovascularisation as follows:

1. Limbal hyperaemia: the existing limbal capillaries become distended. This is more common in soft hydrogel contact lens wearers.
2. Superficial neovascularisation: there is a progression of limbal hyperaemia and in-growth of blood vessels up to 4mm into the cornea.
3. Deep stromal neovascularisation: secondary to chronic hypoxia and can lead to the development of inflammation with blood vessels extending past 4mm into the cornea.
4. Intercorneal haemorrhage: this may occur in very severe cases.

2.7.5.1. Prevalence of Neovascularisation

Neovascularization as well as other signs of corneal hypoxia are seen mainly in soft lens wearers as well as extended wear. Fonn *et al* (2002) conducted a study on the performance of soft hydrogel lens material and concluded that at least 65% of the study population showed signs of corneal and limbal neovascularization at the conclusion of the study. The prevalence of corneal neovascularisation as a result of contact lens wear was 4% in a study population of 1255 participant in a tertiary eye centre in India (Nagachandrika *et al,* 2011). Teo *et al* (2013) reported the prevalence of corneal neovascularisation as 8.1% in 953 contact lens-related complications in a hospital setting in Singapore.

2.7.5.2. Management of Neovascularisation

In the case of neovascularisation as a result of soft contact lens wear, it is suggested by Laurent and Li (2013) to discontinue overnight wear. Contact lenses can be refitted with silicone hydrogel lenses and wearing time should be reduced. According to Josephson and Caffrey (2000), the curvature of the contact lens should be adjusted to promote more movement of the contact lens. Adequate movement of the contact lens allows tear exchange thus providing the necessary amount of oxygen transmissibility. However, ghost bloods vessels may remain which have the capacity to fill again if the cornea is subjected to a similar hypoxic environment.

The incidence of neovascularisation in gas permeable contact lens wear is rare due to the improved oxygen permeable material as well as the smaller lens diameter. Gas permeable lenses are fitted with good centration and edge clearance; hence this fitting prevents neovascularization (Josephson and Caffrey, 2000).

According to Bennet *et al* (2014), the oxygen permeability of scleral lenses is high and will therefore reduce or eliminate neovascularization in contact lens wearers.

2.8. CONCLUSION

This chapter has reviewed the literature relevant to this study. The anatomy and physiology of the eye related to contact lens wear, common refractive errors, contact lens designs and materials, problems experienced by contact lens wearers and methods of management of the problems was discussed. Finally, medical conditions that affect the eye and how these impacts on contact lens wear were discussed. The next chapter will discuss the methodology used in conducting the research.

CHAPTER 3. METHODOLOGY

3.1. INTRODUCTION

This chapter outlines the research methodology design, the study area, the study population and the selection of the sample population. The data collection instrument, the method of data collection, data analysis as well as the ethical considerations will be discussed.

3.2. RESEARCH DESIGN

According to Creswell and Plano Clark (2007), quantitative research allows an unbiased result that can be generalised to the larger population, whereas qualitative research is seen as deficient because of personal interpretations made by the researcher thus creating bias. Furthermore, quantitative data can be easily collected by means of a structured questionnaire and the data can be analysed by means of statistics, graphs and diagrams. Therefore, a quantitative research design was selected to collect data in this study.

3.3. STUDY POPULATION

The primary population in this study included all optometrists, registered with the Health Professions Council of South Africa (HPCSA), practicing in KwaZulu-Natal. The secondary population in this study included all contact lens wearers in KwaZulu-Natal. The contact lens wearers comprised the unit of analysis in this study.

3.4. STUDY SAMPLE AND SIZE

Probability sampling technique was used for the two stage sampling procedure.

Stage 1:

Simple random sampling strategy was used to determine the primary population of optometrists. Efron *et al* (2010) conducted a ten year survey of contact lens prescribing trends in Australia with an average of 146 participants per year. The international contact lens prescribing included participants based on the total number of contact lens practitioners in the different countries. This ranged from 1000 participants in the United States and the United Kingdom to 502 participants in Norway. According to the HPCSA, the total number of contact lens practitioners registered in KwaZulu-Natal as at 06 May 2014 was 642 (Appendix VII). This number was based on personal postal addresses of the practitioners.

To achieve 95% confidence interval, a minimum sample population of 40 participating optometrists was recommended. However, in anticipation of incomplete questionnaires as well as non-response, it was decided to include 55 participants.

Stage 2:

A cluster sampling strategy was used to select the secondary population of contact lens wearers in this study. Each participant selected in the primary population sample was requested to provide generic information on ten consecutive contact lens wearers seen in the optometric practice. The secondary population comprised 1460 contact lens wearers in Australia, 5020 contact lens wearers in Norway and 10000 contact lens wearers in the United States (Efron *et al*, 2010). Furthermore, Thite *et al* (2013) included 2570 contact lens wearers to obtain information on the contact lens prescribing pattern in India in 2011. Therefore, proposed population sample of 400 contact lens wearers was recommended by the statistician. However, in anticipation of incomplete questionnaires as well as non-response, it was decided to include 550 participants.

3.5. INCLUSION AND EXCLUSION CRITERIA

3.5.1. Contact lens practitioners

The participants were selected according to the following inclusion criteria:

- Contact lens practitioners registered with the HPCSA
- Contact lens practitioners practicing in KZN

The following exclusion criteria were used to select the participants:

- Participants employed at the University of KwaZulu-Natal. Optometrists employed by the University are involved in the academic field and do not prescribe contact lenses.
- Participants employed by the Department of Health: Province of KwaZulu-Natal. At present, the optometrists employed by the Department of Health do not prescribe contact lenses. Contact lens wearers are referred to the private contact lens practitioners.

3.5.2. Contact Lens Wearers

The participants were selected according to the following inclusion criteria:

- A comprehensive contact lens consultation was performed and contact lenses were prescribed
- Contact lens wearers of all ages, gender and race was included

The following exclusion criteria were used to select the participants:

- The contact lens wearer that present with any contact lens complication or eye infections
- Speciality contact lens fitting. Orthokeratology was excluded due to the aim of this study was to describe contact lenses prescribed to correct common refractive errors

3.6. DATA COLLECTION INSTRUMENT

The questionnaire designed and used by Morgan *et* al (2001-2014) for the international contact lens prescribing trends was modified and adapted to suite the contact lens market in KZN (Appendix I). The detail of this questionnaire is in the public domain (Appendix II).

The questionnaire which comprised of largely closed-ended questions was used as the data gathering instrument. According to Fink (2013), majority of surveys rely on multiply choice questioning because it has proven to be more efficient and reliable. Furthermore, reliability of the questionnaire as a result of uniform data collection and efficiency comes from ease of usage, data analysis and interpretation of data (Fink, 2013).

The questionnaire was divided into two sections:

Section 1:

This section was optometrist profile based. Demographic information included gender, race (optional), qualification, number of years of experience, type of practice and practice setting. The questions relating to contact lens practicing trends included, as an estimate, percentage of different contact lenses prescribed, prevalence of non-compliance as well as percentage of contact lens wearers that account for the practice. This section contained 14 questions. Thirteen questions were closed-ended and one question was open-ended.

Section 2:

This section was contact lens wearer profile based. Information on ten consecutive contact lens wearers, after receipt of the questionnaire, was requested. The demographic information included gender, age and race (optional). The questions relating to contact lens wear included contact lens design, material, modality of wear and frequency of replacement of contact lenses prescribed. In addition, problems encountered by contact lens wearers and management of problems were also requested. This section contained 15 questions. Fourteen questions were closed-ended and one question was open-ended.

3.7. DATA COLLECTION PROCESS

A survey in the form of a self-administered questionnaire was used in the data collection process. The advantage of self-administered questionnaires is that the participants are comfortable answering questions with regard to sensitive issues. However, the disadvantage of mail surveys is that the survey is subject to non-response bias (Floyd and Fowler, 2009). Failure to collect responses from sample population is also a potential source of selection bias. To effectively increase the response rate, all participants were reminded in the form of an email as well as a telephone call.

Participants of the primary sample population, that were randomly selected, were invited to participate in the research study. The participants of the study were advised on the aims of the investigation together with direction on the method of data submission and return.

The contact lens practitioners were requested to supply information on the first ten contact lens fits performed after receipt of the survey. Contact lens wearers consent forms were provided. The contact lens wearers were informed by the contact lens practitioners as to the nature of the survey and the information collected was used for academic purposes only (Appendix VI). Demographic information (age, gender, race) and contact lens information (lens design, material, modality of wear and frequency of replacement) was obtained from record cards. The questionnaires were completed by the contact lens practitioners in the practice of the practitioner.

A self-addressed stamped envelope was provided to ensure ease of return. The questionnaires, together with the cover letter, consent form and information document were either hand delivered or posted to the participants. Participants were required to return the questionnaire within two months.

Data collection was conducted from 1 November 2014 to 31 March 2015. All returned questionnaires were checked and incomplete questionnaires were excluded from the study.

3.8. DATA MANAGEMENT

The completed questionnaires were coded and represented numerically. Data from the questionnaires was captured on Microsoft Excel 2010 spread sheets. According to Alreck and Settle (2004), the most common programme for data entry with ease of data analysis is a spreadsheet. The responses from the two open-ended questions were classified into simple categories. Each category represented a theme in the response. This allows qualitative data to be analysed quantitatively (Trochim, 2001).

The completed questionnaires and consent forms were stored in a locked cupboard and will be kept for five years, after which it will be shredded. A password protected computer was used to store information. Only the researcher has access to the computer.

3.9. DATA ANALYSIS

The data was analysed in two sections: the optometrist profile as well as the contact lens wearer profile. Data was processed and analysed using the Statistical Package of Social Sciences (SPSS), version 21. Due to the complex survey design, sampling weights was applied to take into account the cluster sampling selection of contact lens wearers. Furthermore, 95% confidence intervals were constructed around all proportions when making inferences regarding the larger population of contact lens wearers. Age was summarized using mean, standard deviation and range (minimum – maximum). If age was skewed then medians and interquartile ranges was presented. Bar graphs were presented to graphically summarize age by various categorical variables.

As the questions are largely categorical, frequency tables and bar charts are presented. Associations between categorical variables were tested using the standard Pearson's chi-square ($\chi 2$) test. When the expected cell count in any cross tabulation was less than 5 then the Fishers exact test was preferred.

This sample size factors in a design effect of two which is routinely used in prevalence surveys employing a cluster sampling strategy. This correlation factor accounts for the heterogeneity between clusters with regard to the measured indicator. An adjustment for design effect was needed as contact lens wearers utilizing any one optometrist practice were more likely to be similar. A proposed sample size also yields a precision of ±7%. The 95% confidence level will have a total width of 14%.

3.10. ETHICAL CONSIDERATIONS

Approval to conduct this study was obtained from the Humanities and Social Sciences Research Ethics Committee (HSSREC), Faculty of Health Sciences, University of KwaZulu-Natal (Protocol reference number: HSS/0722/014M) (Appendix III). Gatekeeper permission was obtained from the relevant participating franchise optometric practices (Appendix IV). All participating optometrists received an information document as well as a consent form (Appendix V). The information document outlined the nature of the study as well as the purpose of the study. The name, telephone number and email address of the researcher, academic supervisor as well as the relevant people in the HSSREC was provided.

Furthermore, contact lens wearers were informed that all information required for the study was collected and used anonymously (Appendix VI). Informed consent was also obtained from all contact lens wearers. Anonymity of all participants was protected and each participant was assigned a research code. In addition, participants were advised that participation in this study was voluntary and can be terminated at any time without any negative consequences.

3.11. CONCLUSION

The chapter describes the methodology employed in conducting the study in order to obtain satisfactory results to the research objectives. The next chapter will present a summary of the findings of the information collected and the analysis of data collected.

CHAPTER 4. RESULTS

4.1. INTRODUCTION

The aim of this study was to determine the contact lens prescribing trends in KwaZulu-Natal for the correction of common refractive errors. A quantitative research method was used to collect data. The data was collected by means of a structured two part questionnaire. This chapter will present the results of this study in two sections; the contact lens practitioner profile and the contact lens wearer profile. The responses to each question will be presented using descriptive statistics and associations between categorical variables will be described.

4.2. SECTION 1: OPTOMETRIST PROFILE

The primary population in this study consisted of 40 participants. The results will include the demographic profile of contact lens practitioners as well as the contact lens practicing trends in KZN.

4.2.1. Demographic Details

The primary population sample consisted of 35% male and 65% female contact lens practitioners as shown in Figure 4.1. Although the racial profile of the contact lens practitioner was an optional question, all participants responded. Majority (60%) of the participants were Indian, 25% were White, 7% were Coloured, 5% were Black and 3% were of other ethnic decent (Figure 4.2.). In terms of the highest level of education achieved, 80% have qualified with only a Bachelor of Optometry degree, 17% have additional post-graduate courses and 3% have other qualifications (Figure 4.3).

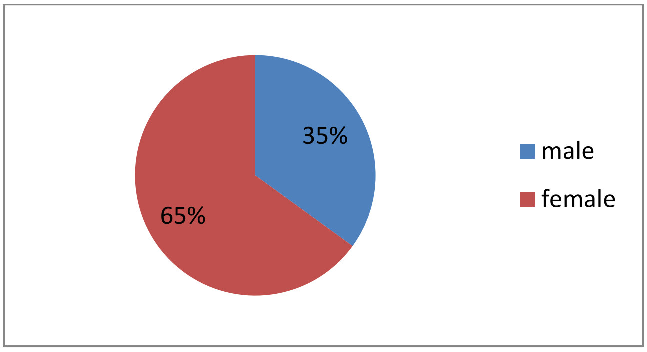

Figure 4.1 Gender distribution of Optometrists

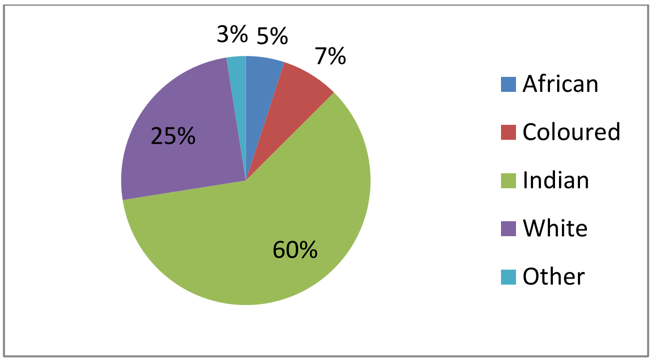

Figure 4.2 Racial profile of Optometrists

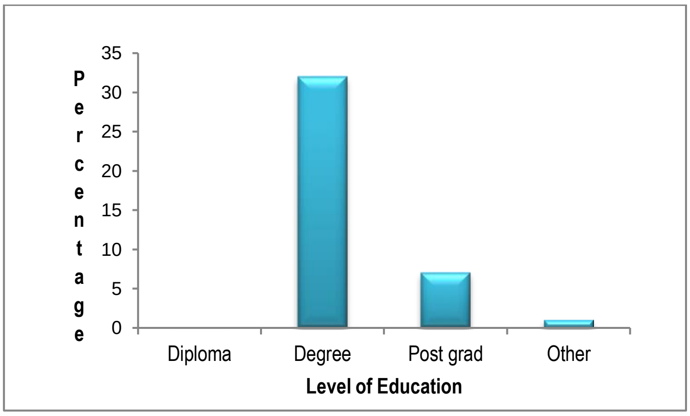

Figure 4.3 The highest level of education achieved

In terms of the number of years of experience in practice, an even distribution was noted as shown in Figure 4.4. Fifty five percent (55%) of participants were in practice for over 10 years.

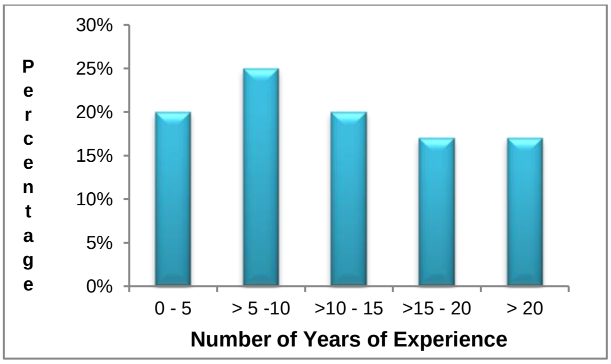

Figure 4.4. The number of years of experience

4.2.2. Contact Lens Practice Trends

The contact lens prescribing trends in KZN will be described. Majority of contact lens practitioners reported that fewer than 20% of their contact lens patients were non-compliant with contact lens instructions and usage (Figure 4.5). Furthermore, results of the survey indicated that 45% of optometric practices total patient base are made up of between 40 to 60% of contact lens patients and 35% of optometric practices consist of between 20 to 40% of contact lens patients (Figure 4.6).

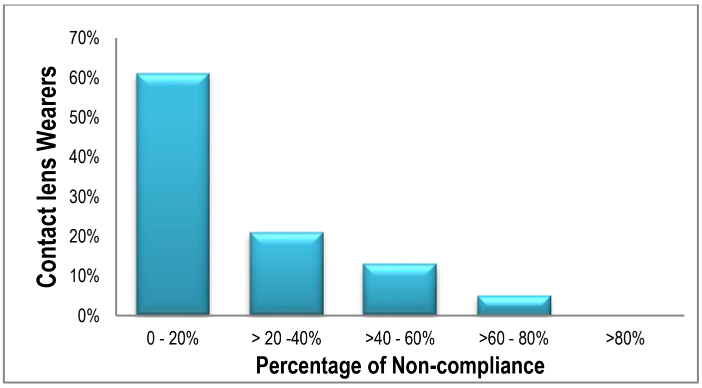

Figure 4.5. Percentage of contact lens wearers that is non-compliant with contact lens care instructions

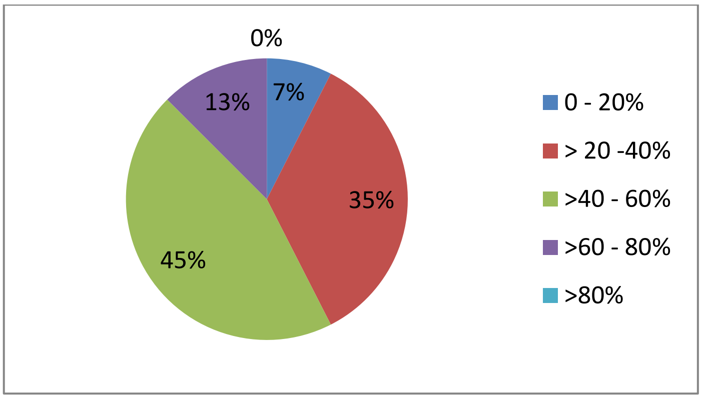

Figure 4.6. Percentage of contact lens wearers that constitute a practice

A high proportion of contact lens practitioners (60%) fit rigid gas permeable lenses as shown in Figure 4.7. When the 40% of contact lens practitioners that do not fit RGP lenses were asked about the reason for not prescribing RGP lenses, 19% indicated that the cost of RGP lenses are considerably higher than soft lenses, 6% indicated that discomfort of RGP lenses reduced success rate and 25% of contact lens practitioners prefer to fit soft lenses due to development in design and material of soft lenses. Furthermore, 50% of contact lens practitioners that do not fit RGP lenses cited “other” as reason for not prescribing RGP lenses. (Figure 4.8)

The majority of contact lens practitioners (94%) that do not prescribe RGP lenses indicated that contact lens wearers suitable for RGP lenses are referred to other contact lens practitioners that prescribe RGP lenses.

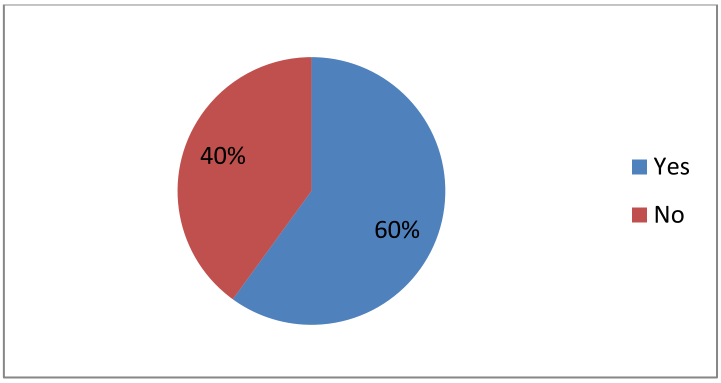

Figure 4.7. Percentage of the contact lens practitioners that prescribe rigid gas permeable contact lenses. 40% of contact lens practitioners do not prescribe RGP lenses.

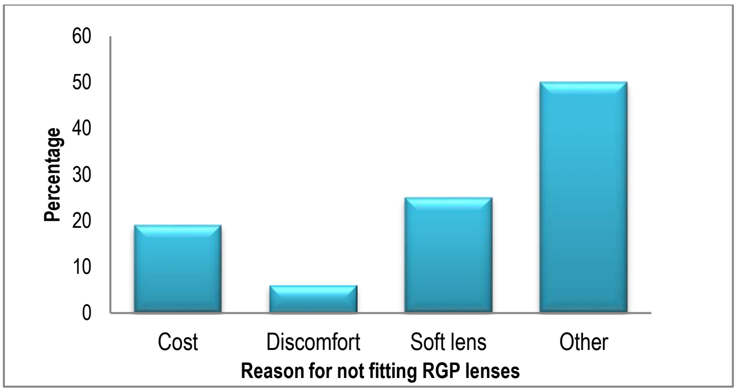

Figure 4.8. Reasons for not fitting rigid gas permeable contact lenses

Conventional and disposable contact lens materials are commonly prescribed. However, results of the survey indicated that 75% of contact lens practitioners prescribe only disposable contact lenses. Furthermore, 20% of participants prescribe between 60 to 79% of disposable contact lenses and 5% of participants prescribe 40 to 59% of disposable contact lenses (Figure 4.9).

Sixty (60%) percent of contact lens practitioners do not prescribe conventional contact lenses as shown in Figure 4.10. Thirty seven (37%) percent of contact lens practitioners indicated that between 1% to 19% percent of their contact lens patient base is prescribed conventional contact lenses and 3% indicated that 20% to 39% of their contact lens patient base is prescribed conventional contact lenses.

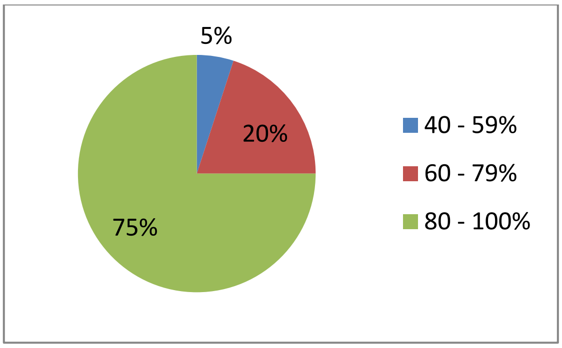

Figure 4.9. Percentage of disposable contact lenses fitted

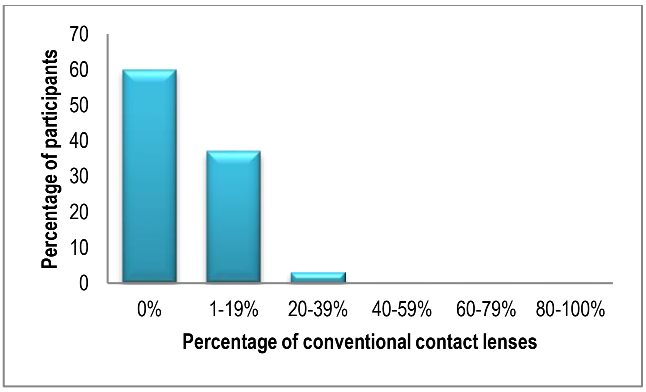

Figure 4.10. Percentage of conventional contact lenses prescribed. Majority (60%) of contact lens practitioners do not fit conventional soft contact lenses.

Scleral contact lenses are large diameter gas permeable contact lenses that are prescribed to contact lens wearers that have irregular corneas and have problems with soft contact lenses. Five percent (5%) of contact lens practitioners indicated that they prescribe scleral contact lenses as shown in Figure 4.11.

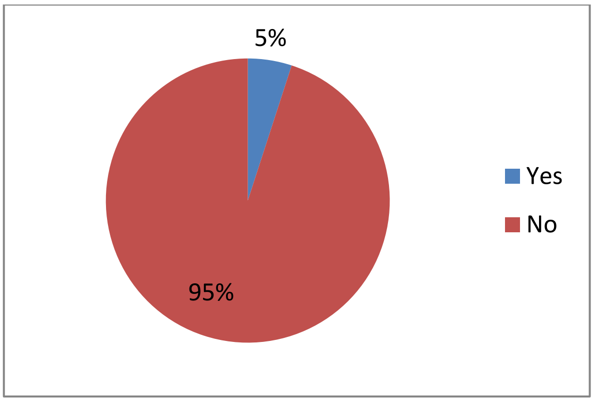

Figure 4.11. Percentage of contact lens practitioners that prescribe scleral lenses

Cosmetic contact lenses are commonly prescribed with only 7% of practitioners indicating that they do not fit cosmetic lenses. Sixty percent (60%) of contact lens practitioners indicated that less than 20% of the contact lens patient base constitutes cosmetic contact lens patients. Furthermore, ten percent of practitioners indicated that up to 39% of their contact lens patients wear cosmetic contact lenses (Figure 4.12.).

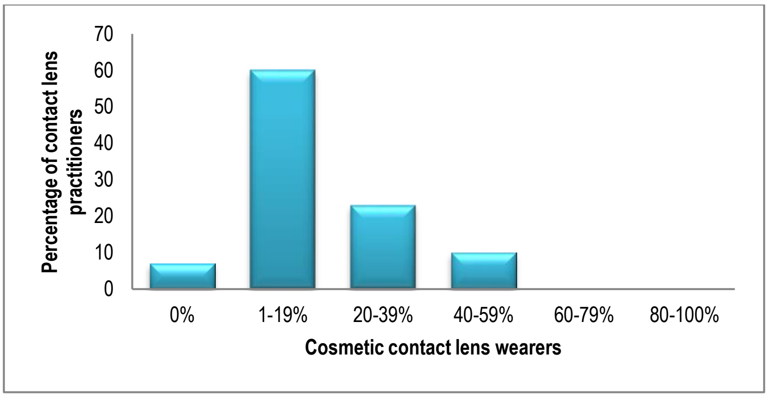

Figure 4.12. Percentage of cosmetic contact lens wearers that make up the contact lens patient base

Toric contact lenses are specifically designed contact lenses that correct astigmatism. Forty five percent (45%) of contact lens practitioners indicated that between 20 to 39% of their contact lens patient base were fitted with toric contact lenses. Furthermore, 20% and 27% of contact lens practitioners indicated that between one and 19% and between 40 and 59% of their contact lens patient base is prescribed toric contact lens respectively (Figure 4.13.).

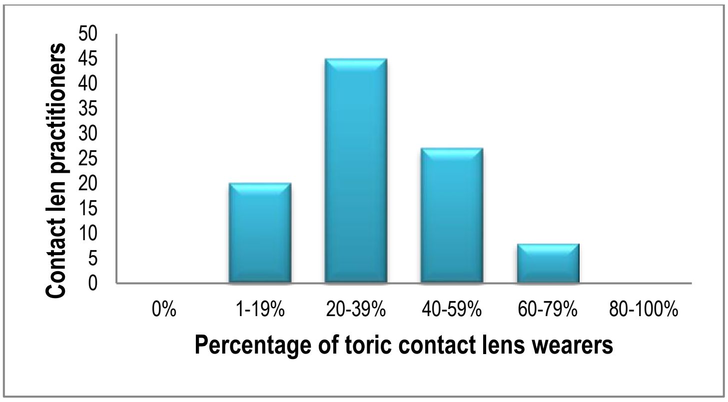

Figure 4.13. Percentage of contact lens wearers fitted with toric contact lenses

4.3. SECTION 2: CONTACT LENS WEARER PROFILE

The secondary population in this study consisted of 400 contact lens wearers. A cluster sampling strategy was used to select the secondary population of contact lens wearers in this study. The responses to each question will be presented using descriptive statistics and associations between categorical variables were tested using the standard Pearson's chi-square (χ2) test. When the expected cell count in any cross tabulation was less than 5 then the Fishers exact test was preferred.

The results will describe the demographic profile of contact lens wearers as well as the design and materials of contact lenses prescribed to correct common refractive errors. Furthermore, the common problems experienced by contact lens wearers and methods of management of the problems will be described.

4.3.1. Demographic details of contact lens wearers

The results of the contact lens wearer survey indicated that the gender distribution was 68% of females and 32% of males were prescribed with contact lenses as shown in Table 4.1. The ages of the contact lens wearers ranged from 7 years to 91 years with a mean of 34.61 (± 13.72) years and mode of 30 years. The age, in different categories, of all the contact lens wearers participating in the study is shown in Figure 4.14. Majority of the contact lens (59,5%) wearers are between the age of 19 and 39 years.

Table 4.1. Frequency table indicating the gender of the contact lens wearer

		Number	Percent
Valid	Male	128	32.0
	Female	272	68.0
	Total	400	100.0

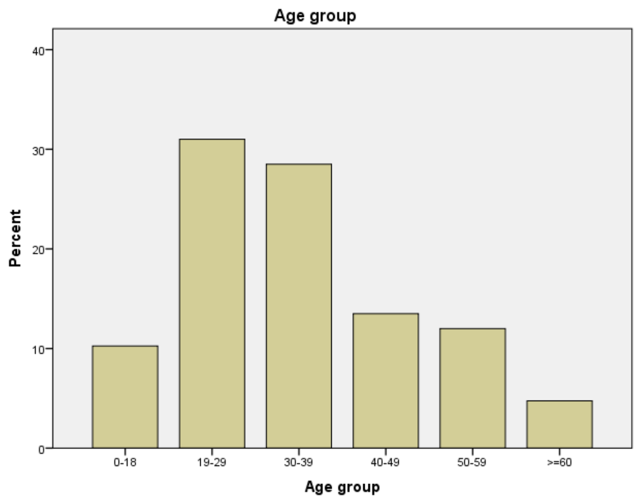

Figure 4.14. The age distribution of contact lens wearers in KZN. The mean age of the contact lens wearer is 34.61 (±13.72).

The racial distribution of contact lens wearers, as illustrated in Figure 4.15, indicated that Indians and Whites represented 41% and 43% of all contact lens wearers in KZN, respectively. Although the racial profile of the contact lens wearers was an optional question, all participants responded.

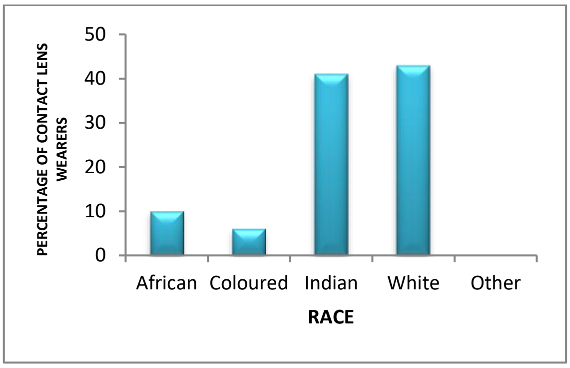

Figure 4.15. The racial profile of contact lens wearers in KZN. Majority of contact lens wearers are Indian (41%) and White (43%).

The majority of contact lens wearers (72%) were existing wearers, also referred to as refits, with only 28% reported as new fits as illustrated in Table 4.2. Results indicated an increase in first time contact lens wearers in all race groups. Thirty percent of Indian contact lens wearers were regarded as new fits (Figure 4.16). Results were further analysed using the Pearson Chi-Square test. Results showed that there was no statistical significance (p = 0.193) in the type of contact lens fit and the race of the contact lens wearer.

Table 4.2. Type of fit: (New fit versus re-fit)

		Number	Percent
Valid	New Fit	111	27.8
	Re-fit	287	71.8
	Total	398	99.5
Missing	System	2	.5
Total		400	100.0

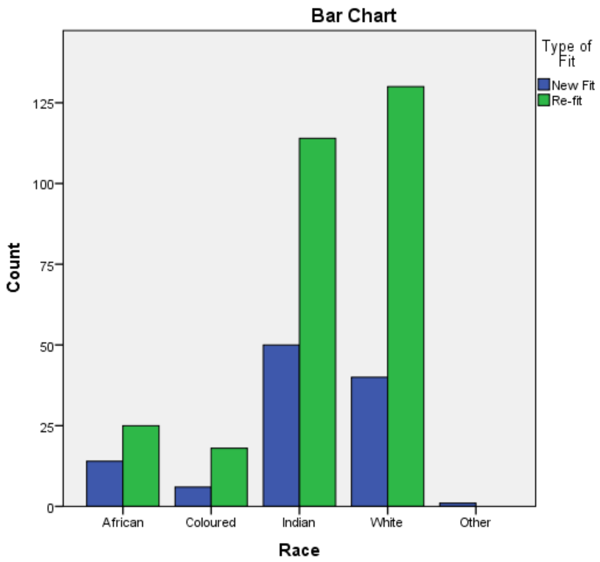

Figure 4.16. The race of the contact lens wearer and the type of fit (new fit versus re-fit).

Contact lenses are prescribed for the correction of common refractive errors such as myopia, hyperopia, astigmatism and presbyopia. The results of the survey indicated that 76% of contact lens wearers are corrected for myopia, 10% are corrected for hyperopia and 22% are corrected for presbyopia, as indicated in Figure 4.17.

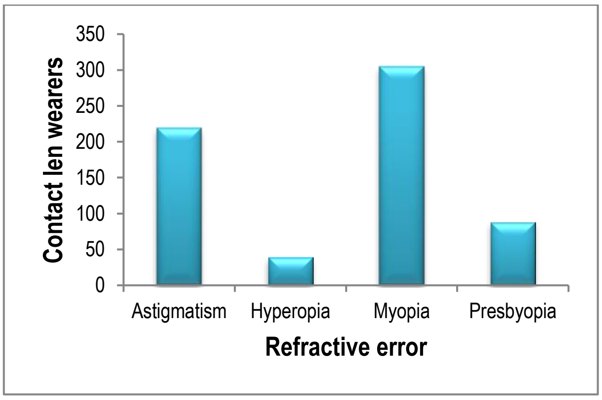

Figure 4.17. Refractive errors presented by contact lens wearers.

Three hundred and five (305) contact lens wearers are myopic, 219 are astigmatic, 88 are presbyopic and 39 are hyperopic. Contact lens wearers also presented with a combination of refractive errors. Results indicated an even distribution of refractive errors and the gender of the contact lens wearers (Table 4.3.).

Table 4.3. Cross-tabulation between the refractive error and the gender of the contact lens wearers.

Gender		N	Mean	Std. Deviation
Astigmatism	Male	80	1,00	0,000
	Female	138	1,01	,085
Myopia	Male	106	1,0000	.00000[a]
	Female	199	1,0000	.00000[a]
Hyperopia	Male	9	1,00	.000[a]
	Female	30	1,00	.000[a]
Presbyopia	Male	23	1,00	.000[a]
	Female	65	1,00	.000[a]

4.3.2. Contact Lenses

The results of the contact lens wearer survey, in terms of contact lens material, lens design, frequency of replacement and modality of contact lens wear will be presented.

The contact lens material most commonly prescribed was silicone hydrogel, with 67% of contact lens wearers prescribed with silicone hydrogel lenses, 18% of contact lens wearers are fitted with hydrogel lenses, two percent (2%) with RGP and one percent (1%) was prescribed scleral lenses (Figure 4.18).

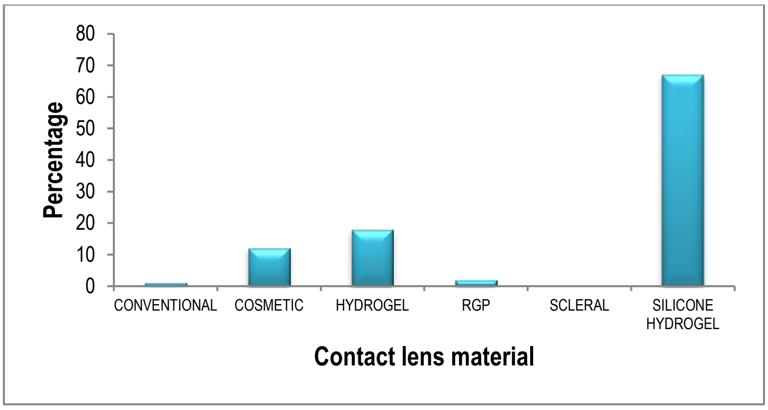

Figure 4.18. Contact lens material prescribed. The majority (67%) of contact lens wearers were prescribed with silicone hydrogel material.

The majority (65%) of contact lens wearers prescribed with contact lenses for the first time, also regarded as new-fits, were fitted with silicone hydrogel contact lens material as shown in Figure 4.19. Furthermore, the results were analysed using the Pearson's Chi-Square Test and this showed a statistically significant (p = 0.029) association between the silicone hydrogel contact lens material and the type of fit.

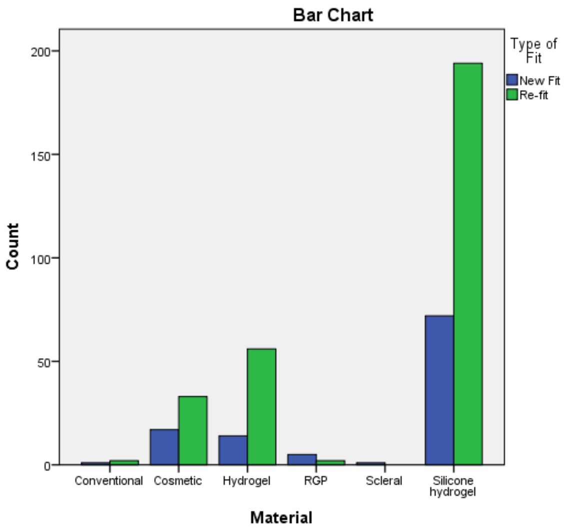

Figure 4.19. The type of fit (new fit versus re-fit) and contact lens material prescribed. Silicone hydrogel material was most common prescription for both the new fit and re-fitting of contact lenses (*p* = 0.029).

Cosmetic contact lenses accounted for 12% of contact lens materials prescribed with 82% being prescription cosmetic lenses and 18% were prescribed primarily for cosmetic purpose as shown in Figure 4.20.

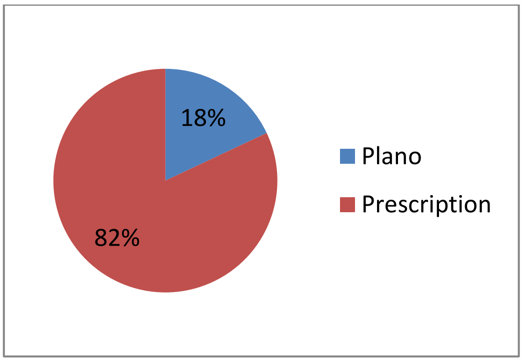

Figure 4.20. Cosmetic contact lenses prescribed. 82% were prescription contact lenses and 18% of the cosmetic contact lenses prescribed were untested (plano).

The contact lens design most commonly prescribed was spherical. Spherical lenses account for 42% of all contact lens fits, with this number increasing to 73% if monovision, multifocal and cosmetic lenses are included in this analysis. Furthermore, toric contact lens design account for 27% of contact lenses prescribed as shown in Figure 4.21.

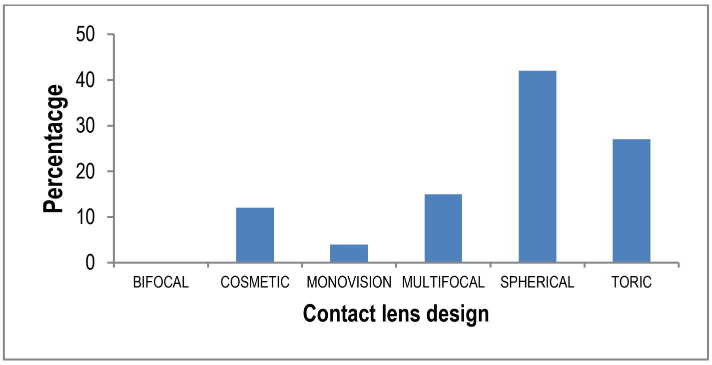

Figure 4.21. Percentage of contact lens fitting by the design of the contact lens

The proportion of toric lens fitted increased with higher degrees of astigmatism in the right and left eyes, as shown in Figures 4.22 and 4.23, respectively.

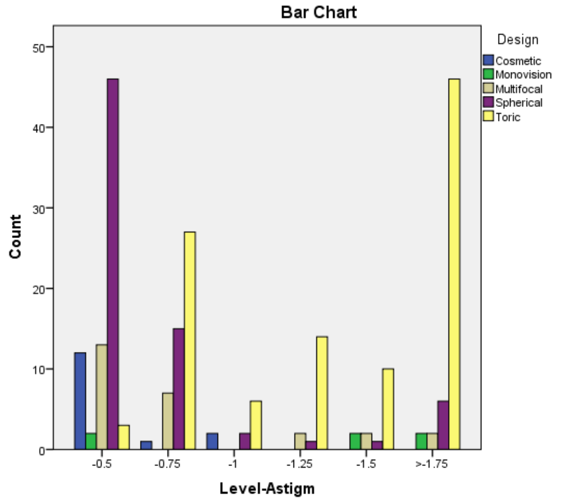

Figure 4.22. Level of astigmatism in the right eye and the design of contact lens prescribed

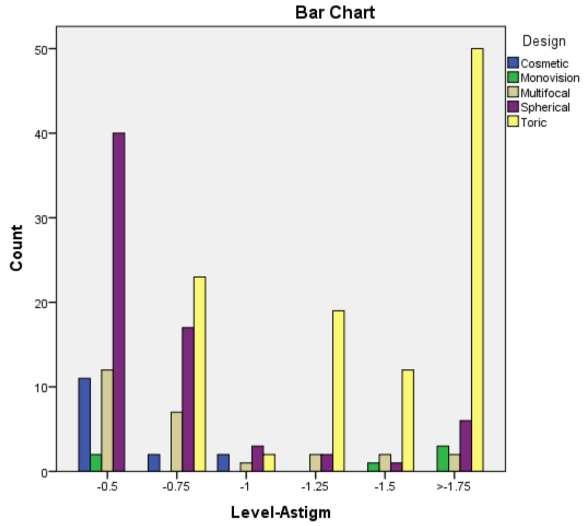

Figure 4.23. Level of astigmatism in the left eye and the design of contact lens prescribed

Toric contact lenses prescribed for all degrees of astigmatism. An increase in toric lenses noted from -0.75DC and above. Toric contact lens prescription increased from -0.75DC and majority of astigmatism of -1.25DC and over is prescribed with toric contact lenses.

Monthly replacement contact lenses were most widely prescribed at 82% with 11% fitted on a daily replacement basis, three percent (3%) fitted for yearly replacement and two percent (2%) fitted on a two weekly and 3- 6 month replacement basis (Figure 4.24). Furthermore, 96% of contact lenses are worn on a daily basis with only 4% of contact lens prescribed for extended wear (Figure 4.25).

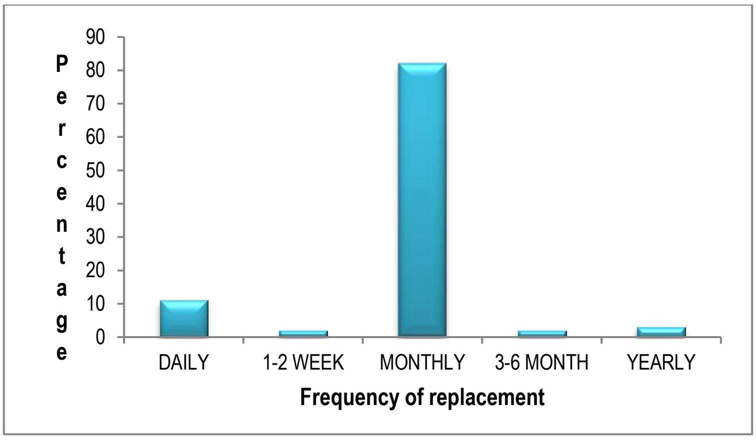

Figure 4.24. Frequency of replacement of contact lenses

The majority (68%) of contact lens wearers are females and results further indicated that 82% of contact lenses are replaced on a monthly basis. The frequency of replacement of the male and female contact lens wearers are shown in Table 4.4. Pearson's Chi-Squared Test indicated that there was no statistically significant (p = 0.540) association between the frequency of replacement of the contact lens and the gender of the contact lens wearer.

Table 4.4. Cross-tabulation between the frequency of replacement and the gender of the contact lens wearer.

		Frequency					
		Daily	1-2 Weekly	Monthly	3-6 Monthly	Yearly	Total
Gender	Male	16	3	100	4	5	128
	Female	23	6	231	5	7	272
Total		39	9	331	9	12	400

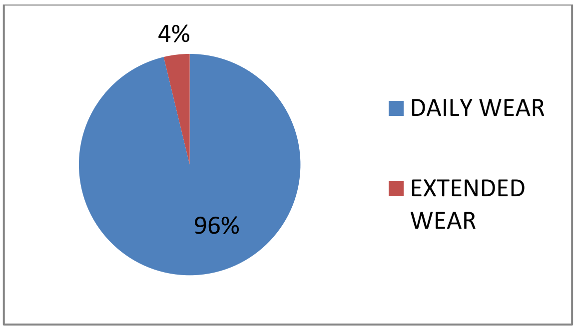

Figure 4.25. Contact lens modality of wear. The majority of contact lens wearers wear the contact lenses on a daily wear basis.

A small percentage (4%) wears extended wear contact lenses. The modality of contact lens wear and the gender of the contact lens wearer are shown in Table 4.5. The expected cell count was less than 5, therefore Fisher's Exact Test was conducted. Results of the test indicted that there was no statistical significance ($p = 0.337$).

Table 4.5. Cross-tabulation between the modality of the contact lens wearing schedule and the gender of the contact lens wearer (*p* = 0.0337)

		Modality		
		Daily	Extended Wear	Total
Gender	Male	122	6	128
	Female	263	9	272
Total		385	15	400

4.3.3. Contact Lens Complications

The results of the contact lens wearer survey, in terms of common systemic diseases, atopic conditions as well as autoimmune disorders experienced by contact lens wearers will be presented. Furthermore, common complications associated with contact lens wear will be described.

The majority (89%) of contact lens wearers have no medical problems (Figure 4.26). Furthermore, 85% of the contact lens wearers did not experience any contact lens-related problems as illustrated in Figure 4.27. Dry eyes were experienced by 13% of contact lens wearers in KZN. The distribution of dry eyes and different age groups is shown in Table 4.6.

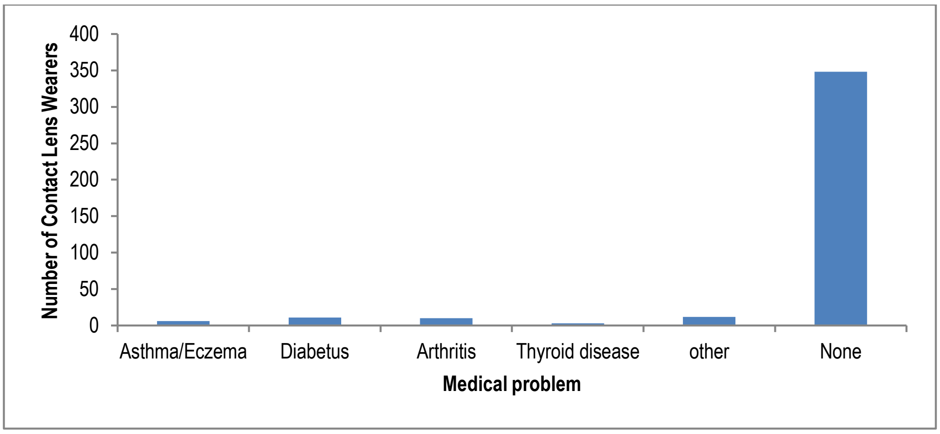

Figure 4.26. Medical problems experienced by contact lens wearers. The majority (89%) of contact lens wearers have no medical problems.

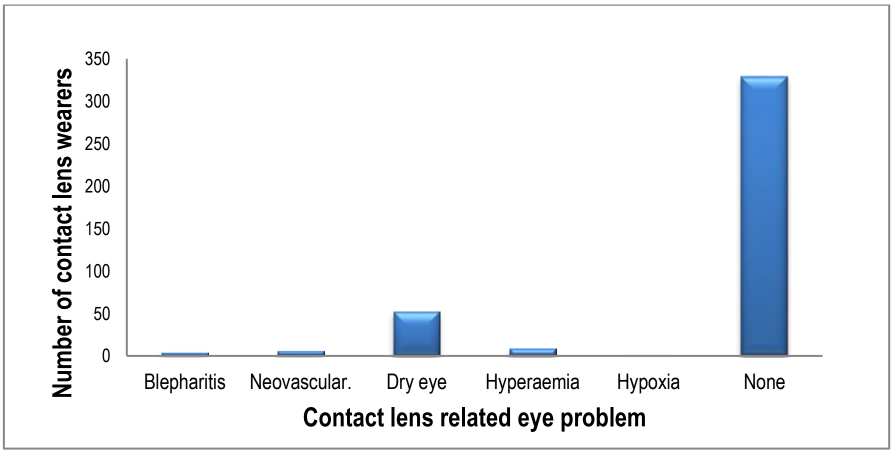

Figure 4.27. Contact lens related complications associated with contact lens wear. The majority of contact lens wearers do not experience any problems with the contact lenses.

Table 4.6. Cross-tabulation between the different age categories and dry eyes experienced.

	Age group						Total
	0-18	19-29	30-39	40-49	50-59	>=60	
Dry Eye Yes	4	15	14	9	5	5	52

The proportion of dry eye experienced and the material prescribed is shown in Figure 4.28. Dry eyes experienced by contact lens wear were proportionate to the percentage of different type of material prescribed.

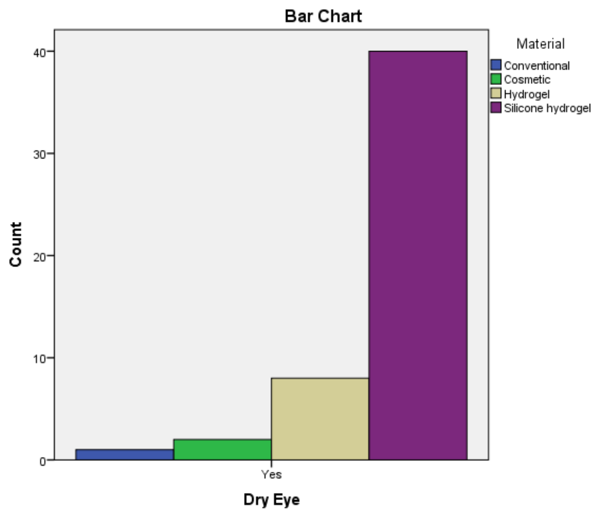

Figure 4.28. Dry eyes experienced and the type of material prescribed

This chapter presented the results in two sections; the contact lens practitioner profile and the contact lens wearer profile. The responses to each question were presented using descriptive statistics and the associations between categorical variables were described using frequency tables and bar charts.

4.4. CONCLUSION

This chapter presented the results of the survey in two sections: the contact lens practitioner profile and the contact lens wearer profile. The responses to each question were presented using descriptive statistics and associations between categorical variables were described using graphs.

The next chapter will discuss the results of the study using literature to explain possible reasons for the responses that were received.

CHAPTER 5. DISCUSSION

5.1. INTRODUCTION

This chapter will discuss the results of this study in two sections; the contact lens practitioner profile and the contact lens wearer profile. The responses to each question will be discussed using descriptive analysis and the associations between categorical variables using the standard Pearson's chi-square ($\chi 2$) test will be discussed. When the expected cell count in any cross tabulation was less than 5 then the Fishers exact test was preferred.

The technological progress of contact lens materials and designs is continually expanding. The improvements in contact lens designs results in various options available to suit different visual needs as well as different lifestyles. Furthermore, contact lenses are a safe, effective and convenient way to correct common refractive errors.

5.2. SECTION 1: OPTOMETRIST PROFILE

The primary population in this study consisted of 40 participants. However, in anticipation of incomplete questionnaires as well as non-response, it was decided to include 55 participants. The discussions will include the demographic details as well as the current contact lens practicing trends in KZN.

5.2.1. Sample Size

The primary sample population (*n*) size was 55 contact lens practitioners. Thite *et al* (2013) included 257 contact lens practitioners to collect information on the contact lens prescribing pattern in India in 2011. Efron *et al* (2010) conducted a ten year survey of contact lens prescribing trends in Australia with an average of 146 participants per year. The international contact lens prescribing included participants based on the total number of contact lens practitioners in the different countries. This ranged from 1000 participants in the United States and the United Kingdom to 502 participants in Norway. According to the HPCSA, the total number of contact lens practitioners registered in KwaZulu-Natal as at 06 May 2014 was 642 (Appendix VII). This number was based on personal postal addresses of the practitioners. Therefore, a study sample population of 40 participants was recommended by the statistician.

5.2.2. Demographic Details

The primary population sample consisted of 36% male and 65% female contact lens practitioners (Figure 4.1). This distribution is representative of gender profile of South African optometrists according to a study by Nirghin *et al* (2011). During the period 1995 to 2008, the gender profile changed to 33.6% males and 66.4% females (Nirghin *et al*, 2011). In comparison, the gender profile of optometrists trained from the period 1930 to 1994 was 64.2% males and 35.8% females.

The racial profile of the contact lens practitioner was an optional question but all participants responded. Majority (60%) of the participants were Indian, 25% were White, 7% were Coloured, 5% were African and 3% were of other ethnic descent. The results from this survey support those of Mashige and Naidoo (2010). Mashige and Naidoo (2010) stated that this could be explained by historical legislation that had ensured that the only tertiary institution offering optometry in KZN used to cater for predominantly Indian students. The Statistics South Africa Census 2001 demonstrated that Africans account for 68.30% of the population of KZN, followed by Asians or Indians at 19.90%, Whites at 8.98% and Coloureds at 2.89% (www.ulwazi.org/index.php/Durban.co.za). Furthermore, 78.03% of the Indian population of KwaZulu-Natal reside in Durban (www.ageconsearch.umn.edu/Demographics.pdf). Nirghin *et al* (2011) demonstrated that 68.8% of the optometric graduates from the University of KwaZulu-Natal, during the period 1995 to 2008, were Indian. The University of Durban-Westville, until 1992, awarded 175 undergraduate degrees of which 125 were Indian and this number increased to 716 undergraduates of which 516 were Indian as at 2008 (Mashige and Naidoo, 2010).

In terms of the highest level of education achieved, 80% have qualified with only a Bachelor of Optometry degree, 17% have additional post-graduate courses and 3% have other qualifications. The results were consistent with Nirghin *et al* (2011) who demonstrated that the majority (77.3%) of optometrists registered with the HPSCA had a Bachelor of Optometry degree as their primary qualification. The low percent of postgraduate courses and degrees available in South Africa could be due to the absence of motivation to study further when in private practice. Furthermore, the majority (55%) of the participants were in practice for 10 years or over, indicating that optometrists in the private sector have already established practices.

5.2.3. Contact Lens Practice Trends

The results of the contact lens prescribing trends will be discussed. This will include the percentage of contact lens wearers making up the practice base, non-compliance of contact lens wearers and the different contact lens designs prescribed.

Majority of the contact lens practitioners reported that fewer than 20% of their contact lens patients were non-compliant with contact lens instructions and usage. The areas of non-compliance included care instructions, storage and replacement schedule. Robertson and Cavanagh (2011) demonstrated that 85% of contact lens wearers perceived themselves as compliant with lens care following their knowledge of risk factors and complications associated with contact lens wear. The low percentage of non-compliant behaviour could indicate that contact lens practitioners are adequately informing the contact lens wearers regarding the contact lens care and wear practices. Furthermore, the mean age of contact lens wearers in this study was 34.61 (± 13.72) and 68% of the contact lens wearers were female. Carnt *et al* (2011) stated that non-compliant behaviour was associated at a younger age ($p < 0.01$) and with the male gender ($p = 0.02$).

A high proportion of optometric practice patient numbers are made up of contact lens wearers. The majority (45%) of contact lens practitioners indicated that between 40% and 60% of their optometric practice comprise of contact lens wearers and 35% of contact lens practitioners indicated that between 20% and 40% of their practice is made up of contact lens wearers.   Nichols (2014) reported that contact lens wearers represented about 34% of a typical practice base in the United States. Furthermore, Nichols (2015) indicated, using data from research analyst Robert.W.Baird, that the United States contact lens sales increased by 5% in 2014 and the worldwide sales increased just fewer than 5% in 2014. The high percentage of contact lens wearers can be further explained by the advancement in the cosmetic, toric and multifocal soft disposable contact lens categories. The technological advancements in the contact lens designs and materials have a significant impact on the contact lens market.

The majority of contact lens practitioners reported fitting rigid gas permeable (RGP) contact lenses. However, this does not indicate that the majority of contact lens prescriptions were RGP lens prescription.   Morgan and Efron (2006) reported a decrease of the RGP new fits, from 22% to four percent, during the period 1996 and 2005 in the United Kingdom. It was suggested that the RGP contact lens would become obsolete by the year 2010 (Efron, 2000). The results from this survey does not support that suggestion, however, there is limited use for the RGP contact lenses. Bennett (2015) reported that the RGP contact lens remains the lens of choice for keratoconus and the research continues to demonstrate the success of RGP contact lenses in orthokeratology. When the 40% of contact lens practitioners that do not fit RGP lenses were asked about the reason for not prescribing RGP lenses, 19% indicated that the cost of RGP lenses are considerably higher than soft lenses, 6% indicated that discomfort of RGP lenses reduced success rate and 25% of contact lens practitioners prefer to fit soft lenses due to development in design and material of soft lenses.

The RGP lens is no longer considered an option as the lens of first choice when fitting contact lenses and the results confirm that the RGP lens category has a limited specialist role in the contact lens market. The RGP lenses are considered only when the conventional soft lens designs offer inadequate visual acuity and contact lens wearers develop additional complications. This includes more specialist applications such as the correction of keratoconus, high levels of astigmatism, post-surgery and for orthokeratology. Furthermore, Eiden (2015) stated that although the RGP contact lens design provides optimum vision and physiological response, the success is limited due to the comfort, adaptation period and the perceived difficulty of the fitting methods.

Conventional and disposable contact lens materials are commonly prescribed. However, results of the survey indicated that majority (75%) of contact lens practitioners prescribe only disposable contact lenses. The disposable contact lens categories include the spherical, toric, cosmetic and the multifocal design. The significant percentage of disposable contact lenses prescribed can be attributed to the advancement in contact lens technology and the extensive soft contact lens design. Morgan *et al* (2015) demonstrated that 91% of contact lenses prescribed worldwide in 2014 are soft contact lenses of which 80% are made up of different categories of disposable contact lenses. Nichols (2015) reported a decrease in conventional or annual replacement contact lenses, in the United States, in favour of disposable contact lenses. The success of disposable contact lenses can be attributed to factors such as initial lens comfort, simplified cleaning and disinfection care routine, availability of lenses as well as more suitable for active lifestyles. Disposable contact lenses are also available in a range of parameters and different powers. This allows contact lens practitioners to stock a selection of disposable contact lenses. Therefore, disposable contact lenses can be easily fitted and contact lens supplies are available for immediate purchase.

Toric contact lenses are specifically designed contact lenses that correct astigmatism. Forty five percent (45%) of contact lens practitioners indicated that between 20 to 39% of their contact lens patient base were fitted with toric contact lenses. According to the Contact Lens Spectrum Reader Survey, 24% of soft contact lenses prescribed are toric lenses (Nichols, 2015). Soft toric disposable contact lenses are also regularly prescribed with an average of 20% of all soft contact lenses fitted worldwide (Morgan *et al,* 2015). Furthermore, Morgan *et al* (2015) demonstrated an increase in soft toric prescribing in countries such as Australia, Canada, Japan United Kingdom and the United states. The high percentage of toric lenses prescribed reflects an improvement in the design, lens stability as well as an increase in practitioner confidence. Furthermore, the international rate of toric prescribing increased to 45% if astigmatism of 0.75DC and 1.00DC are included (Morgan *et al*, 2015). South Africa is included as one of only six nations that meet the minimum prescribing rate for astigmatism (Morgan *et al*, 2013).

The prescribing of contact lenses to correct common refractive errors is a growing trend in the optical industry. This can be attributed to the on-going research and development in contact lens designs and material. In addition to the new technology in this field, the contact lens marketing strategies include communicating with the contact lens wearer and increasing awareness of the benefits of contact lenses, further contributing to the increase in the contact lens market. Furthermore, contact lens practitioners need to actively identify potential contact lens wearers as well as promote the latest trends in contact lens technology to existing contact lens wearers. In the current study, the majority (70%) of contact lens practitioners indicated that they would benefit by receiving further information on new development in contact lens technology and the management of common contact lens-related problems. It was further stated that contact lens suppliers need to contribute to the growing trend in contact lens wear by supplying promotional and marketing material.

5.3. SECTION 2: CONTACT LENS WEARER PROFILE

The secondary population in this study consisted of 400 contact lens wearers. The discussions will include the demographic profile of contact lens wearers as well as the design and materials of contact lenses prescribed to correct common refractive errors. Furthermore, the common problems experienced by contact lens wearers and methods of management of the problems will be described.

5.3.1. Demographic details of contact lens wearers

The demographic details of the contact lens wearer include the gender, age and racial profile. The results of the contact lens wearer survey indicated that 68% of females and 32% of males were prescribed with contact lenses. This gender distribution is also representative of the international contact lens prescribing trends that show 69% of contact lenses were prescribed to females (Morgan *et al*, 2015). Furthermore, this value has remained constant since the inception of the international prescribing trends project which began in 1996. Thite *et al* (2012) also demonstrated that 67% of contact lens wearers in India are females. Similarly, in Australia, 65% of contact lens wearers are female (Efron *et al*, 2010).

The ages of the contact lens wearers ranged from 7 years to 91 years with a mean of 34.61 (±13.72) and mode of 30 years. The age of the contact lens wearers are similar to studies in other countries. Morgan *et* al (2015) demonstrated that the world average age of contact lens wearers is 31.70 (± 14.8). Results from the 2007 International contact lens prescribing survey suggest that fitting of older patients is common in the developed markets such as Australia, Canada, Germany, Netherlands, United Kingdom and United States and have a mean age of 33 years and older (Morgan *et al*, 2008). In South Africa, the contact lens market is growing and this was further demonstrated by Srikissoon (2014). According to the South African consumer survey, 60.04% of contact lens wearers are over the age of 30 (Srikissoon, 2014). The increase in average age of the contact lens wearer can be explained by various designs of contact lenses available to suit the active lifestyle of the presbyopic population. In addition, the visual demands of a variety of activities could benefit from the improved safety and convenience of disposable contact lenses.

The racial distribution of contact lens wearers indicated that Indians and Whites represented 41% and 43% of contact lens wearers in KZN, respectively. The racial profile in this study does not represent the distribution of the population in KZN. The racial composition of KZN from the Labour Force Survey 2007, show that the Black population was 83.55% followed by the Indian population of 8.22% and the white population with 5.68%. Furthermore, the high percentage of Indian contact lens wearers can be explained by majority (78.03%) of the Indian population in KZN residing in Durban (Binkley, 2005).

The black population, especially in KZN, are known to adhere to their traditions and are resistant to change. It is speculated that the most patients prefer to use spectacles instead of contact lenses to correct their refractive error. Furthermore, the cornea in black people has been found to be flatter than the other race groups. Most base curves for contact lenses on the market were too steep to fit the black eye (Moodley, 2009). Fuller and Alperin (2013) reported that the eyes of African-Americans were significantly more prolate (p = 0.003) than those of white Americans. This further substantiates the view that black corneas are flatter than that of the other race groups. Recent developments in which the contact lens companies have increased their base curve range have ensured that South African optometrists have more flexibility and choice when considering contact lenses for their black patients.

The majority of contact lens wearers (72%) are existing wearers, also referred to as refits, with only 28% reported as new fits. The percentage of refits in this study is similar to the overall world average of 68% for the 32 countries surveyed in 2014 (Morgan *et al*, 2015). The high proportion of new fits (28%) showed that an increase in marketing as well as contact lens practitioners' actively promoting contact lenses results in an increase in first time contact lens wearers.

Furthermore, statistical results (p = 0.193) indicated an increase in first time contact lens wearers in all race groups. Pearson Chi-Square test value of $p > 0.05$

indicates that there is no significant association in the type of contact lens fit and the race of the contact lens wearer.

The results of the survey indicated that 76% of contact lens wearers are corrected for myopia, 10% are corrected for hyperopia and 22% are corrected for presbyopia. Pan *et* al (2012) concluded that myopia is the most common refractive error in worldwide population studies. Correction of myopia with contact lenses offers numerous advantages as compared to spectacles (Bhattacharyya, 2009; Bennett and Weismann, 2005; McMonnies, 2013; The British Contact Lens Association, 2014). Furthermore, this study also demonstrated that the gender of the contact lens wearers corrected for myopia, hyperopia, astigmatism and presbyopia is proportionate to the overall percentage of male and female contact lens wearers.

5.3.2. Contact Lenses

The contact lenses will be discussed in terms of contact lens material, design, frequency of replacement and modality of contact lens wear.

5.3.2.1. Contact lens material

The contact lens material most commonly prescribed was silicone hydrogel (p = 0.029). The results of this survey are consistent with international studies. Morgan *et al* (2015) demonstrated that silicone hydrogel materials are most widely prescribed and a review of recent years suggests the rapid increase of silicone hydrogel materials since the start of the century. This can be attributed to the material properties which were initially developed to overcome the complication of hypoxia in extended wear contact lenses (Bhattacharyya, 2009). Furthermore, the silicone-rubber based material allows the lenses to be flexible and durable with exceptional oxygen transmission. Soft silicone hydrogel contact lenses were introduced into the contact lens material in the late 1970s (Lowther and Snyder, 1992). The high oxygen permeability of the silicone hydrogel material has allowed the material to become increasingly favourable and following 20 years of research the silicone material was first marketed in 1998 and has shown tremendous growth.

Visual tasks associated with the use of digital devices have resulted in changes in the blink rate, symptoms of discomfort and dryness (Steffen *et al*, 2014). The extensive use of visual display activities can contribute to tired eyes and this may also result in contact lens discontinuation. Steffen *et al* (2014) demonstrated that the advancement in material chemistry and design of the silicone hydrogel material has allowed improved comfort and vision as visual demands associated with digital display devices increase.

Owing to factors such as marketing of contact lenses and continuing professional development (CPD), contact lens practitioners develop and increase the knowledge regarding various aspects of the profession. The on-going research on the benefits of various contact lens materials has allowed practitioners to further promote and experiment with the wide range of disposable contact lenses available. Furthermore, first time contact lens wearers or 'new fits' with silicone hydrogel material, based on 'trial and error' have shown this type of material to be successful. Silicone hydrogel contact lenses allows the contact lens wearer to achieve a balance of healthy eyes, good vision, comfort and the stiffer material allows this contact lens easier handling attributes. The high percentage of silicone hydrogel lenses prescribed allows the researcher to conclude that contact lens practitioners are actively prescribing silicone hydrogel material and contact lens wearers prefer silicone hydrogel material when trial lenses are initially fitted.

The findings of the survey also indicated that the silicone hydrogel material was the most common prescription for both new fits and existing contact lens wearers. Pearson's Chi-Square Test showed a p value less than 0.05, hence a statistically significant (p = 0.029) association exists between the silicone hydrogel contact lens material and the type of fit.

5.3.2.2. Contact lens design

The contact lens design most commonly prescribed was spherical. Spherical lenses account for 42% of all contact lens fits, with this number increasing to 73% if monovision, multifocal and cosmetic lenses are included in this analysis. Woods *et al* (2007) reported that the majority (59.5%) of soft lenses prescribed in a seven year survey of contact lens prescribing trends in Canada was spherical. Morgan *et al* (2015) maintains this result with 61% of spherical soft lenses prescribed internationally. Furthermore, this number increased to 80% if monovision, multifocal and cosmetic lenses are included in this analysis. This is in agreement with the Contact Lens Spectrum Reader Profile Survey in the United States indicating that 51% of soft lens fitted are spherical and this number increased to 71% when monovision, multifocal and cosmetic lenses are included in this analysis (Nichols, 2015). The findings of the current study indicated that the results are similar to international patterns of contact lens prescribing.

Spherical contact lenses can be used to correct common refractive errors such as myopia, hyperopia and presbyopia. The results of this survey indicated that 76% of contact lens wearers are corrected for myopia, 10% are corrected for hyperopia and 22% are corrected for presbyopia. Furthermore, spherical lenses account for 73% of soft lenses prescribed. Therefore, it can be concluded that the results obtained are reliable and a positive correlation exists between the contact lens design and the refractive error of the contact lens wearers in KZN.

The proportion of toric contact lens fits (27%) is higher compared to the overall international contact lens prescribing trend. Morgan *et al* (2015) demonstrated that 20% of all soft contact lenses prescribed were toric lenses. Results of this survey indicate that contact lens wearers are fitted with toric lenses for the correction of astigmatism including 0.75DC and 1.00DC. This could be due to the wide variety of powers, axes and the effective distribution and marketing of various brands of toric lenses. Furthermore, contact lens practitioners may be motivated to prescribe toric lenses due to the higher profit margins as compared to spherical contact lenses. This can also be explained by a growing confidence in contact lens practitioners to fit toric lenses in first time contact lens wearers. The astigmatic contact lens wearer also benefits from the toric lens due to the advanced lens designs and the optical performance of the toric contact lens.

The multifocal and monovision correction in the present study represented 14.5% and 3.3% respectively. The trend of prescribing contact lenses to correct presbyopia has steadily increased internationally. Morgan *et al* (1999 – 2015) discussed the gradual increase in multifocal contact lens prescribing over a 10 year period. Efron *et al* (2010) and Edwards *et al* (2009) reported an increase in multifocal soft lens prescribing and a gradual decrease in monovision fittings in Australia. The possible explanation of the findings in this study includes the advancement of the multifocal contact lens technology, the availability of multiple additions and the introduction of the soft toric multifocal lens design. Furthermore, multifocal contact lens designs allow for better stereoacuity as compared to the monovision correction for presbyopia (Brujic and Kading, 2015). The success of the multifocal contact lens allows the researcher to conclude that the practitioner confidence in prescribing multifocal contact lenses and contact lens wearer satisfaction can be attributed to the significant percentage of multifocal lens wear.

5.3.2.3. Contact Lenses: Frequency of replacement

Monthly replacement contact lenses were the most widely prescribed at 82% with 11% fitted on a daily replacement basis. The finding of this study is higher in comparison with the findings of international studies. Morgan *et al* (2015) reported an overall monthly replacement schedule of 47% and in increase in daily wear disposables contact lenses. Thite *et al* (2012) also reported that two-thirds of the total soft contact lenses dispensed in India were monthly disposable contact lenses. In Australia, monthly replacement lenses accounted for 53% of soft lenses in the year 2005 and gradually increased yearly thereafter (Efron *et al*, 2010).

Contact lens technology has advanced over the last decade allowing a selection of replacement schedules available to the disposable contact lens wearer. Individual preference and lifestyle is most important when choosing a replacement schedule. However, the benefits of monthly disposable contact lenses include lower overall cost of the contact lenses, available in different modalities and a wider selection of designs and materials. Subsequently, if the contact lens wearer is dissatisfied with the initial trial lens, then another lens with different properties can be sampled. Furthermore, monthly disposable contact lenses are easily available with stock available in optometric practices.

The majority (68%) of contact lens wearers are females and results further indicated that 82% of contact lenses are replaced on a monthly basis. Pearson's Chi-Squared Test results in a p value that was greater than 0.05, therefore indicates that there was no statistically significant (p = 0.540) association between the frequency of replacement of the contact lens and the gender of the contact lens wearer.

5.5.2.4. Contact lenses: Modality of wear

The majority (96%) of contact lens wearers wear the contact lenses on a daily wear basis. The international pattern of contact lens prescribing demonstrates that the extended wear contact lenses remain rarely prescribed (Morgan *et al*, 2015; Efron *et al*, 2010; Thite *et al*, 2012; Edwards *et al*, 2009). This could be due to contact lens practitioners' preference for fitting daily wear contact lenses. The differences in the extent of actively marketing and promoting daily wear disposable contact lenses as compared to extended wear disposable contact lenses may also influence the prescribing rate of daily wear contact lenses.

Although the oxygen transmissibility of extended wear contact lenses has improved, the incidence of eye infections and symptoms of hypoxia was greater among contact lens wearers who slept with contact lenses (Weissman, 2015). Furthermore, contact lens wearers were less likely to comply with contact lens replacement when prescribed with extended wear contact lenses (Dumbleton *et al*, 2013). Therefore, contact lens practitioners prevent possible complications and retain successful contact lens wear by promoting the daily wear modality.

5.3.3. Contact Lens Complications

The discussions will include the common complications associated with contact lens wear and methods of management of these problems. Furthermore, associations between common contact lens related problems and systemic conditions will be discussed.

In this study, the most common problem experienced by contact lens wearers was dry eyes (13%). Studies investigating dry eye symptoms in contact lens wearers have shown that symptoms of ocular dryness and discomfort were common among contact lens wearers (Nichols and Sinnott, 2006; Begley *et al*, 2000). A major reason for discontinuation of contact lens wear is the symptom of dry eyes (Eiden, 2014). According to Papas (2015) the most common risk factor for dry eyes was contact lens wear. Papas (2015) further stated that contact lenses can produce significant changes to the ocular environment manifesting a dry eye condition.

Other factors which may increase the risk of dry eye symptoms include gender and age. Vehof *et al* (2014) demonstrated that females are at a higher risk of developing dry eye disease. Sharma and Hindman (2014); Vehof *et al* (2014) and Schaumberg *et al* (2009) suggested that dry eye syndrome is prevalent in older adults. A possible explanation for the finding in this study is that majority (68%) of the contact lens wearers were female and the age ranged from 7 years to 91 years with a mean of 34.61 (± 13.72) years.

Ablamowicz and Nichols (2014) reported that the frequency of dry eyes among contact lens wearers is higher than among non-contact lens wearers. The majority of contact lens wearers that experienced symptoms of dry eyes were prescribed with silicone hydrogel material. It can also be noted that the silicone hydrogel lens material was the most common contact lens material prescribed. Sengor *et al* (2012) concluded that the silicone hydrogel material, with long-term wear, produce changes of the tear film and the ocular surface. Wearing contact lenses may further intensify existing dry eye conditions in some patients resulting in symptoms of dry eye disease.

The majority (89%) of contact lens wearers in this study presented with no medical problems. This could be explained by the age of the contact lens wearer, which although ranged from 7 to 91 years, the mode was 30 years. Furthermore, the demographic results obtained indicated that majority of the contact lens wearers in this study belong to the 19 to 29 and the 30 to 39 year age group. A possible explanation for the low incidence of medical problems is the age range of the contact lens wearer.

5.3.4. Management of Contact Lens Complications

The most common problem experienced by contact lens wearers in this study was dry eyes. Management of dry eye condition in contact lens wearers depends on whether the condition is as a result of aqueous deficiency or evaporative dry eye. Ablamowicz and Nichols (2014) reported that the most common method of treating contact lens related dry eye was refitting with a more frequent replacement schedule contact lens. McDonald *et al* (2014) and Guthrie *et al* (2015) further demonstrated the use of lubricant eye drops as an effective treatment for reducing the symptoms of contact lens-related dry eyes.

In this study, contact lens practitioners indicated that the most effective treatment for relief of dry eyes as a result of contact lens wear was the use of a lubricant eye drop. Furthermore, contact lens wearers were advised to decrease wearing time with the contact lenses. In incidents of severe dry eye conditions, warm compresses, omega-3 supplements and contact lens discontinuation were recommended.

The advent of silicone hydrogel materials and the introduction of second generation silicone hydrogel materials have resulted in improved comfort and vision and a reduction in ocular complications (www.siliconehydrogels.org). However, the consequences of non-compliance can lead to discomfort, decreased vision and ocular complications. Sivak (2011) suggested that contact lens wearers need to be adequately informed of the importance in maintaining good contact lens practice.

5.2. CONCLUSION

This chapter discussed the results of this study in two sections; the contact lens practitioner profile and the contact lens wearer profile. The responses to each question were discussed using descriptive analysis and the associations between categorical variables using the standard Pearson's chi-square ($\chi2$) test were discussed.

The next chapter will provide a conclusion to this study by using the results discussed in this chapter to address the aim and objectives and make recommendations where necessary.

CHAPTER 6. CONCLUSION

6.1. INTRODUCTION

Contact lens prescribing in various countries has been conducted annually to understand the patterns of contact lens prescribing as well as the factors that influence this trend. While international contact lens practicing trends are well documented, there has been limited research to suggest that contact lens prescribing in South Africa mirrors international trends. The aim of the study was to determine the contact lens prescribing trends in KwaZulu-Natal for the correction of common refractive errors.

6.2. SUMMARY OF FINDINGS

The demographic profile of contact lens practitioners was found to be consistent with previous studies. The contact lens prescribing trends in KZN indicated that majority of contact lens practitioners prescribe only disposable contact lenses. Furthermore, results of the survey indicated that 45% of optometric practices total patient base are made up of between 40 to 60% of contact lens patients. In addition, it was found that the prescribing of RGP lenses to correct common refractive errors is in decline due to the improved technology of the design and material properties of the soft disposable contact lenses.

The demographic profile of the contact lens wearer indicated that the gender distribution was 68% females and 32% males and the age ranging from 7 years to 91 years with a mean of 34.61 (± 13.72) and mode of 30 years. This gender distribution is also representative of the international contact lens prescribing trends. The age of the contact lens wearers are similar to studies in other countries. Results of the study showed an increase in the first time contact lens wearers (new-fits).

Disposable soft contact lenses are the most common contact lenses prescribed and silicone hydrogel material was mostly prescribed for both new fits and existing contact lens wearers. This finding is consistent with the international prescribing trends regarding the contact lens design and material. In addition, the significant toric and multifocal contact lens prescribed indicates the use of advanced lens designs. The daily wear modality is preferred with the contact lenses replaced on a monthly schedule.

The most common contact lens related problem experienced by contact lens wearers in this study was dry eyes and the practitioners indicated that the most effective treatment was the use of lubricant eye drops.

6.3. LIMITATIONS OF THE STUDY

The limitations of the study included the possibility of bias due to the non-response rate with regard to self-administered questionnaires. Furthermore, this could lead to lack of generalizability of the results rather than the bias specifically. A possible limitation could be the nature of the questions posed to the contact lens practitioners. Many questions were estimates based on opinions such as what proportion of a particular lens design was prescribed. Therefore, the results should be interpreted as their opinions rather than the actual proportion of contact lenses prescribed.

Survey return depends on the postal system and this could result in delay or the return questionnaires getting lost in the system. Hence, an online survey tool is recommended to ensure an improved response rate. Furthermore, the survey consisted of largely closed-ended questions as this ensures consistent meaning to all participants and is reliable in interpreting (Floyd and Fowler, 2009). The disadvantage of this method is that the preferred answer may not be a choice and the misinterpretation of a question can go unnoticed.

6.4. RECOMMENDATIONS

In South Africa, contact lens wear is gaining popularity; however there is limited research to compare South African contact lens trends to international trends. The recommendations for future studies include a larger sample population. Furthermore, the study area should include all provinces in South Africa. The results of the study should be used to create awareness that will benefit contact lens practitioners, educators in the field as well as contact lens suppliers. The contact lens suppliers can further effectively market the products based on the prescribing trends of the contact lens practitioner. Staying abreast of current literature provides insight regarding the performance of different contact lens designs and material.

6.5. CONCLUSION

The results of the study indicated that disposable contact lenses with a daily wear modality and monthly replacement schedule was preferred by the contact lens wearer. Silicone hydrogel lenses are the preferred material for both existing wearers and new wearers. Furthermore, toric and multifocal contact lens prescribing trends are comparable to that of the more developed countries. Hence, it can be concluded that the prescribing trends in KZN for the correction of common refractive errors is consistent with international trends in contact lens prescribing.

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APPENDICES

APPENDIX I: Questionnaire

Part 1: Optometrist Profile

1. Gender:

Male		Female	

2. Race group:

African		Coloured	
Indian		White	
Other			

3. Highest level of education achieved:

Diploma		Degree	
Potgraduate Degree		Other	

4. What setting best describes this practice?

City centre		Rural area	
Suburb			

5. Type of practice:

Independent		Franchise	

6. Number of years of experience:

0 - 5 years		> 5 - 10 years	
> 10 - 15 years		> 15 - 20 years	
> 20 years			

7. As an estimate, what percentage of your contact lens patients are non-compliant with contact lens instructions (use, care, storage, lifespan)?

0 - 19.9%		20 - 39.9%	
40 - 59.9%		60 - 79.9%	
80 - 100%			

8. As an estimate, what percentage of this practice does contact lens patients constitute?

0 - 19.9%		20 - 39.9%	
40 - 59.9%		60 - 79.9%	
80 - 100%			

9. Does this practice fit rigid gas permeable (RGP) lenses?

Yes		No	

10. If “No” in Question 9 above, please indicate possible reason/s:

The cost of RGP lenses considerably hgher than soft lenses	
Initial RGP lens discomfort	
Lack of RGP lens training and experience	
Improvement of soft lens design	
Other	

11. If “Other” chosen in Question 10. above, please indicate possible reason:

____

12. If “No” chosen in Question 9 above, indicate management of existing RGP lens wearers:

Refer		Fit scleral lenses	
Fits soft lenses		Other	

13. As an estimate, what percentage of your contact lens patients are fitted with the following lenses?

	0 %	1 - 19%	20 - 39%	40 - 59%	60 -79%	80 - 100%
Cosmetic						
Conventional						
Disposable						
RGP						
Toric						
Scleral						

14. Which component of your contact lens practice would you like to receive further information on?

New development in contact lens technology	
Common problems with contact lens use	
Promotional and marketing material	
Other	

15. If “Other” chosen in Question 14 above, please specify:

____

____

Part 2: Patient Profile

1. Gender:

Male		Female	

2. Age:

____

3. Race:

African		Coloured	
Indian		White	
Other			

4. Type of fit:

New fit		Refit	

5. Refractive error:

Astigmatism		Myopia	
Hyperopia		Presbyopia	

6. Level of astigmatism:

<-0.50		-0.75	
-1.00		-1.25	
-1.50		>-1.75	

7. Lens material:

Conventional		Cosmetic	
Hydrogel		Rigid gas permeable	
Scleral		Silicone hydrogel	

8. If "Cosmetic" lens material is selected in question 7 above, please indicate if contact lenses are:

Plano		Prescription	

9. Lens design:

Bifocal		Cosmetic	
Monovision		Multifocal	
Spherical		Toric	

10. Frequency of replacement:

Daily		1-2 weekly	
Monthly		3-6 monthly	
Yearly			

11. Modality of wear:

Daily wear		Extended wear	

12. What medical comorbidities (if any) does this contact lens wearer have?

Astma/Eczema		Diabetes mellitus	
Rheumatoid arthritis		Throid disease	
Other		None	

13. If "Other" selected in Question 12. above, please specify:

____

14. Does this contact lens wearer experience any of the following?

Blepharitis		Neovascularization	
Dry eye syndrome		Hyperaemia	
Hypoxia		Poor lens care	
Lens intolerance		None	

15. Management of the problem/s referred to in 14. above:

____

____

____

APPENDIX II: Letter from Director, Eurolens Research

22 May 2014

Dear Veni

The details of the questionnaire are in the public domain. We describe the questionnaire in our various publications. This work is used all over the world and lots of people are involved.

Please be assured that because it's in the public domain you can just go ahead and use it or adapt it. You will want to refer to it at some point in your report I would presume, but you don't need formal approval.

I am entirely comfortable with what you propose and I wish you good luck!

Phil

Professor Philip Morgan

(Director, Eurolens Research)

The University of Manchester

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APPENDIX III: Ethics Approval Notification

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

22 October 2014

Mrs Veni Moodley 8829817
School of Health Sciences
Westville Campus

Protocol reference number: HSS/0722/014M
Project title: Patterns of contact lens prescribing in KwaZulu-Natal

Dear Mrs Moodley,

Full Approval – Expedited Application

With regards to your response to our letter dated 02 September 2014, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....

Dr Shenuka Singh (Chair)

/ms

cc Supervisor: Ms Naimah Ebrahim Khan
cc Academic Leader Research: Professor J van Heerden
cc School Administrator: Ms P Nene

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile**: +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

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APPENDIX IV: Request for permission to conduct research in Optometric Practices and Consent Form (Gatekeeper consent)

UNIVERSITY OF KWAZULU-NATAL

To whom it may concern:

RE: Request for permission to conduct research in Optometric practices

I, Veni Moodley, am a postgraduate student at the University of KwaZulu-Natal and I am currently studying for my Masters degree. I am conducting a study on the current trends of Contact Lens prescribing in KwaZulu-Natal. ___________________ has been randomly selected to participate in this research study.

This study will advance our understanding of, as well as compare our own patterns of contact lens prescribing with international practice trends; it will also assist contact lens suppliers to promote and market their products based on the prescribing patterns of contact lens practitioners in KwaZulu-Natal.

By being part of this study, you agree to be a part of a group that will help gather information about contact lens prescribing. Furthermore, as optometrists, our field is continually evolving, and a study of this nature will help us keep abreast of international trends in contact lens practice.

Information will be collected by means of a self-administered questionnaire. The questionnaire is designed to acquire information in the most efficient manner and should take no more than 20 minutes. The information obtained in this study will be kept confidential. All information will be collected anonymously.

There are no risks involved in this study. There are also no costs involved that may result from participation in this study. Your involvement is for academic purposes only, and there are no financial benefits.

If you are willing to be involved would you please sign the attached consent form that acknowledges that you have read the explanatory statement, you understand the nature of the study being conducted, and you give permission for the research to be conducted.

This study has been ethically approved by the UKZN Ethics Committee and the approval number is _________________.

Thank you for your time and consideration in this matter.

Declaration

I _______________________ hereby confirm that I have been adequately informed about the study entitled *Patterns of contact lens prescribing in KwaZulu-Natal.* I understand the purpose and procedures of the study. I understand that participation in this study is entirely voluntary and I have the right to withdraw without any negative consequences.

If I have any questions or queries related to the study then I may contact:

Researcher: Ms Veni Moodley
Telephone: 082 4072808 / 031 8374237
Email: venimoodley@webmail.co.za

Academic Supervisor: Ms Naimah Ebrahim Khan
Telephone: 031 2608645
Email: ebrahimn@ukzn.ac.za

If I have any questions or queries about an aspect of the study or the researcher then I may contact:

Mr P Mohun

University of KwaZulu- Natal Research Office:

Humanities and Social Sciences Research Ethics Committee

Govan Mbeki Centre

Tel +27312604557

Fax +27312604609

E-mail mohunp@ukzn.ac.za

I support the conduct of this research in this organisation.

Signature of Participant Date

-- -----------------------------

Witness Date

-- -----------------------------

APPENDIX V: INFORMATION DOCUMENT AND INVITATION TO PARTICIPATE (Contact Lens Practitioner)

UNIVERSITY OF KWAZULU-NATAL

Study title: Patterns of Contact Lens Prescribing in KwaZulu-Natal

Dear Optometrist,

We are presently conducting a study on the current trends of Contact Lens prescribing in KwaZulu-Natal.

Purpose of this study

The use of contact lenses for the correction of refractive errors such as myopia, hyperopia, astigmatism and presbyopia has increased tremendously over the years. This study will advance our understanding of, as well as compare our own patterns of contact lens prescribing with international practice trends; it will also assist contact lens suppliers to promote and market their products based on the prescribing patterns of contact lens practitioners in KwaZulu-Natal. Furthermore, as optometrists, our field is continually evolving, and a study of this nature will help us keep abreast of international trends in contact lens practice.

What is involved in this study?

Your involvement is purely for academic purposes only, and there are no financial benefits involved. You will share your prescribing practises and experiences, and contribute to the profession through this educational document.

Risks:

There are no risks involved in this study.

Benefits:

This study will help better direct our endeavours as practitioners as well as product suppliers to the contact lens industry.

Costs:

There are no costs involved that may result from participation in this study.

Confidentiality:

The information obtained in this study will be kept confidential. A password protected computer will be used to store information. Only the researcher will have access to the computer. All data on hard copy documents will be kept in a locked cupboard for five years and in due course will be shredded.

Right to withdraw:

Your participation in this study is voluntary and you have the right to discontinue your participation at any time without any negative consequences.

For further information please contact:

1. Researcher: Ms Veni Moodley
   Telephone: 082 4072808 / 031 8374237
   Email: venimoodley@webmail.co.za

2. Academic Supervisor: Ms Naimah Ebrahim Khan
   Department of Optometry, University of KwaZulu-Natal
   Telephone: 031 2608645
   Email: ebrahimn@ukzn.ac.za

3. You may also contact the research office through:
   Mr P Mohun
   University of KwaZulu-Natal
   Research Office: Ethics
   Govan Mbeki Centre
   Tel +27312604557
   Fax +27312604609
   E-mail mohunp@ukzn.ac.za

<u>APPENDIX VI: Consent to participate in research</u> (Contact lens wearer)

UNIVERSITY OF
KWAZULU-NATAL

<u>Study title: Patterns of Contact Lens Prescribing in KwaZulu Natal</u>

I ……………………………………………..hereby confirm that I have been requested to participate in a research study entitled *Patterns of Contact Lens Prescribing In KwaZulu -Natal*. I have been adequately informed of the purpose and procedure of the study by ……………………………………………..

I understand that all information will be requested anonymously and at no time will I be identified. I understand that there will be no costs incurred upon me by participating in this study. I declare that my participation in this study is entirely voluntary and I may terminate my participation at any time.

If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher at 031 8374237 or email at venimoodley@webmail.co.za.

If I have any questions or queries about my rights as a study participant, or if I am concerned about an aspect of the study or the researcher then I may contact:

BIOMEDICAL RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X 54001

Durban

4000

Tel: 27 31 2604769 - Fax: 27 31 2604609

Email: BREC@ukzn.ac.za

______________________________	____________________
Signature of participant	Date
______________________________	____________________
Signature of Witness	Date

APPENDIX VII: Health Professions Council of South Africa (Statistics and Analysis)

Total No of Persons Registered (As at 06 May 2014)

Register/s: OPTOMETRISTS

NB: Regional Distribution based on Personal Postal Address

BRD_CODE	REG_CODE	REGION	Total
ODO	OP	EASTERN CAPE	179
		FOREIGN	49
		FREE STATE	166
		GAUTENG	1,339
		KWAZULU NATAL	642
		LIMPOPO	311
		MPUMALANGA	235
		NORTH WEST	125
		NORTHERN CAPE	50
		WESTERN CAPE	431
	OP Total		3,527
ODO Total			3,527
Grand Total			3,527

Please do not hesitate in contacting me should you require any further information or assistance herewith.

Kind Regards

Yvette Daffue
IT Dept (Statistics & Data Analysis)
HEALTH PROFESSIONS COUNCIL OF SOUTH AFRICA
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