THE SLIT LAMP AND SODIUM FLUORESCEIN:
THEIR USE AND BENEFITS

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Thesis Summary

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Aims: (i) Gather data from optometrists worldwide on their use of the slit lamp and their use of sodium fluorescein. (ii) To measure the effectiveness of performing slit lamp examination and instillation of sodium fluorescein on every patient attending for an eye examination (iii) To measure the number of clinical signs seen when performing polarised biomicroscopy using a circular polariser filter.

Methods: (i) A questionnaire was sent out to optometrists in different parts of the world asking questions concerning the use of the slit lamp and sodium fluorescein. (ii) Ninety-six patients were examined, and all patients had a complete slit-lamp examination, and every patient had sodium fluorescein instilled on their eye. (iii) The same 96 patients' cornea, iris and crystalline lens were examined using a circular polariser filter.

Results: (i) The majority of the survey respondents stated that they used the slit lamp on 75% or more of their non-contact lens patients. However, when asked about the use of sodium fluorescein, most respondents stated that they used it on only 25% or less of their patients. (ii) Using the slit lamp on every patient showed clinical signs in between 86%-95% of the patients. Using sodium fluorescein on every patient showed clinical signs in 54% of patients. (iii) Using the circular polariser on every patient enhanced the view of clinical signs in 29% of patients.

Conclusions: Whilst the use of the slit lamp is high on non-contact lens wearers, the use of sodium fluorescein is relatively low. Using the slit lamp on all patients attending an eye exam is effective as numerous signs can be seen. The circular polariser filter can be helpful in routine practice but only for those patients who already have clinical signs.

Keywords: Sodium Fluorescein, Circular Polariser, Survey, University Clinic, Symptoms

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Chapter 1 Introduction & Literature Review

Optometry, as a profession, is advancing around the world. For example, in some individual states of the United States of America, optometrists can perform minor ocular surgery, some ocular injections and even LASIK. In Scotland, optometry has its own eye care system, and within the United Kingdom, there is the opportunity for optometrists to become independent prescriber optometrists.

With this, patients will expect more from optometrists and expect a greater standard of care. As patients expect more, a systematic approach must be taken for each patient, even if the patient is asymptomatic.

However, if the patient is asymptomatic, there could be a moment when optometrists feel that specific steps of the eye examination are not as necessary as other steps. For example, currently, there is a particularly strong emphasis put on investigating posterior eye changes. This emphasis could lead to less importance being placed on the external eye examination. Also, an optometrist may feel that given that a patient is asymptomatic, there would be no benefit to instil Sodium Fluorescein.

Even though demonstrating the use of the slit lamp is a core competency under the General Optical Council (GOC) training scheme[1], using the slit lamp in an eye exam is not mandatory in the United Kingdom apart from in Scotland.

Only recently do the guidelines from the College of Optometrists explicitly mention the slit lamp when examining the anterior portion of the eye[2]. However, in the United Kingdom's Optician's Act 1989[3], there is no mention of using a slit lamp. It does state that an external examination of the eye must be done under the definition of a sight test, but it does not state how this external examination must be done.

In Scotland, an amendment in 2018 to The National Health Service (General Ophthalmic Services) (Scotland) Regulations 2006 states that an external eye examination must be completed in a primary eye examination and the use of the slit lamp is necessary. Only in domiciliary visits can a "loupe and illumination" be used for an external eye examination[4].

It is also not mandatory to use a slit lamp during an eye exam in many parts of the world. Table 1.1 lists the different components of an eye exam legally needed in the top 5 countries for which respondents answered the questionnaire in Chapter 2. These five countries make up 84% of all the respondents.

The cells indicated with a "✓" indicate that this component of the eye exam needs to be completed legally. The cells indicated with a "*" indicate that the anterior eye examination must be carried out using a slit lamp. The cells indicated with a "&" indicate that this component is left to the decision of the optometrist or the patient's symptoms. Finally, blank cells indicate there is no legal requirement for this component.

As seen in the table, many countries or states mandate that the anterior eye be examined but do not list that a slit lamp is the equipment to be used. For example, from the table, only three states in the USA and two provinces in Canada state that specifically a slit lamp must be used to examine the anterior eye.

The five states selected in the USA are the top 5 states with the most optometrists working in those states[5].

	History	Visual Acuity	Prelims	BV	Refractive	Anterior	Posterior	Tonometry	Visual Fields
United Kingdom									
Optician's Act[3]					✓	✓	✓		
College of Optometrists guidelines[2]	✓	✓	&	✓	✓	✓	✓	&	&
United States of America									
AOA Guidelines[6]	✓	✓	✓	✓	✓	✓	✓	✓	✓
California State Board	No standards listed								
Florida State Board[7]	✓	✓	✓	✓	✓	*	✓	✓	✓
New York State Board	No standards listed								
Pennsylvania State Board[8]	✓	✓	✓	✓	✓	*	✓	✓	✓
Texas State Board[9]	✓	✓		✓	✓	*	✓	✓	✓
Sweden	No standards listed								
Canada									
British Columbia[10]	✓	✓		✓	✓	✓	✓	✓	&
Manitoba[11]	✓	✓	✓	✓	✓	✓	✓	✓	&
Ontario[12]	✓	✓	✓	✓	✓	*	✓	✓	&
Prince Edward Island[13]	✓			✓	✓	✓			
Quebec[14]	✓	✓	✓	✓	✓	*	✓	&	&
Saskatchewan[15]	✓	✓	✓	✓	✓	✓	✓	✓	&
Trinidad & Tobago	No standards listed								

Table 1.1 Legal components of a complete eye exam (not for contact lenses)

1.1.1 Standardised Slit Lamp Exam

Various texts have outlined a suggested routine when using the slit lamp as follows:[16-22]

- Eyelids & Lashes
  - Blepharitis, Chalazion, Concretions, Ectropion, Entropion, Hyperaemia, Meibomian Glands, Ptosis, Stenosis of the Puncta, Stye, Trichiasis
- Conjunctiva & Sclera
  - Conjunctivochalasis, Episcleritis, Follicles, Hyperaemia, Naevus, Papillae, Pinguecula, Pterygium, Scleritis
- Tear Film & Meniscus
  - Debris, Make up
- Cornea
  - Arcus, Opacity (epithelial, stromal, endothelial), Vascularisation
- Anterior Chamber
  - Cells & Flare, Hypopyon
- Iris and Pupil
  - Irregular pupil, Naevus, Rubeosis Iridis
- Lens
  - Cataract, Intra Ocular Lens, Subluxation
- Anterior Vitreous
  - Shafer’s sign/"Tobacco Dust"

The addition of Sodium Fluorescein (NaFl) also allows the examination for:

- Epiphora
- Tear Break up time
- Corneal Staining
- Tear Prism

A slit lamp routine must be developed and maintained. It is advised to perform several sweeps of the anterior eye observing structures in a logical order. An outside to inside method is ideal to ensure that no ocular structures nor clinical signs are missed, and a complete examination can be done. Also of importance is the setting of the microscope's oculars correctly[23, 24].

After the slit lamp examination, the optometrist will be aware of any abnormal findings and what management, if any, needs to be taken.

The slit lamp examination is essential in primary eye care. Its relative ease of use and that it can pick up the first clinical signs of some conditions is noted. Martin states that the slit lamp is needed in the testing room. It is necessary in an eye examination to diagnose several eye diseases[21]. The slit lamp is the gold standard for an anterior eye examination[25-28, 21, 29, 30]. The advantages of the slit lamp over, for example, the direct ophthalmoscope, are excellent image quality, stereoscopic image, flexible illumination and flexible magnification[31].

When Gullstrand designed the slit lamp in 1911, some recognised it as a great device, and courses promoted its use. Even though the slit lamp instrument has been around for over a century, the device's design has not fundamentally changed, and the way to use it has not changed dramatically during this time either. However, the reasons for using it has expanded tremendously, diagnostically and therapeutically, as can be seen in Table 1.2

Diagnostic	Therapeutic
Anterior Eye Examination[32]	Contact lens fitting[33]
Tear Break Up Time (TBUT)[34] & Tear meniscus height[35]	Punctal plugs[33]
Lid wiper epitheliopathy[36]	Epilation lashes[33]
Fundus biomicroscopy[37-39]	YAG Laser[40]
Grading of Diabetic Retinopathy[41-44]	SLT/ALT[40]
Optic disc assessment[45]	Removal of foreign bodies from the cornea[33]
Goldmann Tonometry[46]	Remove foreign bodies from the face[47]
Anterior and Fundus photography[48, 49]	Remove foreign bodies from fingers[50]
Detect signs in keratoconic patients[51, 52]	Epithelial debridement
Used to measure corneal thinning[53, 54]	Corneal scrapings[33]
Measurement of Anterior chamber depth [55-57]	Trimming sutures[33]
Gonioscopy[58]	Anterior Chamber Tap[33]
Anterior segment OCT[59-64]	Rebubbling DMEK grafts[65]
Pupil size[66]	Anterior chamber paracentesis[67]
Exophthalmometry[68]	Treatment of the side effects of trabeculectomy surgery[69]
Flow of aqueous humour[70, 71]	
Check donor corneal tissue[72]	
Farby disease[73, 74]	
To measure ocular blood flow[75]	
Study blebs after trabeculectomy[76]	
Monitoring of paediatric cataracts[77]	

Table 1.2 Diagnostic and Therapeutic uses of the slit lamp

Sparse studies are available that discuss the use of the slit lamp in a negative manner. A study by Anderson[78] stated that general practitioners did not need a slit lamp for patients with red eye. However, whilst this study was aimed at general practitioners, two ophthalmologists organised the study. Some articles have discussed the possibility of retinal damage due to excessive exposure to light via the slit lamp examination[79-82], with Ghafour finding there is no long term effect on vision by using the slit lamp on patients[83].

1.1.2 Grading Scales

Grading scales allow an optometrist to judge a condition they have identified, compared to a defined group of descriptions or photos. Grading scales help the optometrist maintain consistency in recording signs seen during the eye exam. They also allow a comparison of what was seen at a previous visit. A grading scale could also aid the same optometrist or their colleagues, examining the same patient at different dates. However, a grading scale is only as good as the user of the scale. It has been recommended to grade any condition to one decimal point to improve the sensitivity of the scale[20]. There are grading schemes designed for various conditions. Scales are available in different styles such as descriptive scales[84, 85], drawings[86] and photographs[87-89].

Various grading scales have been created:

Grading scales for the ocular surface (Cornea & Conjunctiva):

- Van Bijsterveld[90]
- National Eye Institute (NEI)[91]
- Collaborative Longitudinal Evaluation of Keratoconus (CLEK)[92]
- Oxford system[93]

Grading scales for specific lid conditions:

- Pult's meibomian glands[94]
- Korb's lid wiper epitheliopathy[95]

Grading scales for the anterior eye:

- Brien Holden Institute Grading Scales (formerly know as CCLRU grading scales)[96, 97]
- Annunziato[98]
- Vistakon[99]
- Efron[100]
- Jenvis[101]

The first four anterior eye grading scales have all been validated for clinical use[89]. However, Efron recommends that optometrists should be consistent in using only one grading scale[89]. Wolffsohn in 2004 states that the grading scales are not similar in their scale of measurement and cannot be compared with each other[102]. Likewise, Bron et al. in 2007 noted that no one scale is superior to the other[103].

Studies have shown that most optometrists use grading scales in routine practice. A survey of Queensland optometrists in 2010 indicated that 61% of optometrists who responded used a grading scale. The Efron scale was used by 65% of those optometrists who used grading scales, 25% used the CCRLU, 5% used a different scale, and 5% did not know which scale they used[104]. Wolffsohn et al. found that 84.5% of those asked used a grading scale. The Efron and CCLRU were the most popular, but in different areas of the world, the preferred grading scale was different[20].

Nichols et al. in 2004 found that slit-lamp findings are generally not repeatable for dry eye tests, and findings can be transient[105]. It was suggested that subjective grading was not sensitive enough to visualise subtle differences.

Also, with subjective grading, there is the possibility of observer bias and misclassification bias[106]. Observer bias is when the observer allows their own bias to affect the grading, such as believing that the grading scale should be scored in whole numbers and not smaller increments as recommended. Misclassification bias is when the sign is graded incorrectly.

To get away from the subjectivity of using grading scales, numerous researchers have designed objective ways for clinical grading of the whole or part of the anterior eye using software[107-113, 102, 114-118]. Whilst some have been validated, and already in clinical equipment, they have not made their way into routine clinical practice. Being objective removes any inter and intra-observer errors, meaning the software's measurements are less variable and are repeatable.

1.2 Sodium Fluorescein

A vital stain is one that can be used on living cells, and the stain will not kill those cells[119]. In optometry, vital stains have been used for diagnostic purposes. Fluorescein was the first dye to be used in vital staining of the cornea. Norn, in 1962, discusses Straub and Fromm et al. in 1888 introducing fluorescein staining for various clinical diagnoses and assessment of corneal health[120].

Fluorescein is an organic compound, but it is not a natural substance. Baeyer first produced it in 1871. As it is not soluble in water, it needs to be combined with Sodium salt to give NaFl, a basic organic compound. It has the chemical formula $C_{20}H_{10}Na_2O_5$.

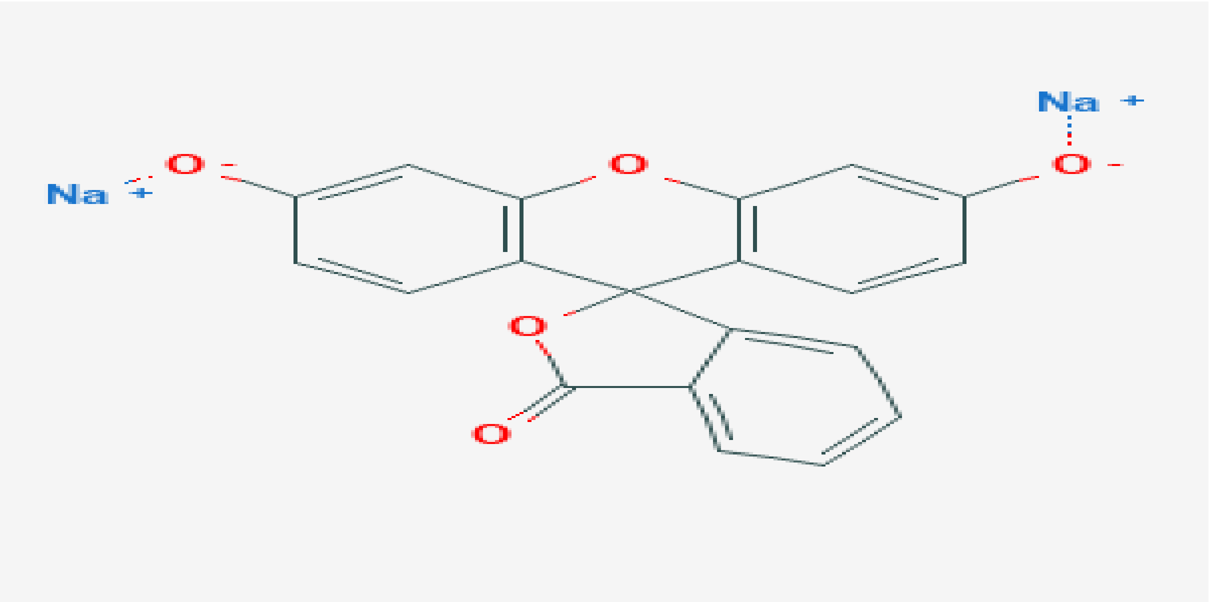

Figure 1.1 Chemical Structure of Sodium Fluorescein[121]

Its fluorescent properties are beneficial in optometry and in many other industries such as engineering, aviation, plumbing and the military. While this thesis focuses on NaFl for anterior eye staining, NaFl has also been used to fit rigid gas permeable contact lenses, Goldmann tonometry, testing the lacrimal drainage system patency, and an indicator for perforation of the cornea or globe, the Seidel test.

It is the most used dye in routine practice. NaFl is listed in the World Health Organisation's list of essential medicines[122]. In a survey of optometrists in the United Kingdom[123], 96% of optometrists frequently used NaFl in their routine practice, but it is not stated if this is with contact lens patients or all patients.

An interesting study by Davies & Veys[124] gave a questionnaire about the use of NaFl to 2000 optometrists in five countries. They showed that 77% of the optometrists used fluorescein on most or all of their contact lens aftercare patients in the UK. However, 21% only used fluorescein if they felt there was a problem and 2% never used fluorescein on a patient during a contact lens aftercare. The last two values increased in the four other European countries.

It is interesting to note from the Davies & Veys[124] study that those optometrists that used fluorescein the least also reported less accuracy in determining the amount of staining on the cornea. This study involved discussing patients who were attending a contact lens aftercare. No literature could be found concerning the value of using fluorescein on patients who attended a routine eye examination in clinical practice.

NaFl fluoresces maximally at a wavelength of 520nm when it is excited by light of a wavelength of 480-490nm. These wavelengths equate to green light and blue light, respectively. Most slit lamps have a blue filter to enable viewing the fluorescence when NaFl is instilled in the eye. Bron et al. suggest using an exciter filter like a Wratten 47A, which is also blue, but states that the blue light from the slit lamp filter will suffice[93]. Ultraviolet-A light (315-400 nm) could be substituted to cause the excitation. The main instrument in optometric practice that uses UV-A as a source of excitation is the Burton Lamp, also known as Wood's Lamp. The fluorescence can be seen easier using a Wratten Filter #12 in front of the observation system. It filters out the original blue light visible on the eye, enhancing the contrast of the fluorescence[125, 126].

There are a few cases reporting a reaction to NaFl when used topically[127-130]. Some of these reports were linked to patients with existing general health problems. Also, some of the reports are associated with minim drops[129, 130] and not the paper strip form. The fluorescein strip does not contain any preservative agent. It is thought that the preservative agent is likely to cause the reaction in some of the studies.

Other reports of reactions to NaFl, mainly nausea and vomiting but sometimes fatal reactions, are related to its use intravenously, such as for fluorescein angiography[131-138]. In addition, Halperin stated that excessive sneezing could be an early sign of an allergy to the fluorescein dye[139].

There is also a risk of the patient obtaining an eye infection from the use of NaFl due to the ease of contamination of NaFl with Pseudomonas aeruginosa[140]. Again, studies show this is due to either the reuse of minim drops[141] or using NaFl from a vial[142, 143]. Some optometrists may fear using NaFl from these reports; however, it has been shown that the proper use of single-use Minims does not allow contamination[144]. Using the paper strip form, which is disposed of after every use, also prevents infections.

With the knowledge that bottles of NaFl can lead to bacterial colonies, especially Pseudomonas aeruginosa, Kimura published in 1951 the idea of using filter paper impregnated with NaFl which could be easily sterilised[145].

However, NaFl does not appear to have any long term effect on the cornea. In addition, it has been shown to be non-toxic to rabbit's endothelium in concentrations similar to those used in daily optometric practice[146].

Various authors have discussed the ideal way to use a NaFl strip with a patient[147, 93, 148]. First, the NaFl strip is opened halfway down the packaging, and the cover is removed. Next, a drop of saline is placed on the strip with any excess shaken into a bin. The inferior lid is then pulled down, the patient is asked to look up, and the strip is gently touched on the inferior palpebral conjunctiva.

There is also literature on sequential staining and how it can increase the percentage of corneal staining seen. Josephson and Caffery[96] in 1988 discussed sequential staining as instilling NaFl 6 times, with 3-minute gaps. Using this technique, 17.6% of their subjects had corneal staining. Caffery & Josephson[126] in 1991 then used NaFl 7 times, with 3-minute intervals daily over one month and found staining in 67%-83% of their subjects.

Josephson & Caffery[149] in 1992 then used NaFl 7 times with 4-minute gaps and found 47.6% had corneal staining, although they admit they had asked patients who were known "stainers" from their previous studies to partake.

NaFl is interesting as it can convert almost 100% of absorbed light to fluorescent light. The concentration of NaFl instilled can change the amount of fluorescence. There is a maximum concentration that gives the maximum intensity of fluorescence. After this point, we get quenching where the ability to get the fluorescent response lessens[150, 151, 148, 152]. The pH of NaFl can also affect how it fluoresces; a pH of 7.4 gives the maximum fluorescence. However, patient tears can have varying pH levels. Fluorescence can also vary with the quantity and quality of the tear film.

Peterson et al. showed that a moistened NaFl strip would reach a clinically useful fluorescence level almost 2.5 times quicker than a saturated strip. They also showed that the moistened strip would reach peak fluorescence over five times faster than a saturated strip[148].

Caffery and Josephson stated that corneal staining is variable, and perhaps no clinical decision should be made with one viewing[126]. Kikkawa said in 1972[153] that the cycle of variability in corneal staining in rabbits is 4.2 days, whilst Schwallie et al.[154], in 1997, found the cycle to be 1.2 days in humans. They stated that if a patient has doubtful corneal staining or staining of unknown cause, it should be rechecked in 2 days to see if it is still there. If the staining is still present, the staining could be noted as significant.

NaFl can affect tear thinning time and tear breakup time[155], but Loran et al. state that NaFl strips provide the minimum amount to not affect TBUT[156]. Other studies suggest using a micropipette to ensure that the volume of NaFl instilled is no more than the tear volume, 7uL, or a consistent volume of saline is applied to the NaFl strip[157-159]. Different modifications to the NaFl strip have been designed to try to allow consistency in each strip: Dry Eye Test (DET)[160] and Modified Fluorescein Strip (MFS)[161].

Schwallie et al. in 1997 found some corneal staining on 78% of non-contact lens wearing subjects[154]. Dundas et al. in 2001 stated that some corneal staining is a normal finding in up to 79% of corneas[162]. The exact functioning of NaFl and corneal staining is still unsure[163]. It is commonly thought that NaFl flows into breaks in the epithelium barrier when the epithelium is damaged[120, 164-166] although it has been shown that NaFl can still stain healthy cells[167, 168].

1.3 Patient Symptoms

Patient symptom questionnaires can be used to help measure and standardise any symptoms reported by a patient. A range of patient questionnaires is listed in Table 1.3. Most of these questionnaires are used in research, but some could and are used in routine practice.

Name	Year	Author	Questions	Sensitivity	Specificity	Timeframe
McMonnies Questionnaire	1986	McMonnies[169-172]	14			Now
Canadian Dry Eye Epidemiology Study (CANDEES)	1997	CCLRU[173, 171]	13			Now
Schein Questionnaire	1997	Schein[174, 175]	6			Now
Dry Eye Screening for Dry Eye Epidemiology Projects (DEEP)	1998	Oden[176]	14	0.6	0.94	Now
McCarty Symptom Questionnaire	1998	McCarty[177]	11			Now
Ocular Surface Disease Index (OSDI)	2000	Schiffman[178-180]	12	0.83	0.6	One week
Contact Lens Dry Eye Questionnaire (CLDEQ)	2000	Begley[181, 182]	36	0.83	0.67	
Dry Eye Questionnaire (DEQ)	2002	Begley[183-185]	23			Past week
Women’s Health Study Questionnaire	2003	Schaumberg et al[186, 187]	3	0.77	0.83	Now
Impact of Dry Eye in Everyday Life (IDEEL)	2005	Rajagopalan[188, 189]	57			Two weeks

Texas Eye Research and Technology Center Dry Eye Questionnaire (TERTC-DEQ)	2005	Narayanan[190, 171]	28	0.75	1.00	Now
Ocular Comfort Index (OCI)	2007	Johnson and Murphy[191, 192]	12	0.567	0.550	Past week
Symptom Assessment In Dry Eye (SANDE)	2007	Schaumberg et al[193, 194]	2			Now and 2 Months
Standard Patient Evaluation of Eye Dryness Questionnaire (SPEED)	2012	Blackie[195, 196]	8	0.90	0.80	Now, 3 days, 3 Months
University of North Carolina Dry Eye Management Scale (UNC DEMS)	2014	Grubb[197]	2			Past week

Table1.3 Various Patient Questionnaires available

Each questionnaire listed has its strengths and weaknesses. The McMonnies, OSDI and OCI questionnaires have a practical number of questions to allow them to be used in routine practice. However, the OCI needs an Excel spreadsheet to calculate the score, which is not practical in daily practice. The OSDI may need a shorter time to fill in than the others[180]; however, some optometrists may find the time taken to actually administer the OSDI may prevent it from being used in routine practice[198]. A weakness of the OSDI questionnaire is that it does not ask about several relevant symptoms that patients may be experiencing, for example, burning sensation, dry eyes, watery eyes, foreign body sensation. In addition, it does not ask about severity[179, 180]. Simpson et al. state that OSDI, McMonnies and DEQ all give similar results and distinguish between symptomatic and asymptomatic patients[184].

Some researchers do not use questionnaires but rely on patient symptoms for their entry criteria and or research endpoints. Table 1.4 below lists research that used questionnaires and or symptoms on their patients. It lists each symptom that the article mentions. Some symptoms can be counted twice in a column, for example, gritty eyes and foreign body sensation.

In clinical practice, Williamson et al. surveyed ophthalmologists and optometrists in the North Carolina area. Those who responded reported that burning, foreign body sensation, tearing and itchiness were the most common symptoms heard from patients. They noted that almost 70% of the professionals used patient history to guide the therapeutic effect of any treatment[199].

The Dry Eye WorkShop (DEWS 1) stated that a patient should report at least two dry eye symptoms and listed examples, a foreign body sensation, burning, photophobia, blurred vision, pain, itching[200].

Author	Year	Dry	Gritty Foreign Body	Sore Irritation Achy	Burning Stinging	Itchy	Discomfort	Photo phobia	Watery	Blurry Poor Disturbed Vision	Fatigue	Red	Scratchiness	Stuck shut	Crust on lashes	Discharge	Heaviness	Number of Symptoms
McMonnies[169]	1986	✓	✓	✓	✓								✓					5
Lakkis[201]	1996	✓	✓			✓	✓		✓									5
Doughty[173]	1997	✓	✓	✓			✓	✓			✓						✓	8
Schein[175]	1997	✓	✓		✓							✓		✓	✓			6
McCarty[177]	1998	✓	✓			✓	✓	✓	✓									6
Pflugfelder[16]	1998	✓	✓	✓	✓	✓		✓	✓	✓						✓		10
DEEP Oden[176]	1998	✓	✓	✓	✓	✓		✓	✓			✓	✓	✓				12
Nichols[202]	1999	✓		✓	✓	✓		✓		✓								6
OSDI[178]	2000		✓	✓				✓		✓								5
Nichols[203]	2003	✓	✓	✓							✓	✓						5
Chia[204]	2003	✓	✓			✓	✓											4
Tabery[205]	2003	✓	✓	✓	✓			✓	✓	✓								7
Nichols[105]	2004	✓	✓	✓							✓	✓						5
Nichols[206]	2004	✓	✓	✓			✓				✓	✓						6
TERTC-DEQ Narayanan[190]	2005	✓	✓	✓	✓	✓	✓						✓					9
Nichols[207]	2006	✓	✓		✓	✓	✓											7
Gifford[208]	2006	✓	✓		✓								✓					6
Begley[209]	2006	✓				✓	✓			✓								5
OCI Johnson[191]	2007	✓	✓	✓	✓	✓					✓							6
Simpson[184]	2008	✓																1
DEQ 5 Chalmers[185]	2010	✓					✓		✓									3
Symptoms of Discomfort Questionnaire (SODQ) Cuevas[210]	2012	✓	✓	✓	✓	✓		✓		✓								8
Williamson[199]	2014		✓		✓	✓			✓									4
Tang[172]	2016	✓	✓		✓		✓			✓	✓							6
Total		22	20	13	13	12	10	8	7	7	6	5	4	2	1	1	1	Average 6

Table1.4 Breakdown of patients symptoms used as entry criteria and or research endpoints for various studies

1.4 Birefringence & Polarisation Biomicroscopy

Birefringence is defined as the double refraction of light in a transparent material due to different refractive indices within the material[211, 212]. This double refraction causes the light rays going through the material to become polarised.

Brewster noted birefringence present in the human cornea in 1814, where he noticed seeing colour rings when viewing the cornea[213, 214].

There are three main categories of birefringence:

- Intrinsic birefringence is when the arrangement of the molecules in the individual tissue itself is the cause of the birefringence.
- Form birefringence occurs when the tissue is oriented in a regular manner within areas/materials of different refractive indices.
- Stress birefringence is caused by a force on a tissue that may or may not be intrinsically birefringent.

A transparent material that has the same refractive index in all directions is called isotropic. An isotropic material cannot display birefringence unless under stress. A transparent material that has different refractive indices is called anisotropic. Anisotropic materials can display all three types of birefringence.

Various parts of the eye can display birefringence. The cornea[215-221] accounts for 80% of the total birefringence of the eye[215, 216]. The tear film, aqueous humour, crystalline lens and the vitreous account for a minimal amount[222-231]. The remaining birefringence from the eye comes from the retinal nerve fibres and the nerve fibre layer of Henle in the macula[232-236, 217, 237, 238].

Corneal birefringence is due to the layers in the stroma[239]. Every layer comprises parallel collagen fibrils surrounded by an optically similar tissue and acts as a birefringence material. Changes to the fibrils themselves or the ground substance can change the cornea's birefringence. The arrangements of these layers also account for the cornea's transparency and strength[239].

Intrinsic and form birefringence are present in the cornea[240, 241, 225]. The intrinsic birefringence of the cornea originates from each collagen fibril and comes from the asymmetry within the collagen particles[242]. Form birefringence usually is found in tissues that contain collagen.

The corneal fibrils are thinner with a consistent diameter, hydrated, and organised compared to other collagen structures in the body[243, 244].

Stress birefringence may also be visible in the cornea. The stroma could be under natural stress due to the extra-ocular muscles or the intra-ocular pressure[245, 246]. The cornea could also be under stress due to surgery or corneal oedema[241, 247].

The birefringence of the cornea is different in corneas with keratoconus with thinning compared to a normal cornea[248-250]. Abnormal birefringence has also been observed in keratoplasty patients[249]. Corneal Cross-linking has also been shown to change the birefringence of the cornea[251].

Transparent materials can be categorised based on the arrangement of their optical axes, uniaxial or biaxial. Uniaxial, axisymmetric materials have a single optical axis, and layers are randomly arranged. Biaxial, non-symmetric materials have two independent optical axes, and layers are arranged in a preferred way in a random background[252].

There is no agreement on what form the cornea is, with some researchers stating the cornea acts as a uniaxial material[215, 239] whilst others say it acts as a biaxial material[232, 253, 217, 219, 221, 229, 254]. Other researchers state this disagreement is due to measurements being only taken from the central cornea[252, 219, 255].

Polarised microscopy of any material/tissue can be done using crossed polarisers - that is, polarisers orientated 90° to each other or one linear polariser and a half-wave plate retarder at 45°. This arrangement allows any birefringence of the material/tissue to be visible. One of the earliest groups of studies of polarisation biomicroscopy was by Stanworth, using a cat's cornea[241, 215, 216]. These studies have helped uncover the possible organisation of the stromal fibrils. Some slit lamps come with linear polarisers that are crossed to help reduce specular reflections.

It could be thought that linear polarisation biomicroscopy is a helpful technique for examining corneal health; however, a disadvantage of using linear polarised light in viewing the cornea is the need for two rotatable polarising filters at 90° to each other, one in front of the illumination system and the other in front of the observation system.

Another way of performing polarisation biomicroscopy is by using circularly polarised light. One technique to produce circularly polarised light is passing light through a linear polariser and then through a quarter-wave plate with its axis at 45° to its polarisation axis. If the quarter-wave plate is not at 45°, the light will be elliptically polarised. However, this technique involves two items and has a similar inconvenience to linear polarisers.

A more straightforward solution would be purchasing a circular polarising filter. The filter has the polariser and retarder combined. Doing this enables ease of use and more comfortable handling when viewing the cornea.

The circular polariser should be placed in front of the illumination system and the observation system. The retarder layer should be toward the patient[256-258].

The observer can see different images when viewing the cornea under polarisation biomicroscopy depending on the polariser used. Cope writes on seeing a cross-like image when viewing the cornea using linear crossed polarisers. He proposes that the cross area is an area of the cornea that is unaffected by polarisation or has zero or near zero birefringence. He termed these areas as Isogyres[253]. Isogyres are not visible when using circular polarisers.

When polarised light is used to view the cornea, colour rings near the limbal area in a diamond pattern will appear[217]. These rings are thought to be areas of equal corneal birefringence for a particular wavelength of light. These rings are called Isochromes. Whether a linear or circular polariser is used, isochromes are always visible[259].

When using a circular polariser, two smaller dark areas are seen around the pupil location; these areas are thought to be areas of no birefringence or low birefringence. Misson called these areas Isotropes[260].

Other areas of the anterior eye have also been examined using polarised light. For example, O'Sullivan used crossed polarisers to enhance the viewing of the eyelids[261]. In addition, Weale[262] and Pierscionek[263] discuss using crossed polarisers to improve the viewing of the crystalline lens.

Misson & Stevens discuss using a circular polariser to visualise stress birefringence at suture wounds in patients after cataract surgery. However, there is no detail of what type of filter was used in that research[247].

The use of circular polarisation biomicroscopy to enhance viewing of the corneal structure in vivo is suggested in a paper by Misson[264] and his doctoral thesis[260]. He writes that changes to the corneal epithelium had little effect on the images seen with polarised light[260].

Peli discusses using a circular polariser to enhance the viewing of the corneal endothelium, but he discusses nothing else about using the filter[256]. No other articles discuss the clinical use of circular polarisation biomicroscopy with everyday patients and its use to view the whole cornea.

Fariza states that retinal photographs taken with a circular polariser were of a significantly higher quality than those without the polariser[257].

For other viewing techniques using circularly polarised light, for example, the increased use of Polarisation-sensitive optical coherence tomography (PS-OCT)[229, 265, 266], the amount of corneal birefringence is essential to be accounted for, as it will improve the accuracy of the calculation for the amount of birefringence of the Retinal Nerve Fibre Layer(RNFL) to pick up RFNL dropout.

No studies are available using a circular polariser in routine optometric practice. As stated above, given that some corneal pathologies do change the birefringence of the cornea, it would be beneficial to study the cornea using the polariser. If there is a change in corneal birefringence, there could be a change in the visibility or regularity of the isochromes.

1.5 The Eye Examination

As discussed, the eye exam has moved on from merely being refraction to one of visual and ocular health assessments. The optometrist now has more diagnostic equipment than before, and the correct use of the results from this equipment is vital.

There are various shared care schemes around the United Kingdom in which optometrists need to decide whether to recall the patient, manage the patient or refer the patient to the Hospital Eye Services.

Reeves et al. state that any clinical test has three primary roles; to identify any pathology, aid in making any differential diagnosis, and help with the management of the patient[267].

Long discusses that when a clinician sees a sign in a patient in practice, the clinician needs to make choices between whether that sign is abnormal or normal, the same or different characteristics if it was seen before, to aid in the management of that patient[268].

Researchers have previously explored the use of certain areas of the eye examination in routine practice, such as retinoscopy[269], visual field testing[270-274], direct & indirect ophthalmoscopy[275-277, 271, 273], tonometry[278, 279, 273, 274]. There is also research on the risk of using phenylephrine[280] and of using tropicamide[281, 282] during the eye examination. The effectiveness of the eye examination itself has also been studied[283-288]. However, there is very little evidence for the use of the slit lamp.

There is debate on how long an eye exam should last. With optometry becoming more commercial, there is a desire for some businesses to have their optometrists test faster, with anecdotal reports of expectations of seeing patients every 20 minutes. To achieve this, are these optometrists rushing their eye exam with perhaps a lack of patient care?

A survey done in 2010[289 290], completed by 555 optometrists, found that the average time for an eye exam was 25.8 minutes, whilst the average time desired by the optometrists to do an eye exam was 29 minutes.

In Scotland, the legislation (The National Health Service (General Ophthalmic Services) (Scotland) Regulations 2006 paragraph 14(7))[291] has set the number of patients to be seen each day as 20 and optometrists are advised, as a general rule, that an eye exam should be 30 minutes minimum[292].

The World Council of Optometry (WCO) classifies Optometry into four different scopes of practice levels. These levels are:

Level 1. Optical Technology Services

Level 2. Visual Function Services

Level 3. Ocular Diagnostic Services

Level 4. Ocular Therapeutic Services

Under these WCO scopes of practice levels, a qualified optometrist is defined as practising as described in level 2 or above. More detail is available on the four levels in Appendix 1.

The countries with the most respondents in the survey in Chapter 2 can practice at level 3 or above. For example, in the United States & Canada, optometrists can practice at Level 4. When they graduate, the United Kingdom optometrists can practice at Level 3, but there is a pathway to Level 4. Sweden and Trinidad & Tobago optometrists can practice at Level 3.

1.6 History of Biomicroscopy & The Slit Lamp

Purkinje is credited as one of the first to use microscopy on the living eye. He is said to have used a handheld lens and lamp to study the iris in 1823.

The first binocular microscope to study the cornea was said to be used by Aubert in 1891. The first corneal microscope was developed by Czapski, working for Carl Zeiss in 1899[293]. Wecker later joined an eyepiece lens, an objective lens, and an adjustable condensing lens within a tube, but it could not focus in detail on the anterior eye. Czapski added binocularity to Wecker's microscope.

Gullstrand, in 1911, invented a way to give better illumination on the eye and be able to change the illumination thickness into a slit to make these devices clinically useful. Henker, in 1916 combined Czapski's corneal microscope and Gullstrand's slit illumination, placing them be on the same axis to improve further the ability to see the eye in detail. This modification gave birth to the slit lamp that is known today[294, 293, 295].

Comberg, in 1936 made further modifications to this shared axis. In 1938, Goldmann designed a slit lamp that used a joystick to control movement. In 1950, Littmann changed the design of the slit lamp once more by adding a magnification changer[296]. Since then, there has been no significant modification to the basic design of a slit-lamp.

In relation to articles about the slit lamp, there was keen interest in the slit lamp when it was first invented. In 1914, Erggelet wrote an article on his findings on using the instrument on patients. In the 1920s, there were reports of many atlases and classes been given on the use of the slit lamp. Vogt was a key individual at this time to increase practitioners' awareness of the slit lamp. He studied and improved the various ways to use the slit lamp, detailed notes of his findings in many textbooks, and gave week-long classes[295].

Bedell, in 1922 wrote about using the slit lamp and seeing the fine details of an iris coloboma[297]. Butler, in 1923 describes in detail the week-long course given by Vogt in Zurich on Slit Lamp Microscopy[298]. He also referred to specular reflection as mirror light.

In 1924, specular reflection was no longer called mirror light. Graves suggests that his illumination routine consisted of sclerotic scatter, direct illumination, specular reflection and retro illumination. He describes seeing pathology in the endothelium for the first time using a slit lamp[299].

Bedell, in 1925 further expresses the value of the slit lamp in routine corneal examination[300]. Mann, in 1925 also describes how she finds the slit lamp useful and mentions how much easier it is to find pupillary membranes with the slit lamp[294]. Mayou, in 1926, stated that with the new form of slit lamp, the examination should take less than a minute[301].

In the late 1920s, prominent ophthalmologists recommended that the slit lamp be used in daily clinical practice, even before the type of slit lamp we are using today was developed. So much so that an article by Weymann[302] has a quote from a textbook by Butler that those who are not already using the slit lamp would find themselves in difficulty should they end up in court.

In a letter written in 1931, Hansraj stated he appreciated the usefulness of the slit lamp after detecting an intraocular foreign body in his patient that could not be detected with ophthalmoscopy[303].

Mackie, in 1933 lamented that the slit lamp was not used as much as it should be, given its many benefits[304]. He put the lack of slit lamp use lamp down to the cost of the instrument. He stated that the benefits of the slit lamp could only be understood by using it frequently. In 1948 Doggart[293] debated the usefulness of the slit lamp, concluding that it was indeed a helpful instrument.

1.7 Study Objectives

The research is split into three areas with their aims, hypothesis and objectives.

The first part of the research examines how often optometrists use the slit lamp on non-contact lens patients in various countries worldwide. From the literature review, this information is not available. Whilst there is legalisation in some parts of the world, stating that a slit lamp must be used for all eye examinations (Table 1.1), it is not consistent in other parts of the world. The null hypothesis for the first part is that there is no difference in the use of the slit lamp throughout the world. The objective of the first part is to measure optometrists' views on the use of the slit lamp in routine optometric practice in various countries in the world.

This chapter shows a need to examine the use of the slit lamp in routine practice as there is little information available on this topic. There is also little information available on the use of NaFl. As shown, the use of various parts of the eye exam has been studied before. The second part of the research examines how many patients attending a University Optometry clinic for a routine eye examination have symptoms and what are those symptoms. It will be reviewed how many of these patients report anterior eye problems as their chief complaint. If these patients are further questioned, how many will report more anterior eye problems. Finally, the literature review found that extensive research is available for patients wearing contact lenses but is limited in data about non-contact lens patients attending for a routine eye examination.

This will be further investigated using the slit lamp on every patient in the research and studying if any signs seen on the slit lamp are associated with the patient's symptoms. This section will further investigate the number of patients that have findings only seen on the slit lamp and white light, regardless if they are symptomatic or not. Again, the number of findings will be measured and linked to if the patient was symptomatic or not. This will then be repeated with Sodium Fluorescein and blue light. Again, this will be linked to if the patient was symptomatic or not.

The null hypothesis for this section is that no increase in clinical signs will be found when all patients are examined using a slit lamp biomicroscope to perform the external eye examination, and no further signs can be found by using Sodium Fluorescein.

The objectives will be to determine if there is a correlation between the patients' symptoms and the findings on external eye examination using the slit lamp with white light and Sodium Fluorescein and blue light. Also, to measure the number of patients that report any initial symptoms of anterior eye problems, that is, the main reason for their visit is due to these symptoms. Finally, to measure the number of patients who report any anterior eye problems after further questioning.

The final part of the research will examine using a circular polariser filter on the same patients attending the University Optometry Clinic. Whilst the literature review shows that using a circular polariser filter with the slit lamp changes the view of the cornea, making isochromes visible, there is no research in whether the use of the filter is beneficial to optometrists in routine clinical practice. There is also no research into whether using the polariser will make more ocular signs visible using the slit lamp. Each patient will be examined using the filter, and the number of patients who have findings seen on the slit lamp with the filter will be counted. The number of patients with altered corneal structure due to Keratoconus, LASIK and other causes will also be examined.

The null hypothesis for this section is that there will be no benefit in using a circular polariser filter on every patient attending the University Optometry Clinic.

The objectives are to discover how many patients attending an optometric clinic will have signs on the slit lamp using a circular polariser filter and record how many patients were found with altered corneal structure, such as Keratoconus, LASIK or other refractive surgeries by using the circular polariser filter.

Chapter 2: Online questionnaire for optometrists on their use of the slit lamp

2.1 Introduction

The previous chapter shows a lack of clear evidence of when optometrists use the slit lamp in routine practice, why they use a slit lamp and how they are using a slit lamp. The previous chapter discussed the benefits of using a slit lamp, but there are still gaps in how, why, and when optometrists use the slit lamp.

Some studies have previously touched on slit lamp use, sodium fluorescein (NaFl) or lid eversion. These fall under how optometrists record soft contact lens fitting[305], gas permeable lens fitting[306] and how optometrists record anterior eye health findings[20]. However, all of these articles involved contact lens use.

It can also be seen that whilst some studies have been done on the slit lamp only, they do not distinguish between contact lens patients and non-contact lens patients. They also do not study the actual use of the slit lamp; that is, the previous studies ask if the optometrist performs slit-lamp biomicroscopy regularly. The optometrist is then given the option of yes or no. They do not ask why the optometrist is using the slit lamp.

There are limited studies on the use of NaFl. They have been limited to contact lens patients and again on a yes / no basis. The same can be said for lid eversion.

Finally, there is no available research on whether optometrists use the slit lamp for examining the lids in detail, and if so, why.

With this gap in the literature, a survey was developed to obtain data if there is a link between slit lamp procedures and year of qualification, working location, type of practice or number of patients seen.

2.2 Methodology

An online questionnaire was designed with input from the researcher, supervisor and a focus group; comprised of six local optometrists in the executive committee of the Trinidad & Tobago Optometrists Association. The final version of the online questionnaire was produced using Google Forms.

The questionnaire consisted of ten questions, a mixture of 8 short answer questions and two multiple-choice questions. The questionnaire is shown in Appendix 2.

The questionnaire was available online via a web link to the Google Forms page set up for the questionnaire. It was open for three months to anyone who had the web link. The questionnaire was available in English only.

The questionnaire web link was sent to optometrists internationally who had critical roles within the World Council of Optometry (WCO) or national optometric organisations of whom the researcher knew. It was sent via email and social media worldwide, especially targeting the areas where the optometrists above lived. These optometrists resided in North America, The Caribbean & Central America, South America, Europe (Ireland, the United Kingdom, Scandinavia and Finland), the Middle East (Jordan & Palestine), Africa (South Africa, Nigeria and Zimbabwe), Asia (India & Hong Kong) and Australia.

All the above optometrists who were asked to help in distributing the web link were contacted once.

The inclusion criteria for the questionnaire was any qualified optometrist anywhere in the world who had access to the web link for the Google form. A qualified optometrist is defined as practising at level 2 or above under the WCO scope of practice. The different levels of WCO scope of practice are in Appendix 1.

The following respondents were excluded from the questionnaire results

- Optometrists who only see contact lens patients as it was felt that they would always use a slit lamp with their patients.
- Ophthalmologists as their scope of practice is different from optometrists, and they do not fall under the guidance of local optometric bodies
- Contact Lens Opticians as it was felt that they would always use a slit lamp with their patients.
- Dispensing Opticians as they are not classified as Optometrists under the WCO scope of practice definition.
- Students as they are supervised by someone else and so are not independent thinkers on what judgements to make for managing a patient.

Data analysis was done using IBM SPSS 25.0 software. The Chi-square test of independence was used to investigate any associations between the grouped responses. A p-value of less than 0.05 from the two-tailed Chi-square test was taken to be statistically significant.

2.3 Results

Of the 19 optometrists that were sent emails to help distribute the questionnaire to different parts of the world, feedback and definite responses were given by:

- A web link posted on "ODs on Facebook" Facebook page (https://www.facebook.com/groups/122070001227892). This Facebook group is a closed member group with optometrists from all around the world as its members. (35,000 optometrists are members)
- The web link was sent to the Trinidad & Tobago Optometrists Association members via their mailing list. (50 Members)
- The Canadian Association of Optometrists published the web link to the questionnaire on their website. (5,411 Members)
- The Association of Optometrists in the UK posted the web link to the questionnaire on their website. (11,500 Members)
- The Swedish Optometric Association sent the web link to the questionnaire to their members. (1,550 Members)

These confirmations of the distribution of the questionnaire weblink give a method of distribution response rate of 26.3% of the 19 optometrists contacted. Although the other optometrists who were asked to help with the distribution did not respond, responses were still received from optometrists in those countries.

The number of responses received in the Google form was 595. It is difficult to calculate a response rate as there is no way of knowing how many received the link nor how many opened the link but did not complete the questionnaire for whatever reason.

When the responses were analysed, it was found that 7 of the entries were exact duplicates of entries entered before, where the respondent had submitted the questionnaire and then resubmitted it again with the same responses.

Two entries were not included as they said they only dealt with contact lens patients.

When these entries were removed, it left a sample size of 586 completed responses.

Question 1: What year did you qualify as an optometrist?

This question had 586 responses ranging from 1957 to 2016. 2016 was the most popular response at 47 responses (8.02%). The responses were then grouped into ten years for statistical analysis, starting with 1980 and before.

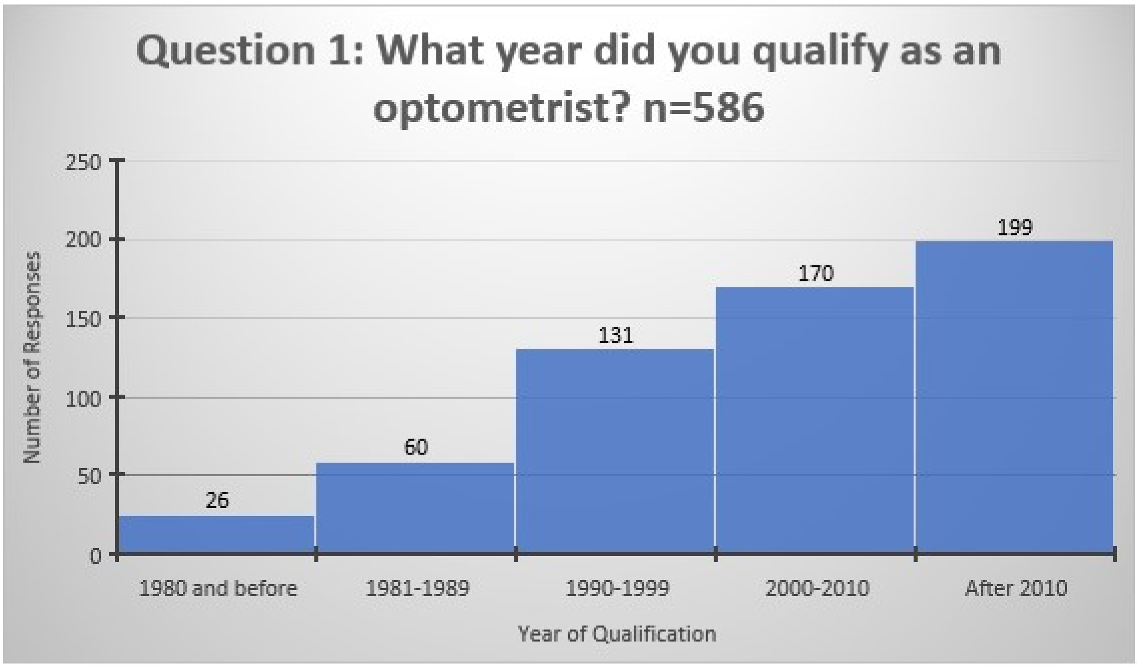

Figure 2.1 Grouped responses to Question 1: What year did you qualify as an optometrist?

Question 2: In which country do you work?

The United Kingdom was the most popular response to this question at 162 responses (27.6%) in the ungrouped responses.

For analysis, the responses were first grouped under the regions of the WCO and grouped by under which level of the WCO Scope of practice each country has. As shown in figure 2.4, most of the Optometrists who responded work in countries that allow an optometrist to practice at a WCO Level 3 scope of practice. There were no responses from countries that can practice at the WCO Level 1 scope of practice. Health care workers that work at level 1 cannot call themselves optometrists under the WCO model.

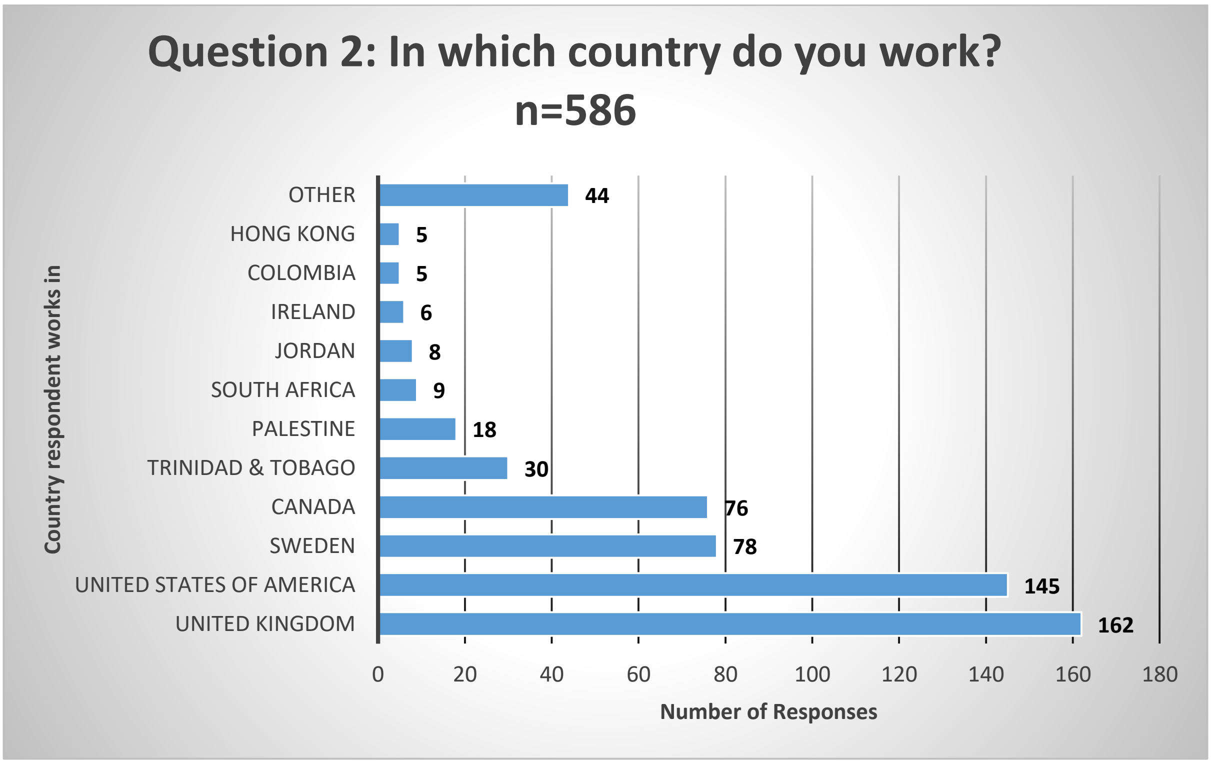

Figure 2.2 Responses to Question 2: In what country do you work?

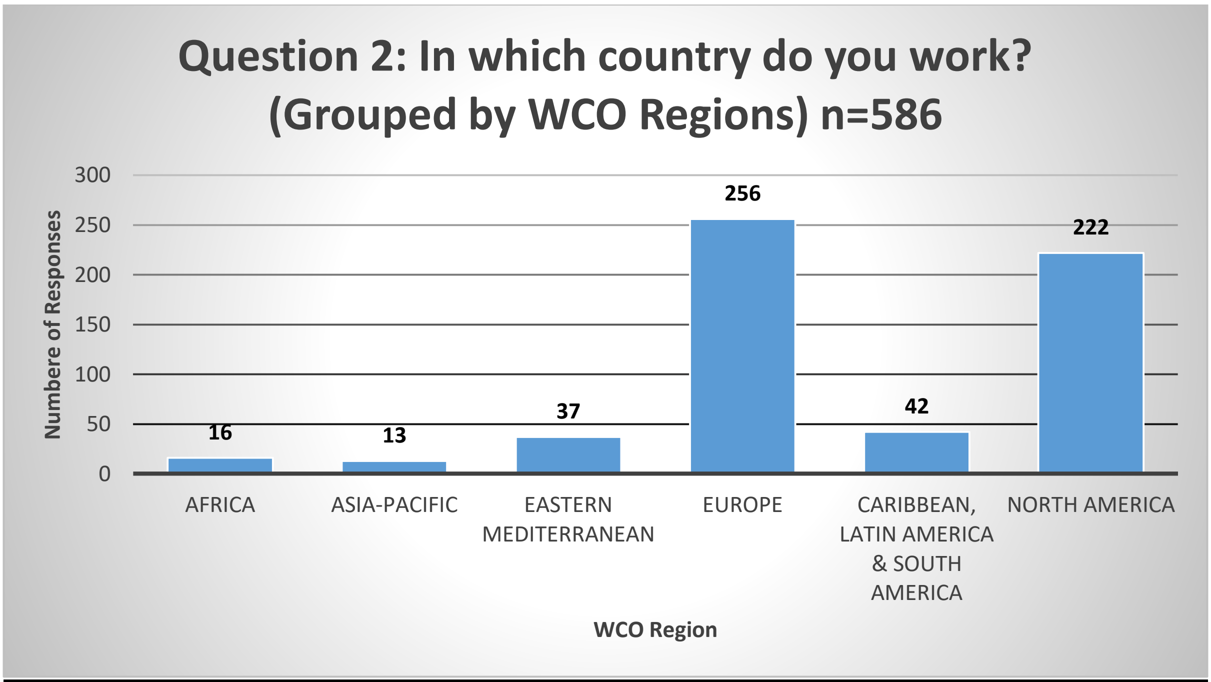

Figure 2.3 Grouped responses to Question 2: In what country do you work? According to WCO regions

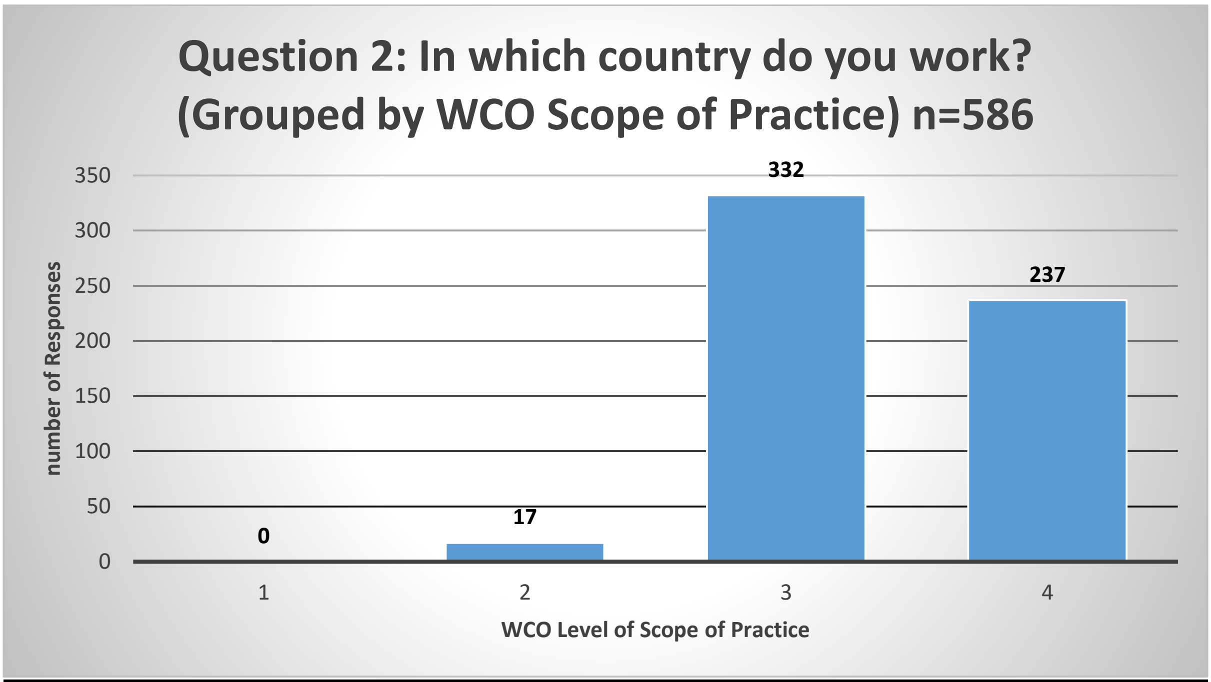

Figure 2.4 Grouped responses to Question 2: In what country do you work? According to the scope of practice levels defined by the WCO.

Question 3: What type of practice do you work in for the majority of the week?

Most of the respondents worked in independent (Single Location) practices, as shown in figure 2.5.

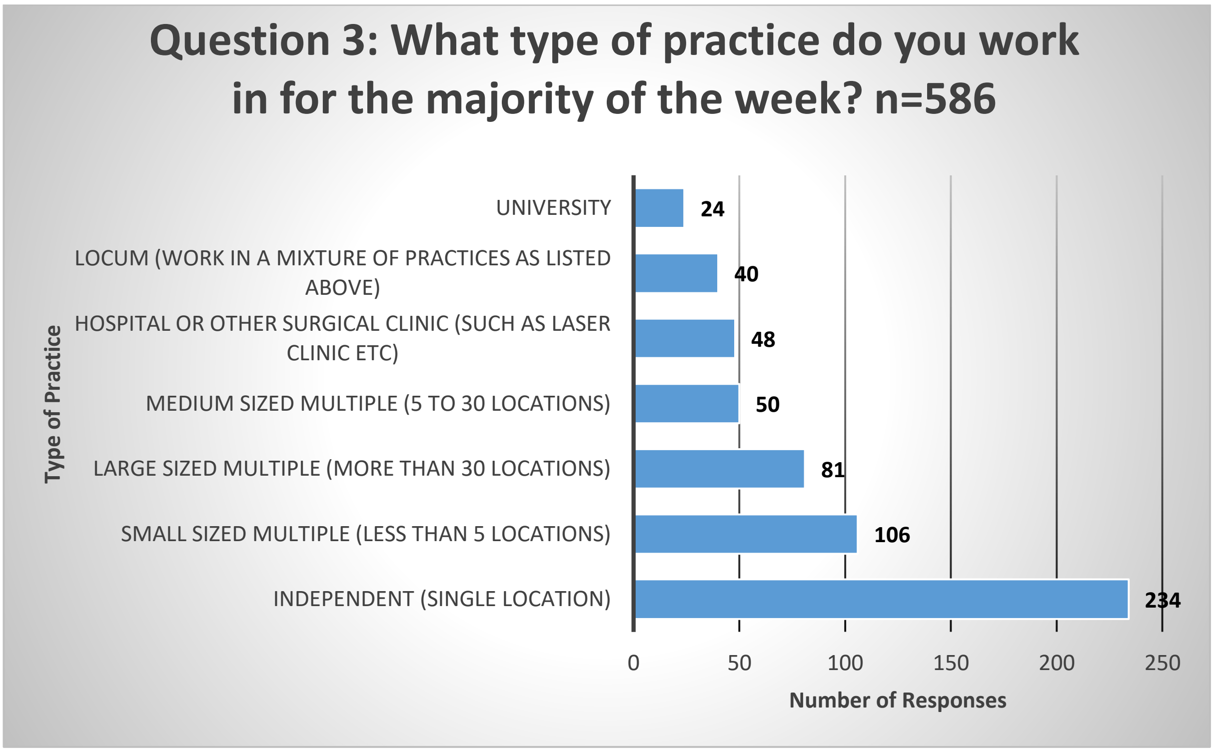

Figure 2.5 Responses to Question 3: What type of practice do you work in for the majority of the week?

4. How many non-contact lens patients do you see a day for an eye exam in your main place of work?

The responses to this question ranged from 0 to 40, with ten patients (18.94%) being the most popular response. The responses were then grouped into ten or less patients, 11-20 patients and more than 20 patients, with the ten or less being the popular response.

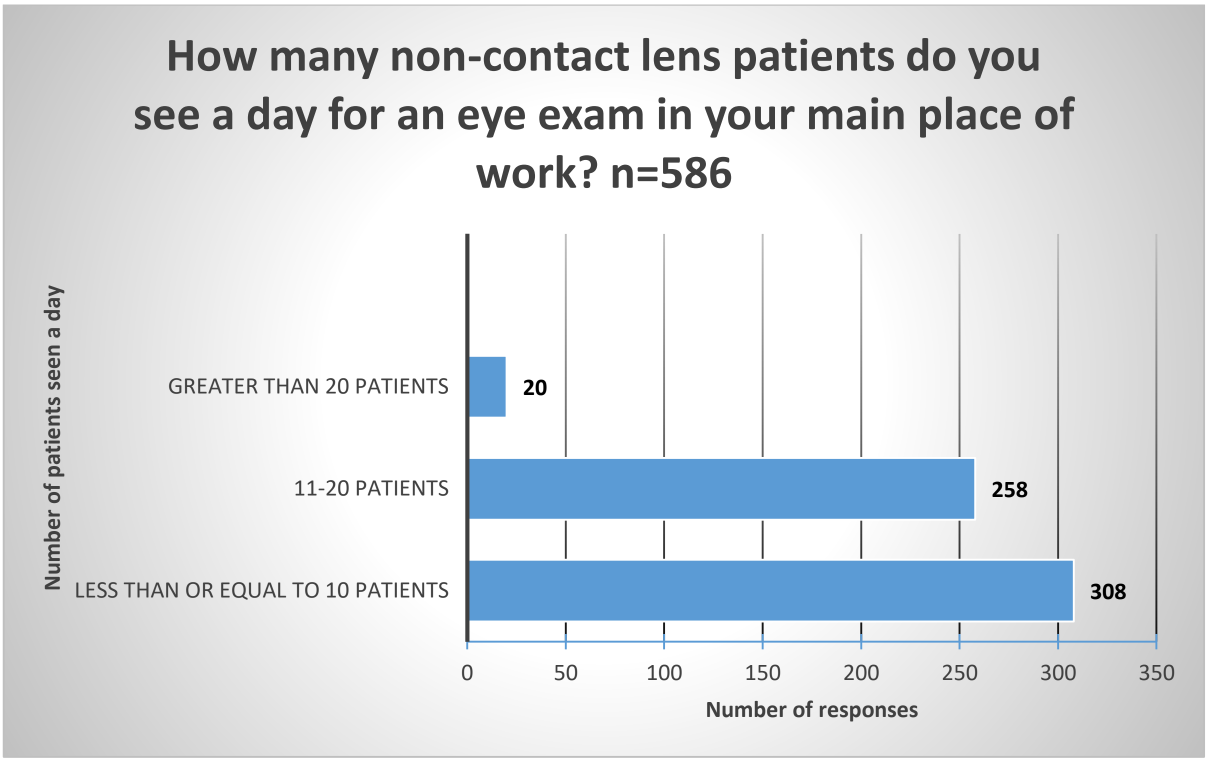

Figure 2.6 Grouped responses to Question 4: How many non-contact lens patients do you see a day for an eye exam in your main place of work?

5. On what percentage of those patients (non-contact lens wearers) do you use a slit lamp?

The range for this question was from 0 to 100. Three hundred and fifty-seven optometrists (60.92%) stated that they used the slit lamp on 100% of all their non-contact lens patients. Eight (1.37%) said they do not use the slit lamp on any non-contact lens patients. The responses were then grouped into percentage quartiles, with more than 75% being the most common group (74.91%).

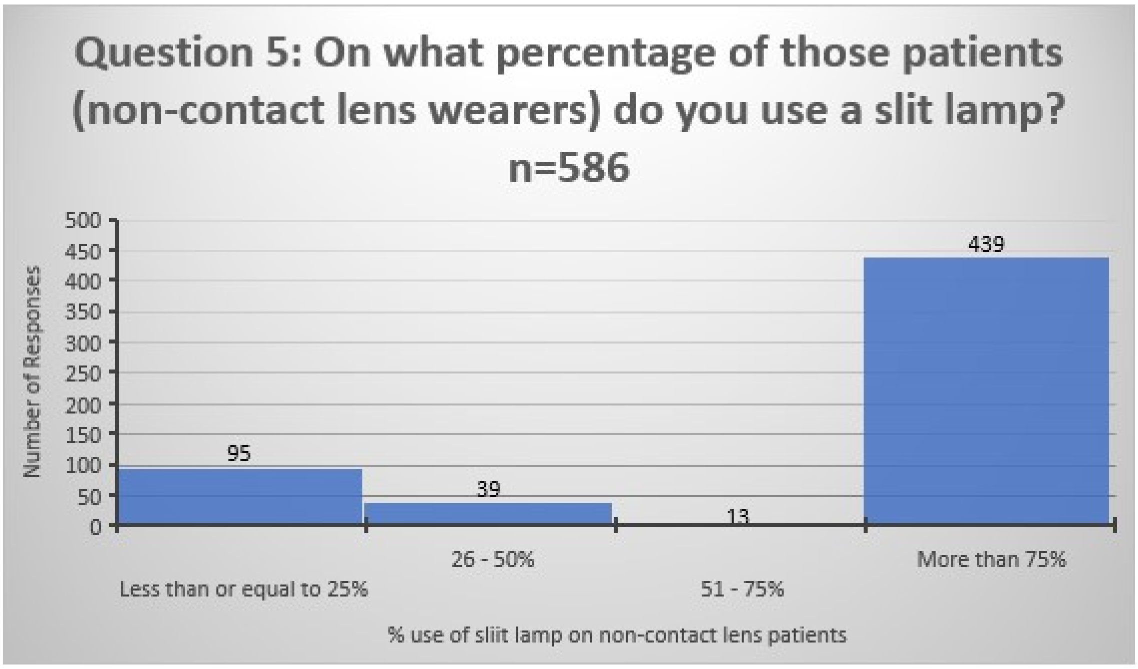

Figure 2.7 Grouped responses to Question 5: On what percentage of those patients (non-contact lens wearers) do you use a slit lamp?

5. (ii) Why do you use a slit lamp on these patients? (Open Answer)

This question allowed the optometrist to list, in their own words, why they used the slit lamp on their patients. Before grouping, 19.30% stated that they used the slit lamp to check the anterior segment of the eyes.

As this question was an open answer, the respondents could list more than one reason for using the slit lamp. In total, 1,127 responses were received, which were then divided into 20 categories, as detailed in figure 2.8. Using the slit lamp to check the anterior segment was the most popular reason, with 214 (36.5%) out of the 586 optometrists listing this as the main reason to use the slit lamp. The mode of the number of responses was one, meaning that most optometrists gave one answer to this question. The minimum number of reasons given in the answers was one, and the maximum number of reasons given in the responses was 11.

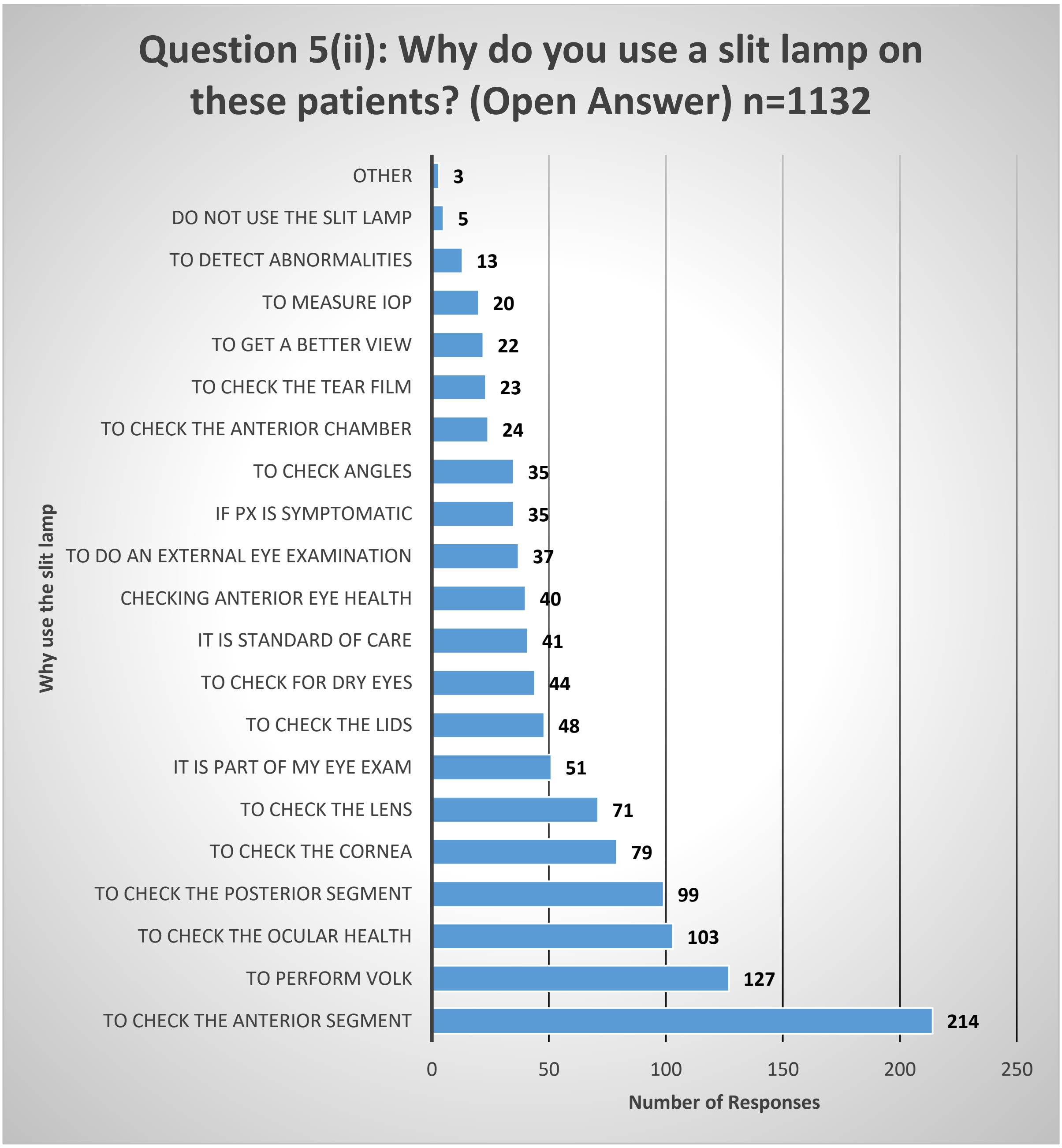

Figure 2.8 Grouped responses to Question 5(ii): Why do you use a slit lamp on these patients? (Open answer)

6. On what percentage of non-contact lens patients would you use Sodium Fluorescein?

The most popular answer to this question was that optometrists use NaFl on 10% of their non-contact lens patients. Ninety optometrists, 15.36% of all the respondents, stated this. Fifty-three optometrists (9.04%) said they use NaFl on 100% of their patients, and thirty (5.12%) stated they did not use NaFl on any of their patients. The range was 0 to 100%.

The responses were then grouped in percentage quartiles, with less than or equal to 25% being the most prominent group.

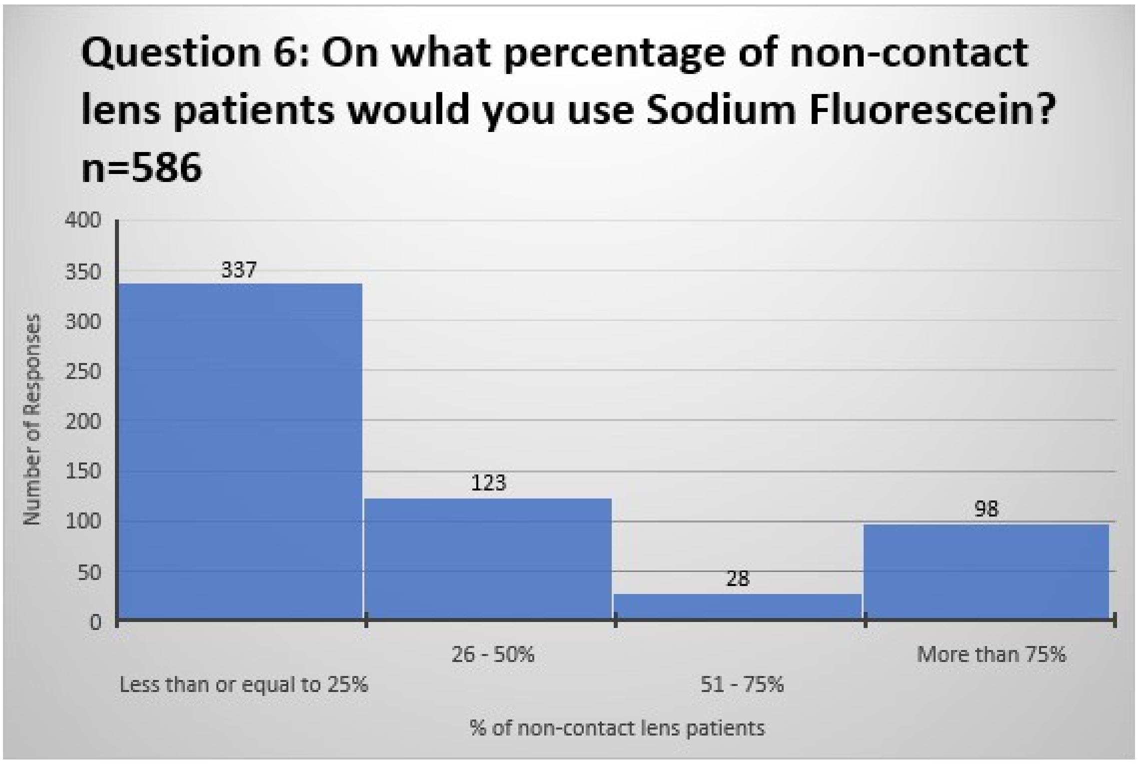

Figure 2.9 Grouped responses to Question 6: On what percentage of non-contact lens patients would you use Sodium Fluorescein?

7. On what percentage of non-contact lens patients would you perform lid eversion?

The range of responses was from 0 to 100. Performing lid eversion on 5% of their non-contact lens patients was the most popular response by 120 (20.48%) optometrists. The percentage of optometrists who stated they do not do lid eversion on any of their non-contact lens patients was 10.92%. Whilst 3.41% said they do lid eversion on 100% of their non-contact lens patients. The responses were then grouped in percentage quartiles, with less than or equal to 25% being the largest group.

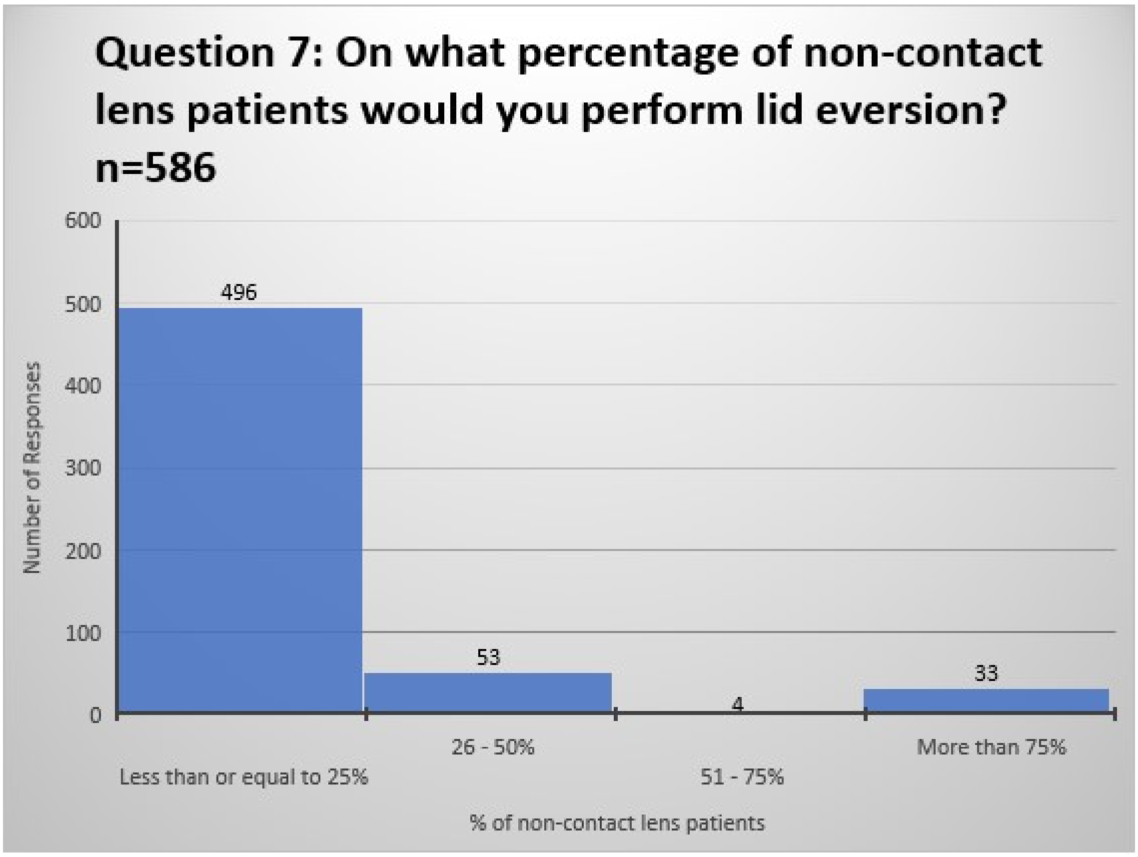

Figure 2.10 Grouped responses to Question 7: On what percentage of non-contact lens patients would you perform lid eversion?

8. Do you perform a detailed lid examination on your patient using the slit lamp?

This question was a “Yes / No” question. 81.57% of optometrists in the questionnaire answered that they do perform a detailed lid examination. 18.43% stated that they do not perform a detailed lid examination. The optometrists who answered “No” stopped completing the questionnaire, and the webpage directed them to the last page to click on the submit button.

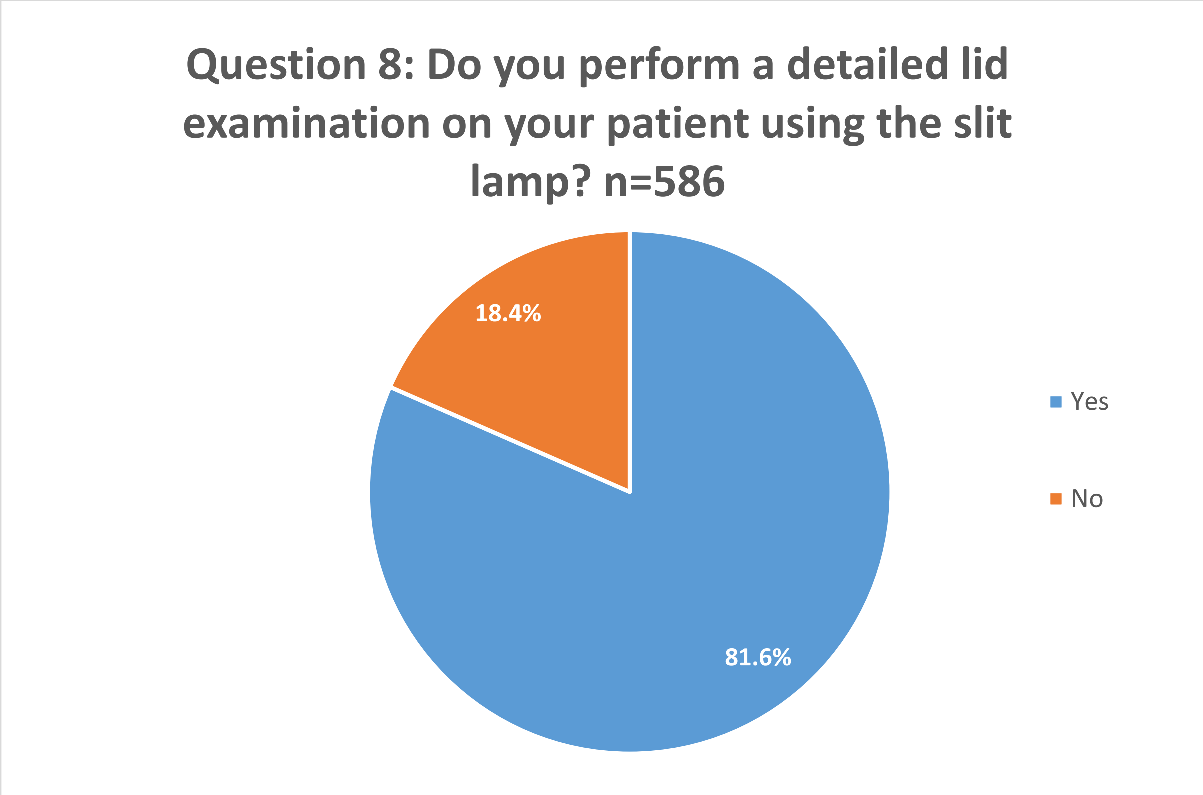

Figure 2.11 Responses to Question 8: Do you perform a detailed lid examination on your patient using the slit lamp?

8. (ii) What areas/conditions are you looking for/at during the lid examination? (Open answer)

This question allowed the optometrist to list, in their own words, what they were looking for/at when doing the detailed lid examination. 478 optometrists out of the 586 optometrists answered this question: all of the respondents who answered yes to question 8(i). Three Optometrists said yes, they did perform a detailed lid examination but responded to this question by stating they did not look for anything particular during the lid examination.

As this question was an open answer, the respondents could list more than one area/condition. One thousand six hundred ninety-one responses were received, which were then divided into 25 categories, as detailed in figure 2.12. Meibomian glands were the most prevalent condition optometrists were looking for during a lid examination, with 284 (59.2%) optometrists listing this condition in the questionnaire.

The mode of the number of areas/conditions was 3, meaning that in the questionnaire, most optometrists gave three areas/conditions that they are looking at when doing a lid examination. The minimum number of areas/conditions given in an answer was 1, with the maximum number of areas/conditions given in one response was 18.

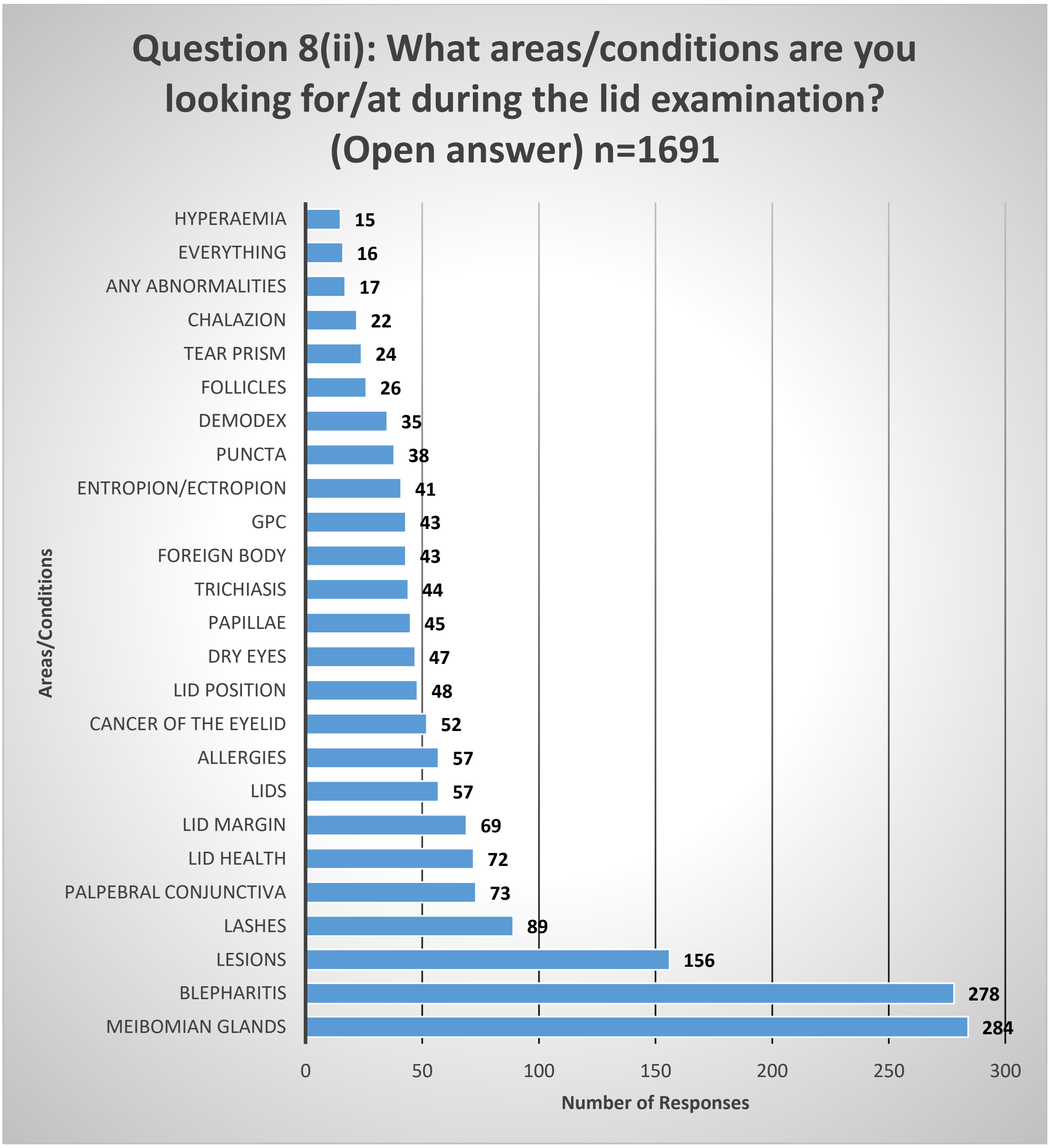

Figure 2.12 Grouped responses to Question 8(ii): What areas/conditions are you looking for/at during the lid examination? (Open answer)

2.4 Data Analysis

Table 2.1 shows a summary of the Chi-square analysis results for the various questions in the questionnaire. The shaded areas indicate where no analysis was done due to no apparent link between the two questions. Appendix 3 lists all the contingency tables used in the analysis.

	Type of Practice	Number of Patients Seen	% Use of the Slit Lamp	% Use of NaFI	% Performing Lid Eversion	Doing a Full Lid Examination
Year of Qualification			**.006**	.571	.075	.900
Scope of Practice			**< .001**	**.007**	**.004**	**< .001**
Type of Practice		**< .001**	.506	**.002**	**< .001**	.082
Number of Patients Seen	**< .001**		**< .001**	.839	**.006**	.365

Table 2.1 Chi-Square probabilities score for the various questions asked in the questionnaire.

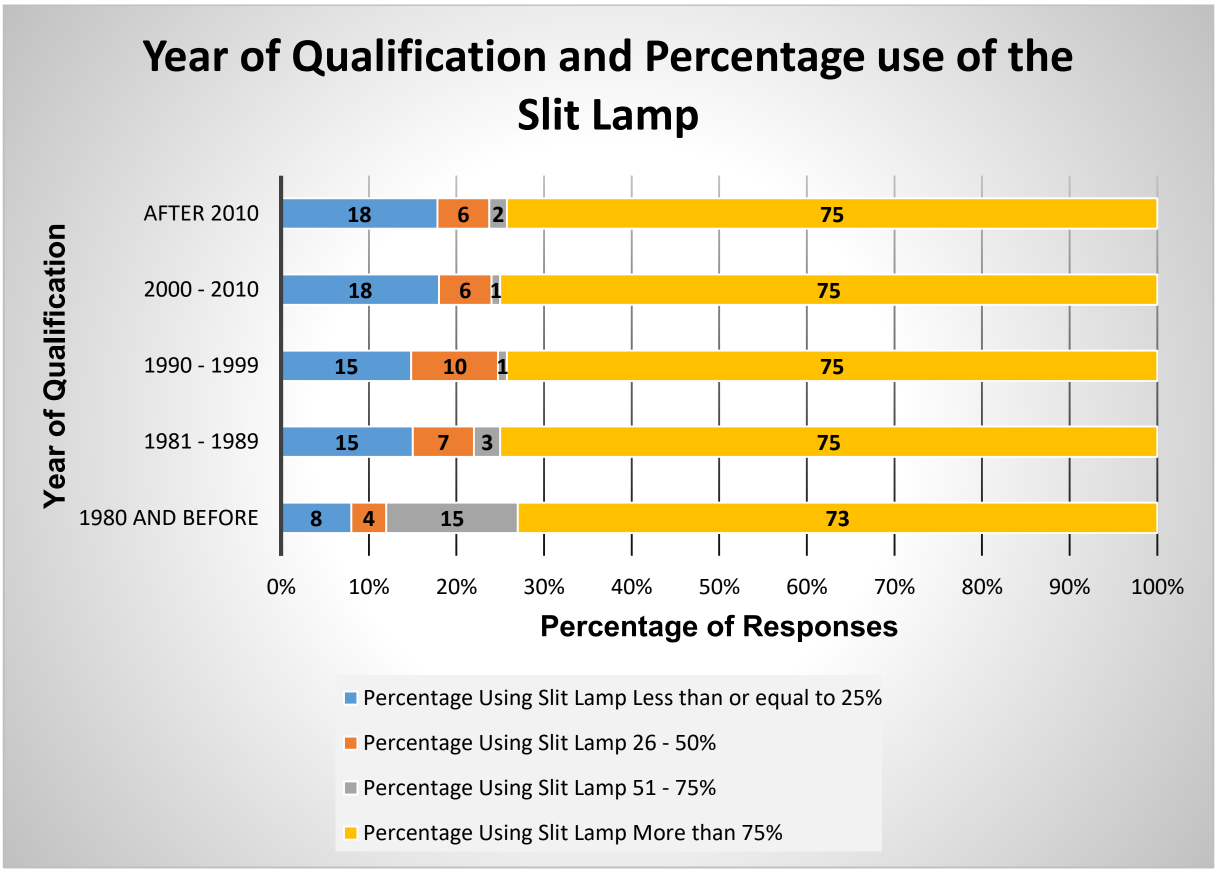

Figure 2.13 Year of Qualification and Percentage use of the Slit Lamp

For each year group of qualification, the highest proportion of respondents in each year group stated they use the slit lamp on more than 75% of their patients. The Chi-Square test gives a p-value of **0.006**, which means there is a significant link between when the respondent qualified and their use of the slit lamp. For example, of the respondents who qualified in 1980 and before, 88% reported that they are more likely to use the slit lamp on at least more than 50% of the time with their non-contact lens patients, which was higher than the other year group.

The post hoc analysis shows a higher proportion of those optometrists who qualified in 1980 or before using the slit lamp on between 51-75% of their patients than those optometrists qualified in 1990-1999, 2000-2010, and after 2010, p **< .001**.

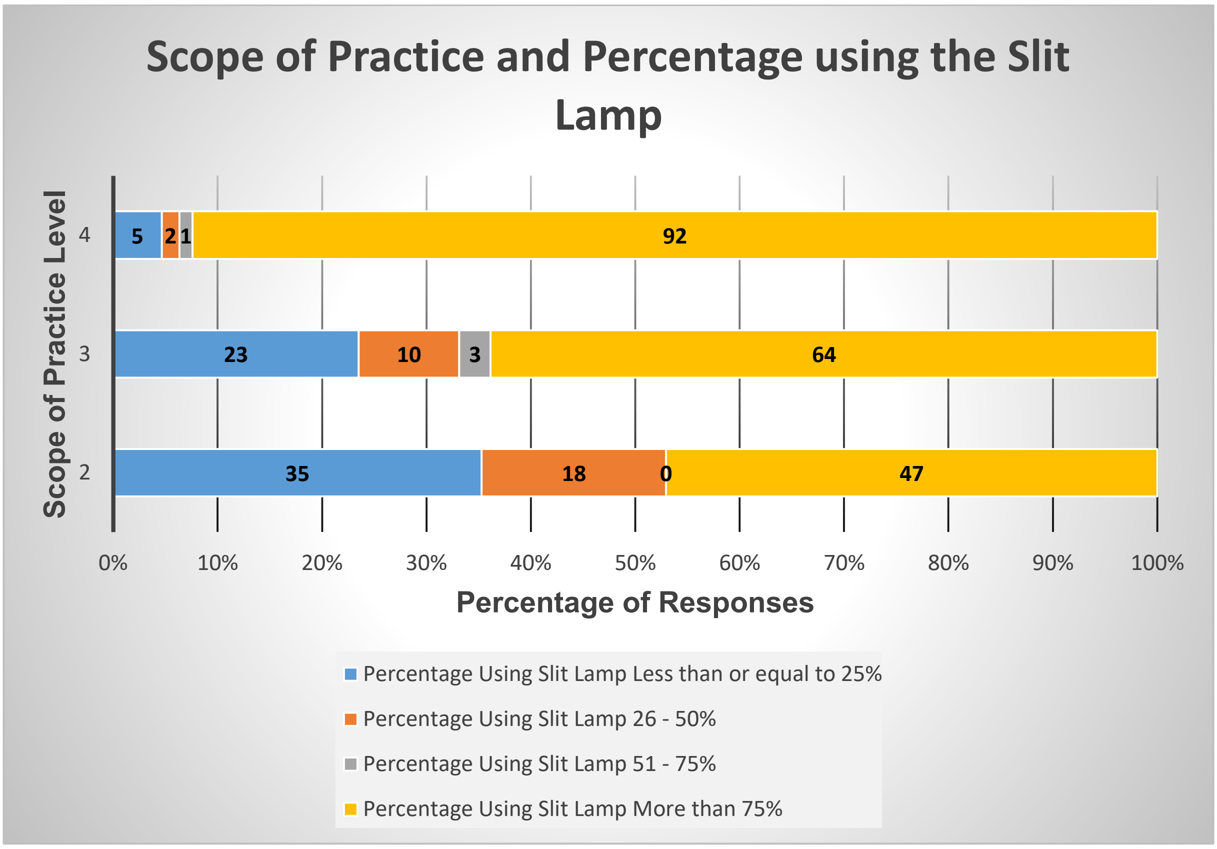

Figure 2.14 Scope of Practice and Percentage use of Slit Lamp

Analysis shows that 92.4% of those optometrists who work at a level 4 scope of practice stated that they use the slit lamp more than 75% of the time. This percentage goes down to 47.1% for those who work at level 2.

Only 4.6% of level 4 respondents say they use the slit lamp less than or equal to 25% of the time. This percentage rises to 35.3% for level 2 optometrists. Level 3 Optometrists responded 63.9% and 23.5% respectively.

The analysis shows a significant difference and hence a link between the respondent's scope of practice and the percentage use of the slit lamp, p **< .001**.

The post hoc analysis shows the optometrists who can work at a level 2 scope of practice have a significantly higher proportion on using the slit lamp on less than or equal to 25% and on 26-50% of their patients compared to the optometrists who can work at level 4 scope of practice. The level 4 optometrist's responses have a significantly higher proportion in using the slit lamp on more than 75% of their patients compared to those who can work at level 2 or 3. p **< .001**

The type of practice a respondent worked in and the percentage use of the slit lamp was examined. For this analysis, the highest response group for each type of practice was optometrists who use the slit lamp on more than 75% of their patients, ranging from 68.0% in medium-size practice companies to 81.3% small-sized practice companies. The second highest response from each group apart from the university clinic was those using the slit lamp on less than or equal to 25% of their patients. However, there is no significant link between the type of practice the respondent works in and the percentage use of slit lamp p= 0.506

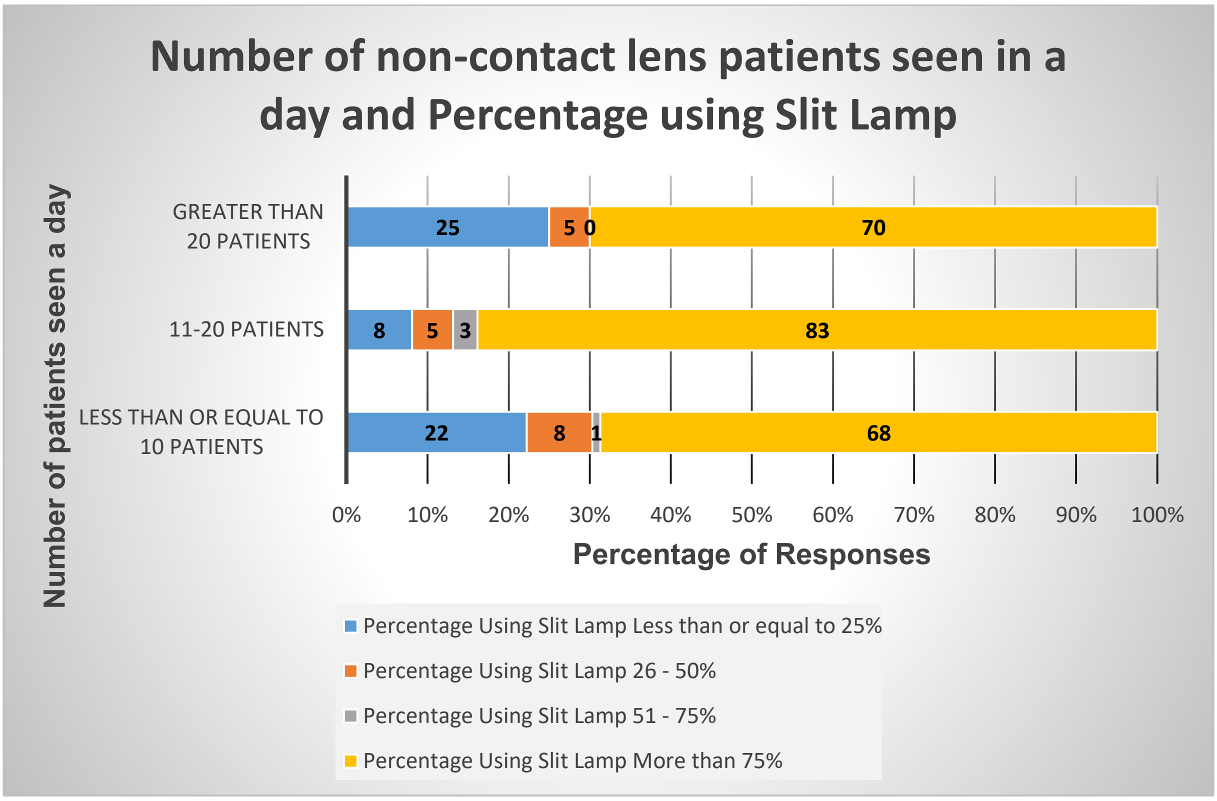

Figure 2.15 Number of non-contact lens patients seen in a day and Percentage using Slit Lamp

Optometrists who see 11-20 patients a day have a higher proportion of using the slit lamp on more than 75% of their patients. The Chi-Square analysis states that there is a significant link between the number of patients seen each day and the percentage use of the slit lamp p **< .001**.

Post-Hoc analysis indicates that the optometrists who reported they see less than or equal to 10 patients a day and those reporting seeing greater than 20 patients a day responded in significantly higher proportions that they use the slit lamp on less than or equal to 25% of their patients than those optometrists who reported seeing 11-20 patients a day. Those who reported seeing 11-20 patients a day responded in significantly higher proportions than those who see less than or equal to 10 patients a day using the slit lamp on more than 75% of their patients. p **< .001**

More than 50% of the respondents from each year of qualification group stated that they use NaFl on less than or equal to 25% of their patients, from 50.0% in those qualified in 1980 or before to 62.3% in those qualified after 2010. All the other responses were spread over each year of qualification groups for the three other NaFl categories. Using Chi-Square analysis, the results were not significant, and there is no link between the year of qualification and the use of NaFl in non-contact lens patients, p= .571.

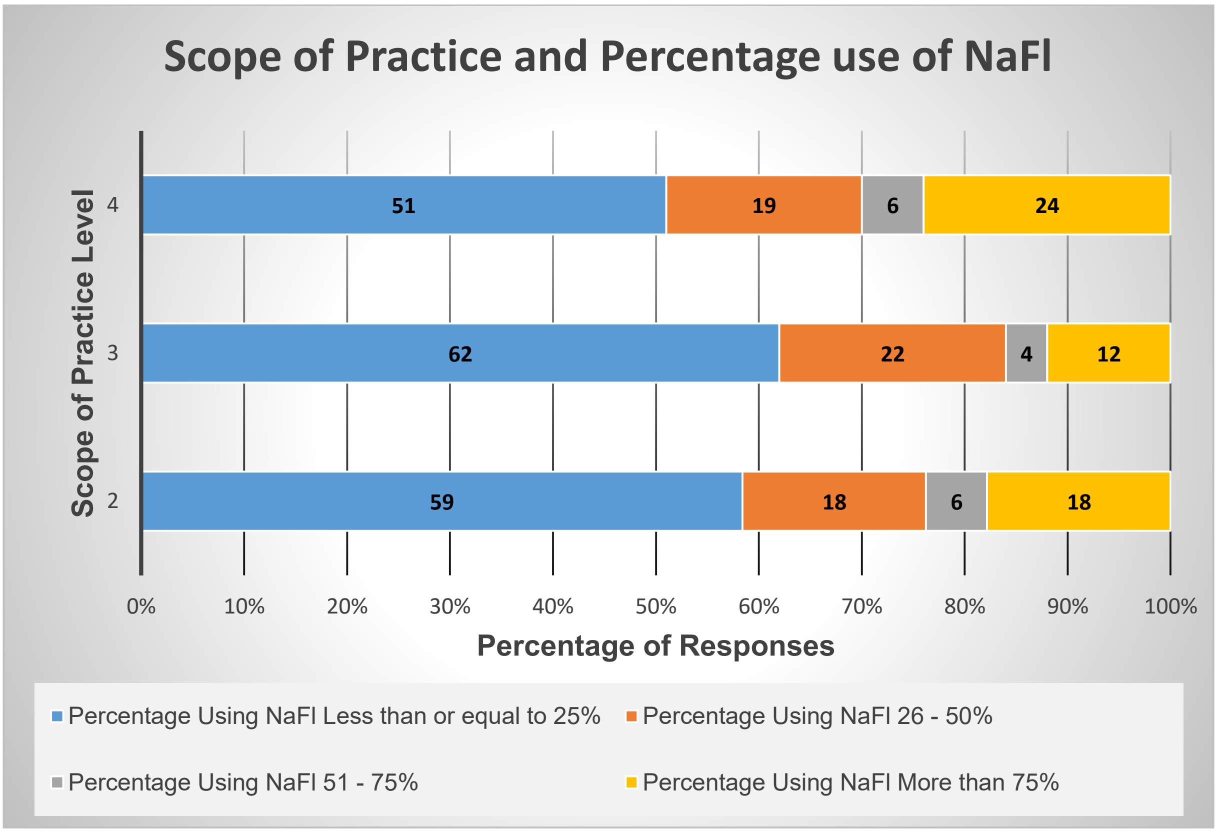

Figure 2.16 Scope of Practice and Percentage use of NaFl

The highest proportion for each scope of practice was respondents stating they use NaFl on less than or equal to 25% of their patients, with each scope of practice stating that most optometrists use NaFl on less than or equal to 25% of their patients. Chi-square analysis shows a significant link between the scope of practice and the percentage use of NaFl p= **0.007**

The post hoc analysis shows that optometrists at level 3 have a significantly higher proportion of responses, stating that they only use NaFl on less than or equal to 25% of their patients than optometrists at level 4. Similar significance is seen between level 4 optometrists using NaFl on more than 75% of their patients compared to level 3 optometrists. p **< .001**

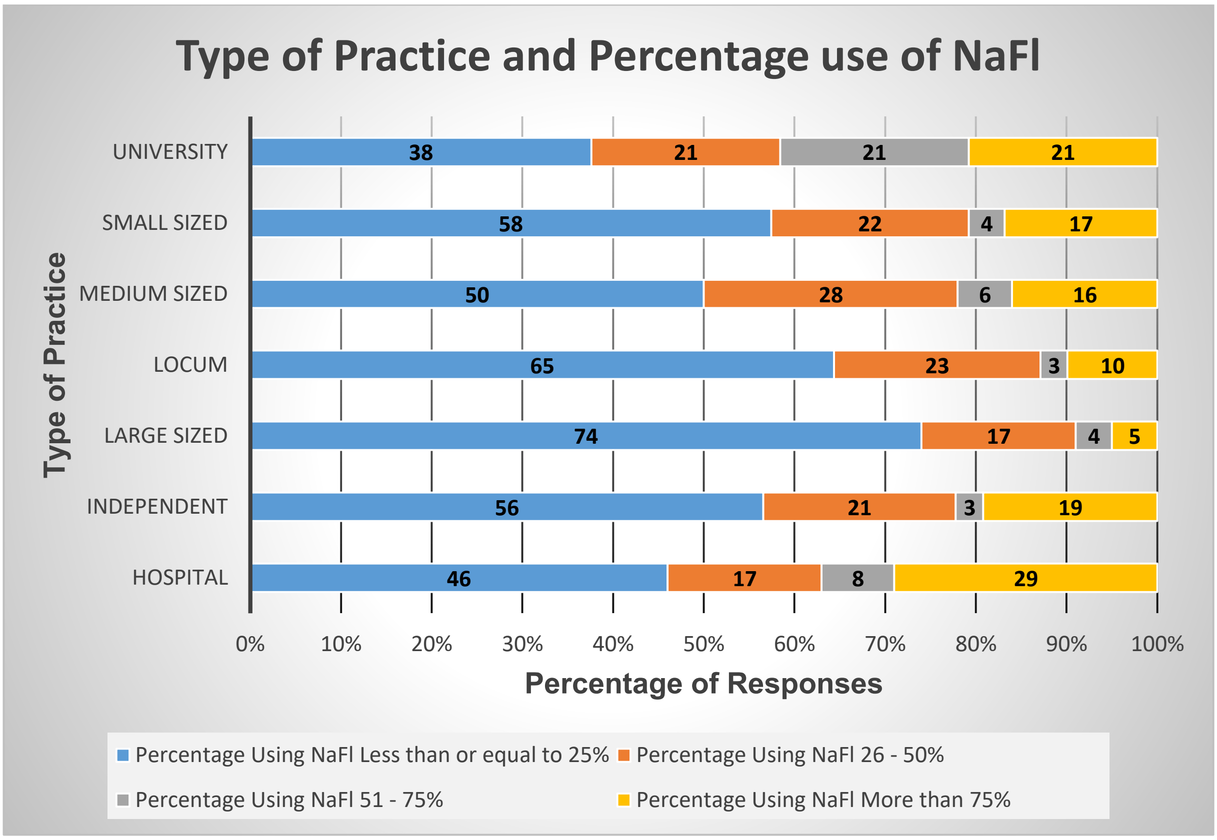

Figure 2.17 Type of Practice and Percentage use of NaFl

Optometrists working in a hospital/laser clinic, independent practice or a university clinic are more likely to use NaFl on more than 75% of their patients than the other categories. However, all categories had the most responses from the less than or equal to 25% of patients.

All categories apart from the hospital/laser clinic had over 50% of their responses, stating that they use NaFl on only less than or equal to 25% of their patients. The hospital/laser clinic had 45.8% of their responses stating this. There is a significant link between the type of practice and the percentage use of NaFl p= **0.002**

The post hoc analysis shows optometrists who work in large-sized practice companies responded significantly higher proportions to using NaFl in less than or equal to 25% of their patients compared to those optometrists who worked in a hospital/laser clinic or a university clinic. In addition, optometrists who work in a university clinic responded significantly higher proportions to using NaFl on 51-75% of their patients than the optometrists who work in independent practices.

Optometrists who work in hospital/laser clinics or independent practices answered significantly higher proportion that they would use NaFl on more than 75% of their patients than those optometrists who work in large-sized practices. p = **0.001**

The number of non-contact lens patients seen a day and the percentage use of NaFl was examined. Optometrists using NaFl on more than 75% of their patients have similar proportions to seeing less than or equal to 10 patients (49.0%) and seeing 11-20 patients (46.9%). Optometrists who use NaFl on less than or equal to 25% of their patients on the majority see less than or equal to 10 patients a day (52.5%). However, there is no significant link between the number of patients seen each day and the percentage use of NaFl p= .839

Whilst all the year of qualification groups had the majority number of respondents stating that they only did lid eversion on less than or equal to 25% of their patients, all those qualified after 1981 responded more in this category than those qualified in 1980 and before. However, analysis shows no significant differences in the responses to this question. There is no link between the year of qualification and the percentage performing lid eversion p= 0.075.

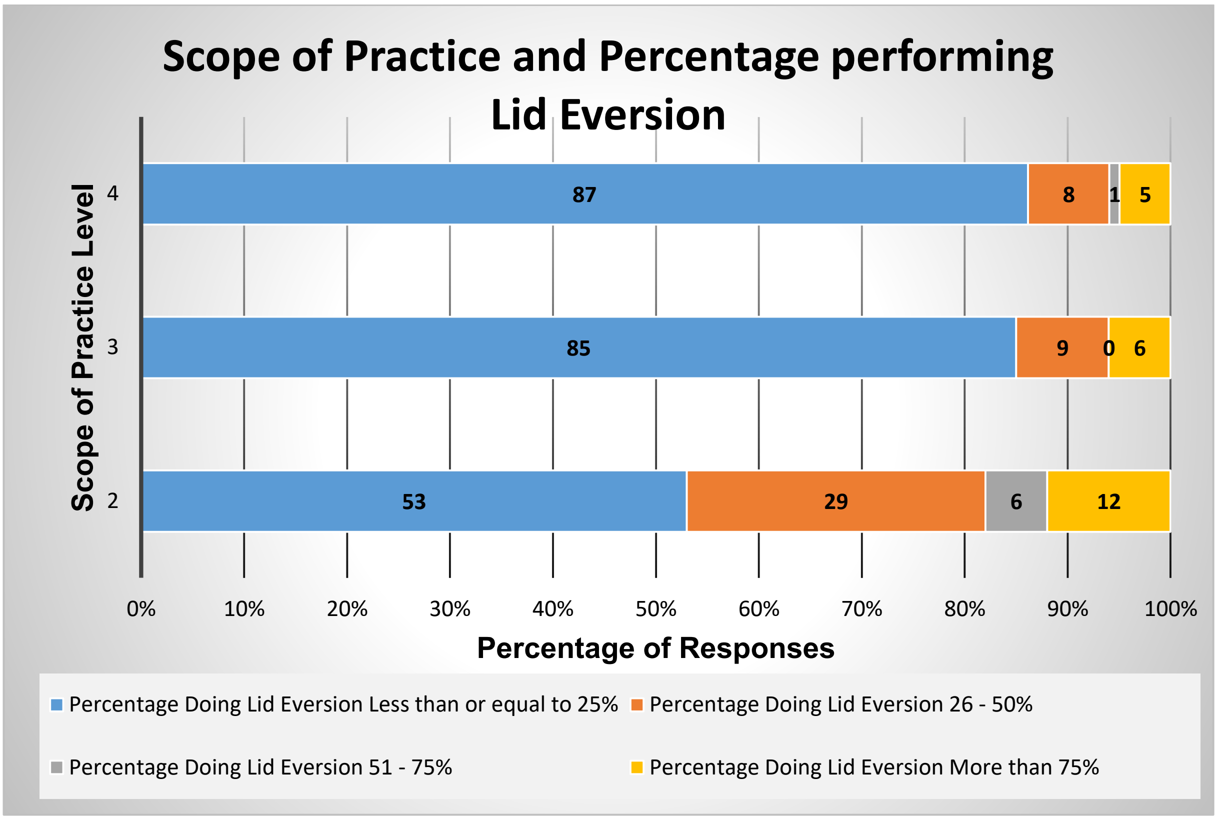

Figure 2.18 Scope of Practice and Percentage performing Lid Eversion

Here the trend is in the reverse in that those at level 2 scope of practice are the highest group to do lid eversion on more than 75% of their patients. Of the level 2 respondents, 11.8% said they did lid eversion on more than 75% of their non-contact lens patients. Whilst 6.0% and 4.6% for level 3 and level 4 respectively said they do lid eversion on more than 75% of their patients. For level 4 optometrists, 86.5% do lid eversion on only less than or equal to 25% of their patients. For level 3 optometrists, this is 84.9%. It then drops to 52.9% for level 2 optometrists doing lid eversion on less than or equal to 25% of their patients.

The chi-square analysis gives a p-value of **0.004**, which means there is a significant link between the scope of practice and the percentage of optometrists doing lid eversion.

The post hoc analysis shows that for the responses to the percentage doing lid eversion on their patients, level 3 and level 4 optometrists had a significantly higher proportion of responses stating they would only do lid eversion on less than or equal to 25% of their non-contact lens patients in routine practice compared to level 2 optometrists.

Meanwhile, level 2 optometrists responded that they are more likely to do lid eversion on 26-50% of their patients than level 3 and level 4 optometrists and are significantly more likely to do lid eversion on 51-75% of their patients compared to level 3 optometrists only. p **< .001**

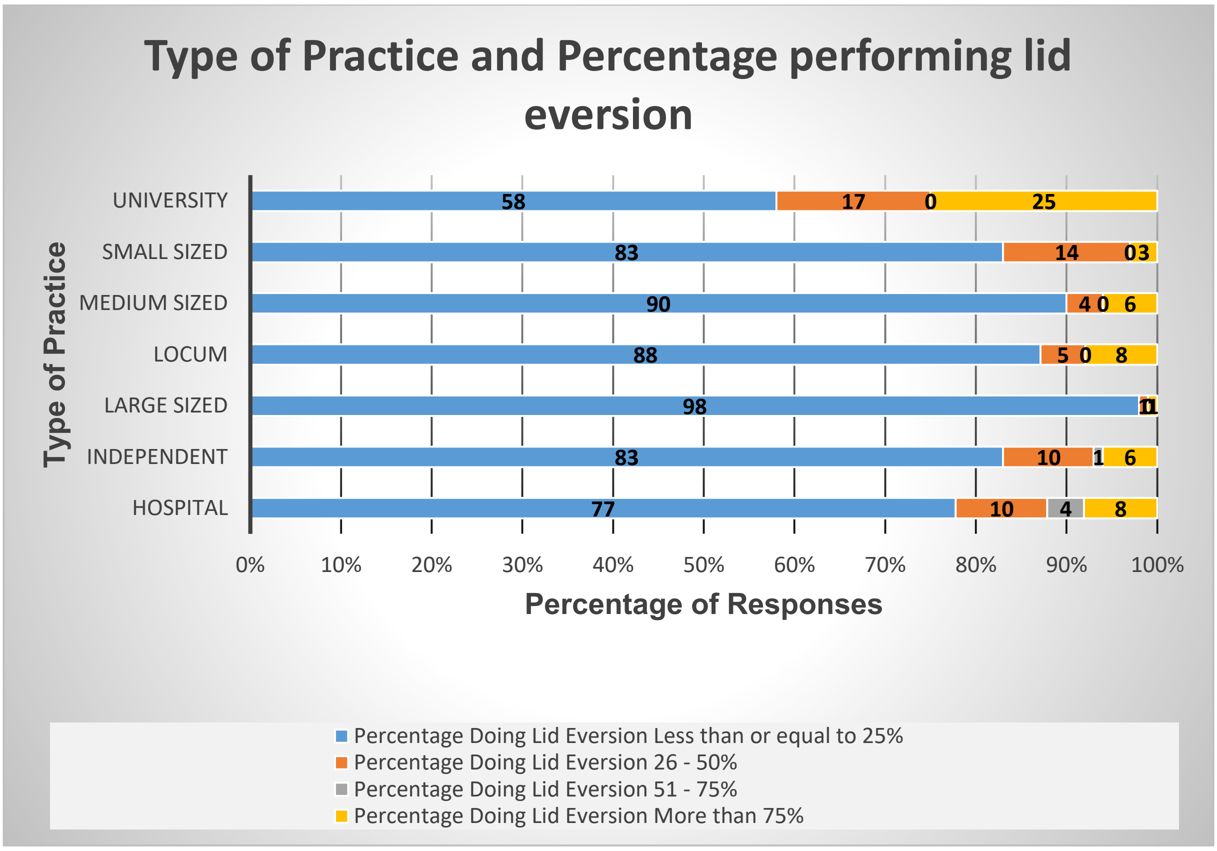

Figure 2.19 Type of Practice and Percentage performing lid eversion

The most prominent response (25%) from the optometrists that evert the lids on more than 75% of their patients came from those who work in a university clinic. None of the other categories matches this percentage. The hospital/laser clinic is the second-highest group, showing 8.3% of the respondents do lid eversion on more than 75% of their patients. For the optometrists who work in large-sized practice companies, 97.6% perform lid eversion on less than or equal to 25% of their patients

There is a significant link between the type of practice worked and the percentage of lid eversion p **< .001**.

The post hoc analysis shows optometrists who work in large-sized practice companies responded significantly higher proportions that they only perform lid eversion on less than or equal to 25% of their patients compared to hospital/laser clinics, independent practices, small-sized practices and university clinics**.** Optometrists who work in medium-sized practice companies responded significantly higher proportions for the same category than university clinics. Optometrists working in small-sized practice companies and university clinics stated they perform lid eversion on 26-50% of their patients, significantly higher than large-sized practices. University clinic optometrists answered significantly higher proportions to performing lid eversion on more than 75% of their patients than optometrists who work in independent practices, large-sized practices and small-sized practices. p **< .001**

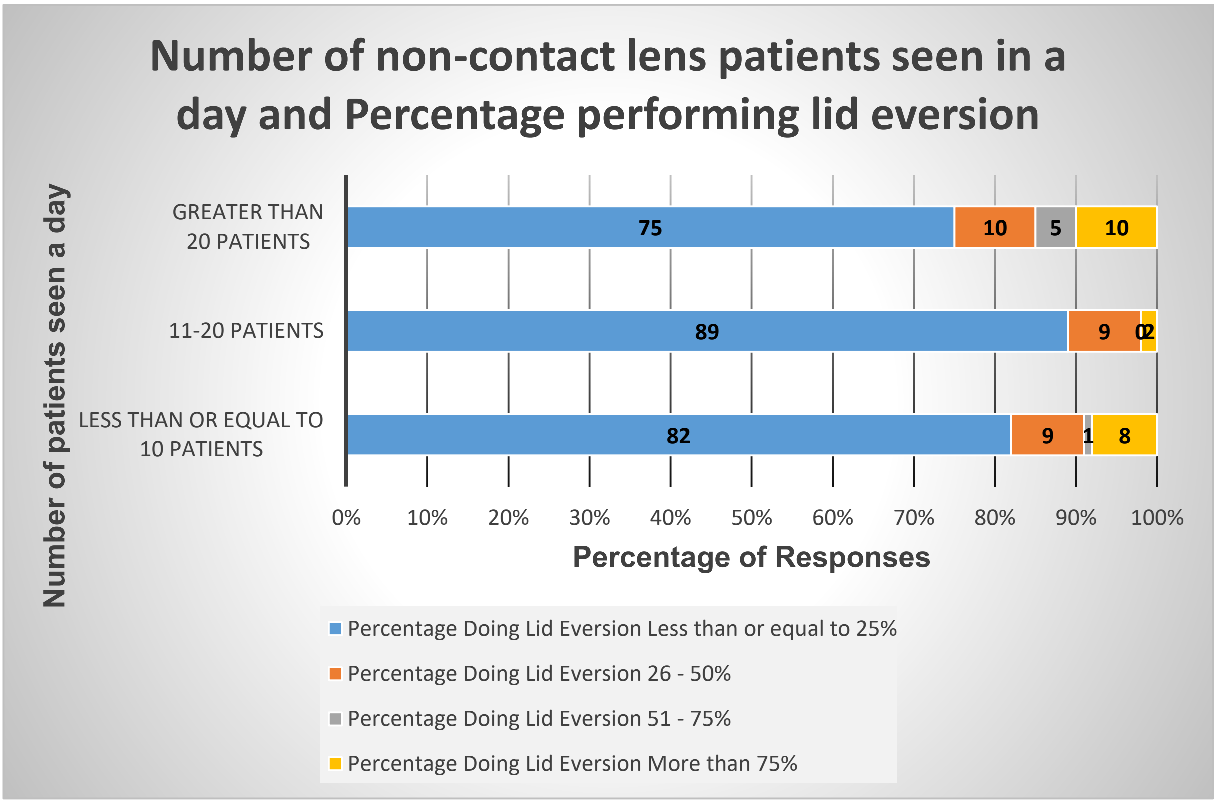

Figure 2.20 Number of non-contact lens patients seen in a day and Percentage performing lid eversion

All categories with the highest response in the percentage performing lid eversion see less than or equal to 10 patients a day. Optometrists who only perform lid eversion on less than or equal to 25% of their patients and 26-50% of their patients have a high proportion of seeing 11-20 patients a day. There is a significant association between the number of patients seen and the percentage of lid eversion p= **0.006**

Post-Hoc analysis indicates that optometrists who responded that they see 11-20 patients a day stated that they do lid eversion on less than or equal to 25% of their patients, in a significantly higher proportion than those optometrists who see less than or equal to 10 patients. The optometrists who see less than or equal to 10 patients a day responded significantly higher than those who see 11-20 patients a day doing lid eversion on more than 75% of their patients. p = **0.002**

The five, year of qualification groups stated that between 80.0% and 88.5% of the optometrists do a detailed lid examination on their patients. However, there is no significant link between the responses for the year of qualification and if they do a full lid examination p= 0.900

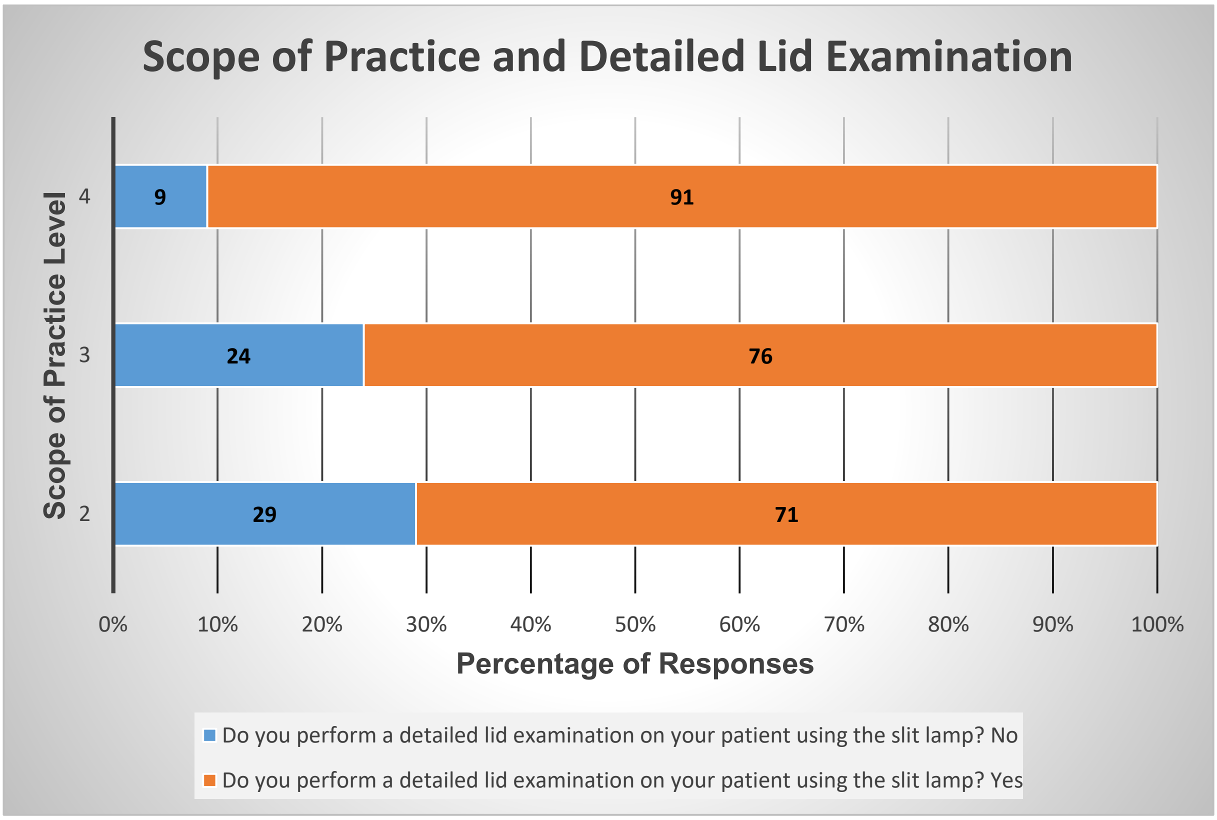

Figure 2.21 Scope of Practice and Detailed Lid Examination

Of all the respondents who can work at level 4, 90.7% say they do a full lid examination on their non-contact lens patients, whilst 70.6% of level 2 optometrists responded yes, and 75.6% of level 3 optometrists responded yes.

The analysis gives a p-value of **< .001**, which implies a significant link between the scope of practice and if the optometrists do a detailed lid examination.

The post hoc analysis shows optometrists who can work at level 2 or level 3 responded significantly more to not doing a detailed lid exam than those who responded from the level 4 category. Following this result, level 4 optometrists answered that they are more likely to do a detailed lid examination than their colleagues at level 2 or 3. p **< .001**

The type of practice a respondent worked in and the percentage doing a detailed lid examination was examined. The majority of the optometrists who work in all the different types of practices stated they perform a detailed lid examination using the slit lamp. The smallest proportion was from optometrists who work as locum optometrists. The highest was from optometrists who work in small-sized practices. However, there is no significant link between the type of practice and if the optometrist does a full lid examination using a slit lamp p= 0.082

The number of non-contact lens patients seen a day and doing a detailed lid exam was examined. Whether the optometrist saw less than or equal to 10 patients a day or 11-20 patients a day, the same proportion said they did not do a detailed lid examination using the slit lamp (49.1%). Whilst, for those optometrists who said they do a detailed lid examination, there was a difference in the proportion who see less than or equal to 10 patients a day (53.3%) than those seeing 11-20 patients (42.9%). However, there is no significant relationship between the number of patients seen each day and if an optometrist does a full lid exam p= 0.365

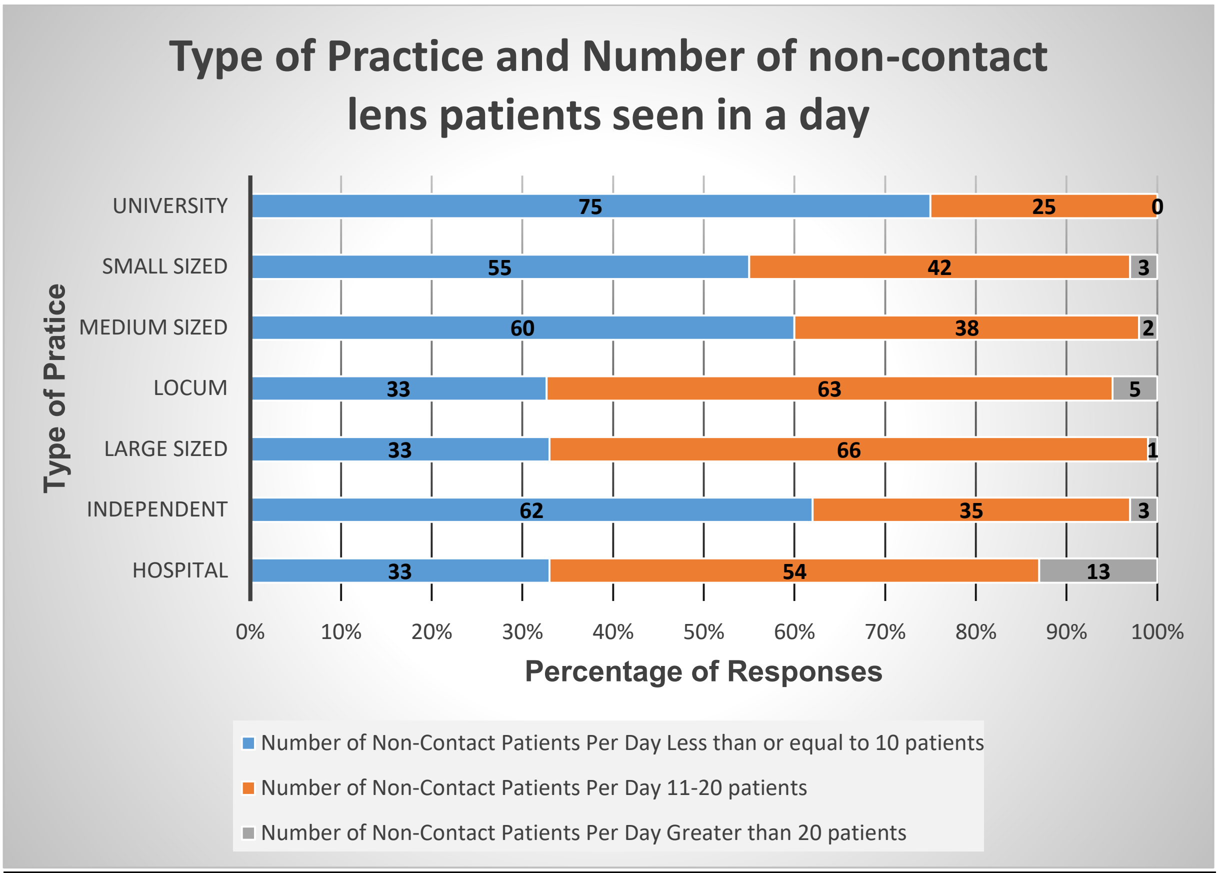

Figure 2.22 Type of practice and Number of non-contact lens patients seen in a day

Respondents who work in a hospital/laser clinic, a large-sized practice company or doing locum work are seeing on average 11-20 non-contact lens patients a day, whilst those who work in independent, small-sized, medium-sized companies or university clinics are seeing on average less than ten non-contact lens patients a day.

From the responses, university clinics have the most significant proportion that sees the smallest number of patients each day. 75% of respondents stated they see less than or equal to 10 non-contact lens patients a day. With the other 25% saying they see between 11-20 patients a day. There were no responses from anyone working in a university clinic seeing more than 20 patients a day. The highest answer for seeing more than 20 patients a day came from those working in a hospital/laser clinic; 12.5% of those who work in a hospital/laser clinic see more than 20 patients a day. Five per cent of those who do locum work state that they see more than 20 patients a day.

Of those who responded from independent, small-sized and medium-sized practice companies, the majority of the responses stated they see less than or equal to 10 patients a day. While most of the responses from hospital/laser clinic 54.2%, large-sized practice companies 65.9% or locum work, 62.5% stated they see between 11-20 patients a day.

With a p-value of **< .001**, there is a significant link between the type of practice and the number of patients seen each day.

The post hoc analysis shows optometrists who work in independent practices and university clinics are more likely to see less than or equal to 10 patients a day compared to their colleagues in hospital/laser clinics, large-sized practice companies and those doing locum work. Small and medium-sized practice companies are more likely to see less than or equal to 10 patients a day than large-sized practice companies. Large-sized practice optometrists responded significantly higher in seeing 11-20 patients a day than independent practices, small-sized practices, medium-sized practices, and university clinics. Optometrists doing locum work responded significantly higher in the same category than independent practices. p **< .001**

2.5 Discussion

The results of this questionnaire and its 7,511 data points give a snapshot of daily practice and how often the slit lamp is used, why it is used, the use of NaFl, lid eversion and what optometrists are looking for when examining the lids.

The percentage of optometrists (60.9%) who said they use the slit lamp on 100% of their patients was greater than expected based on the literature review in Chapter 1.

Eight (1.4%) of the responses stated that they never use their slit lamp on their non-contact lens patients.

The questionnaire results suggest that optometrists either decide to use the slit lamp on over 75% of their patients or use it on less than 25% of their patients. There are many examples of this in the results.

No matter which year the optometrists qualified, the majority stated that they use the slit lamp on 75% or more of their patients. However, apart from the optometrists who qualified 1980 and before, the next largest group for the other year groups only used the slit lamp on 25% or less of their patients.

Again, it was seen that the majority of optometrists from all the different types of practices stated they use the slit lamp on more than 75% of their patients. Apart from the responses from those who work in university clinics, the next largest group from the various types of practices indicate that they use the slit lamp on less than or equal to 25% of their patients.

Finally, for this point, the optometrists who stated they use the slit lamp on less than or equal to 25% mostly came from optometrists who see less than or equal to 10 patients a day. As these optometrists would have more time to spend with each patient, it is surprising that they would only use the slit lamp on less than 25% of their patients. Therefore, the question could have been asked why these optometrists do not use their slit lamp more frequently and investigate if the lack of use is due to time or another factor.

The study by Wolffsohn et al. in 2015 stated that just under 7 minutes was the average time spent recording the anterior eye, with the range of time spent being 1-45 minutes. However, this also varied depending on the location of the optometrist[20].

Optometrists with a higher scope of practice need to use the slit lamp more to manage their daily patients. It could also be expected that those optometrists that can work at WCO level 4 scope of practice would use their slit lamp more frequently than those practising at lower levels due to increased responsibility in their daily routine. Level 2 optometrists could be thought of as more refractionists and hence would not have the need, nor desire, to use the slit lamp.

This expectation is shown in the questionnaire. It was shown that there is a link between the respondent's scope of practice and the percentage use of the slit lamp. The result showed that the optometrists that responded working at level 4 are almost twice as likely (92.4% v 47.1%) to use the slit lamp on more than 75% of their patients than an optometrist practising at level 2. At the opposite end of the scale, 35.3% of level 2 optometrists would only use the slit lamp on less than or equal to 25% of their patients, whilst only 4.6% level 4 optometrists stated this.

As discussed in Chapter 1, some studies have looked at the percentage of optometrists that own or use a slit lamp. For example, in 1984, optometrists in Nigeria surveyed stated that 63% of them provide a slit-lamp examination as part of their eye examination[307].

In 2004, optometrists in Norway were surveyed; 46.6% responded that they used their slit lamp as part of their routine examination[308]. A study of optometrists working in the KwaZulu-Natal province in South Africa in 2006 shows that 90% had a slit lamp in their practice. However, only 59% of them used the slit lamp on a routine basis[309].

A study of optometric practices in Ghana in 2015 shows that 88.8% had a slit lamp, with 87.5% of the optometrists responding to use the slit lamp routinely[310].

A survey of Malaysian optometrists in 2019 indicated that 67.6% of the optometrists that responded had a slit lamp in their practice. Nevertheless, 84.4% of the optometrists who responded stated they fitted contact lenses regularly. Thirty-eight per cent used the slit lamp regularly, and 31% never used the slit lamp on any patients[311].

A College of Optometrists clinical practice survey in 2008[312] showed that 90% of the optometrists who filled in the survey had access to a slit lamp. Sarah J Smith reports in her doctoral thesis[313] that in 2008, 99.26% of the optometrists who responded to her questionnaire had a slit lamp, and in 2010, 99.05% who responded to her questionnaire had a slit lamp. Gill in 2010 found via a survey that 100% of the optometrists that responded had a slit lamp[314].

A survey by Stevenson in 1998 showed that 95% of the optometrists who responded used a slit lamp routinely[315]. The College of Optometrists survey in 2008 also reported that 37% of the respondents would always use the slit lamp to examine the anterior eye during a routine eye examination. Sixty per cent would sometimes use the slit lamp, and 1% never use the slit lamp.

Another study by the College in 2014 shows that 60.2% of optometrists always use the slit lamp to examine the anterior eye[316].

In Shah's doctoral thesis[317], optometrists were presented with electronic vignettes of 3 standardised patients. For a patient who was a young myope presenting with headaches, 99% selected that they would use the slit lamp on this patient. For a presbyopic patient reporting flashes of light, 100% selected that they would use the slit lamp. Finally, for the patient who was a presbyopic patient of African racial descent who reported near visual problems, 98% said they would use the slit lamp.

Yet by using standardised patients, Shah discusses in a series of articles that the percentage of optometrists that said they would use the slit lamp on those patients is very different from reality. For example, in one of Shah's articles[276], the 20-year-old myope attended for an eye examination reporting headaches. Of the 100 optometrists that tested the standardised patient in their consulting room, only 35 used the slit lamp to examine the anterior portion of the eye.

In another article by Shah[277], the standardised patient who was presbyopic and reporting flashes of light attended for an eye examination, only 48% of the optometrists used the slit lamp. Finally, Shah's last standardized patient[271] was the presbyopic patient of African racial descent who reported near visual problems, and only 37% used the slit lamp.

The top 5 reasons why optometrists use the slit lamp make up over 50% of the answers. Out of these answers, two of the uses for the slit lamp were to check the posterior of the eye; that is, to perform volk and check the posterior segment. These responses could account for the many optometrists who stated they use the slit lamp on 100% of their patients.

After having a large group of optometrists stating they use the slit lamp 75% of the time or more on their non-contact lens patients, the percentage use of NaFl drops dramatically, to only 16.7% optometrists stating they use NaFl on more than 75% of their patients. There was widespread opinion on the use of NaFl.

The largest response was from those who only use NaFl on less than or equal to 25% of their non-contact lens patients. Even though a surprising number of optometrists stated they use the slit lamp on 100% of their patients, the number of optometrists who stated they used NaFl on 100% of their non-contact patients drops to 9.0%. The percentage of optometrists who said they never use NaFl on any of their non-contact lens patients was 5.1%

Intriguingly, the percentage use of NaFl is not comparable to the percentage use of the slit lamp. Given that using NaFl does not add a considerable amount of time or discomfort for the patient, it is curious that an optometrist may not do it on every patient, especially as they have the patient already on the slit lamp. This question will also form the basis of the next chapter investigating the efficacy of NaFl on every patient.

Against what could be expected, the optometrists who saw more than 20 patients a day were not the group to use NaFl the least amount on their patients. However, the optometrists who see ten or fewer patients a day reported using NaFl the least.

The Malaysian study of optometrists stated that 49.3% had NaFl in their offices[311]. However, it did not indicate how often they used it on their patients.

From Shah's standardised patient research, it can be seen that their results are different from this questionnaire. For the patient who was a young myope presenting with headaches, only one optometrist out of 100 used NaFl[276]. For the presbyopic patient reporting flashes of light, only 5% used NaFl on the patient[277]. For the patient who was a presbyopic patient of African racial descent who reported near visual problems, only 4% used NaFl[271].

All year of qualification groups had most optometrists using NaFl on less than or equal to 25% of their patients.

Optometrists who can work at WCO level 4 had the highest proportion of using NaFl. This result could be because WCO level 4 optometrists are therapeutic and can manage anterior eye diseases. Therefore, they would need to use NaFl more to function at this level. Nevertheless, the percentage of optometrists using NaFl on more than 75% of their patients drops when the percentage is compared to the use of the slit lamp on more than 75% of the patient.

Comparing all the types of practice, those optometrists who work in a hospital/laser clinic, an independent clinic or a university clinic are more likely to use NaFI on more than 75% of their patients than the other categories.

Interestingly, 45.3% of hospital/laser optometrists who responded stated that they use NaFI on only less than or equal to 25% of their patients.

Also interesting is that optometrists in large-sized practices had the largest proportion of optometrists that use NaFI on only less than or equal to 25% of their patients.

However, all categories had the largest percentage of responses from the less than or equal to 25% of patients.

The number of patients seen each day does not have any bearing on the percentage use of NaFI, with most optometrists using NaFI on less than or equal to 25% of patients, no matter how many patients they see a day

An even lower response stated that they do lid eversion on more than 75% of their patients. A much higher proportion said they only do lid eversion on less than or equal to 25% of their patients. The percentage of optometrists doing lid eversion on 100% of their patients drops lower to 3.4%, compared to 60.9% of the optometrists using the slit lamp 100% of the time and 9.0% optometrists using NaFI 100% of the time. This result contrasts with a study that states that 69% of optometrists examine lid roughness on their contact lens patients[20].

From the responses, 10.9% stated they never do lid eversion on any of their non-contact lens patients. As stated above, most optometrists would only do lid eversion on their contact lens patients. However, performing lid eversion on all patients is essential to check the health of the palpebral conjunctiva. For example, patients with allergies can present with rough palpebral conjunctiva. In addition, the ease of lid eversion on a patient could help the optometrist suspect Floppy Eyelid Syndrome, which can cause ocular discomfort. The identification of Floppy Eyelid Syndrome is also crucial due to its association with sleep apnoea[318-323]. Lid eversion also is essential with dry eye diagnosis as everting the lid makes the lid wiper area visible. Lid eversion also allows examination of the Meibomian glands using infra-red light.

Again the question could have been asked why the optometrists did not do lid eversion, especially as it does not take much time. Efron states that lid eversion should not last more than 15 seconds due to patient discomfort[324], and Wolffsohn et al. confirmed that lid eversion should take less than ten seconds[325].

Whilst there was no significant relationship between the year of qualification and percentage performing lid eversion, all year groups had their highest numbers in the less than or equal to 25% group. However, those qualified after 1981 responded in this category higher than those qualified in 1980 and before.

There is an intriguing result with the comparison between the scope of practice and the percentage performing lid eversion as here the trend is in the reverse in that those at the lower level of the WCO scope of practice model, level 2, stated they were more likely to perform lid eversion on more of their non-contact lens patients than their colleagues working at a higher scope of practice. The optometrists at a level 2 scope of practice are the highest group to do lid eversion on more than 75% of their patients. This could be an example of the difficulties of using surveys to gather data; the optometrists at this level could have responded to the question in a manner they think they should respond. This result will be discussed in Chapter 5.

It was shown that the optometrists working in university clinics perform lid eversion the most. This result could be due to these optometrists knowing the benefit of lid eversion on their patients. It could also be because they could be teaching their students the process and benefits of lid eversion. Optometrists who work in a hospital/laser clinic were next. Again, it is interesting to note that 97.6% of optometrists who work in large-sized practices perform lid eversion on less than or equal to 25% of their patients.

Optometrists who see less than or equal to 10 patients a day are more likely to do lid eversion on more than 75% of their patients.

As the percentage use of the slit lamp was high, it would follow that the optometrists do a full lid examination whilst using the slit lamp. Over 80% of respondents stated they do a full lid examination.

For all the different analysis breakdowns, the proportion of optometrists saying “yes” to doing a full lid examination was always in the majority. However, statistical significance was only found with the scope of practice the optometrist worked in. $p < .001$

There was no significant link between the year the optometrist qualified and if they did a full lid examination. All year groups responded that they were more likely to do a full lid examination.

The optometrists at level 4 have a higher proportion of doing a detailed lid examination than the lower levels. 90.7% of level 4 optometrists say they do a full lid examination on their non-contact lens patients, whilst this is 70.6% for level 2 optometrists. Level 3 shows 75.6%

No matter which type of practice setting, the majority of the responses from the optometrists indicate that they do detailed lid examinations using a slit lamp. There was no significant trend from any type of practice group.

The number of patients seen each day had no bearing on whether an optometrist would do a detailed lid examination or not. All categories were in the majority of saying yes; they do a full lid examination.

There is no research on the optometrist's opinion on doing and reasoning for doing a detailed lid examination. However, performing a detailed lid examination is essential as it has been stated that the lids are responsible for 86% of all dry eye disease due to Meibomian Gland Dysfunction[326]. It has been found that 85% of people who use digital devices had Meibomian Gland Dysfunction[327]

Meibomian glands, blepharitis, lids lesions, lashes and palpebral conjunctiva were the top 5 answers to what areas/conditions optometrists were looking for/at during the lid examination. These conditions also make up just over 50% of all the answers to this question (52.0%).

Whilst all of these could be seen via the naked eye or the direct ophthalmoscope, the magnification of the slit lamp makes it much easier to examine the lids for these conditions. A study using Wood's lamp also found the lack of magnification to be a concern in detecting anterior eye problems[328]. The authors recommend using the slit lamp whenever possible.

The fact that the palpebral conjunctiva was in the top five is interesting, given that 84.6% of the responses indicated by the previous question said they would only do lid eversion on less than 25% of their patients. Does this mean that when the respondents stated they examine the palpebral conjunctiva, they really mean examining the inferior portion?

More than 50% of the respondents were qualified within the last 15 years, with 42.3% qualified within the last ten years. 25.6% within the last five years. Whilst this is similar to results from another study[329], this breakdown could suggest biases in the results as it could be expected that those who are qualified more recently would be keen to practice optometry like they were taught in optometry school, that is, slit lamp, use of NaFl and lid eversion. Also, it could be said that newly qualified are more likely to want to learn new skills; many of these skills involve using the slit lamp.

University training has become more advanced even within the last five years with the advent of OCT, the resurgence of scleral lenses and various shared care schemes.

One would think that those optometrists who have recently qualified would be more inclined to use the slit lamp. A paper by Biswas in 2018 stated that Ophthalmology residents trained since 2003 rated their training better than a resident who trained before 2003 rated their training[330].

All the responses came from countries that are allowed and trained to use the slit lamp. The largest responses were from optometrists from the WCO Europe region and the WCO North America region. With this, the majority of the optometrists can work at either level 3 and level 4.

As these two regions are significant regions with the WCO, it was good to get their responses. Moreover, as the majority of the countries in these regions can work at a scope of practice of level 3 and level 4, there would be the expectation that they would function at a higher level than respondents who work in countries that do not have an increased scope of practice.

Forty per cent of the responses, which is the highest proportion, came from optometrists who work in single location practices, with 14% of responses coming from optometrists who work in companies with more than 30 locations. These responses are similar to optometry worldwide, with more independent optometrists than multiples[329, 273, 274].

It would be expected that optometrists that work in university and hospital/laser clinic locations would use the slit lamp more in their daily clinics. Also, it could be said that those optometrists that work in single locations would have more freedom in their eye exam routine than those optometrists who work in large companies where typically the eye exam routine is dictated by company policy. The results in the questionnaire show this.

University clinics see the smallest number of patients each day. Seventy-five per cent of respondents stated they see less than or equal to 10 non-contact lens patients a day. With the other 25% saying they see between 11-20 patients a day. There were no responses from anyone working in a university clinic seeing more than 20 patients a day.

The highest response for seeing more than 20 patients a day came from those working in a hospital or laser clinic. Of those who said they work in a hospital or laser clinic, 12.5% see more than 20 patients a day. Of the optometrists who responded that they do locum work, 5% stated that they see more than 20 patients a day.

Of those who responded from independent, small-sized and medium-sized practices, the majority of the responses stated they see less than or equal to 10 patients a day.

While most of the responses from hospital or laser clinics, large-sized practices, or locum work stated, they see between 11-20 patients a day.

Those that work in independent practices, small-sized practices (less than 5), medium-sized practices (between 5 and 30 practices) and university clinics tend to see less than ten patients a day. Is this due to the working practices of the optometrist or the demand? On the other hand, hospital/laser clinics, large-sized companies, and optometrists working as locums tend to see more patients, between 11-20 patients.

It was proposed that those optometrists who see many patients a day would be less likely to use the slit lamp, use NaFl, perform lid eversion and do a detailed lid examination. However, this was only shown for performing lid eversion.

2.6 Conclusion

Overall, the percentage use of the slit lamp on non-contact lens patients is significantly linked to the year of qualification of the optometrist, the scope of practice the optometrist can work to, and the number of patients seen each day. There was no significant relationship with the type of practice the responding optometrist works.

The study's first objective is to measure optometrists' views on using the slit lamp in routine optometric practice in various countries in the world. This chapter reviewed the results of a survey sent out to optometrists in different locations around the globe. The responses showed that most optometrists use their slit lamp on more than 75% of their patients. However, when using NaFl, this figure drops, with the majority using it on less than 25% of their non-contact lens patients.

This chapter has shown that the null hypothesis that there is no difference in the use of the slit lamp throughout the world is rejected.

These results link with the next chapter that will examine the usefulness of using the slit lamp on all patients, whether they are asymptomatic and symptomatic and recording any findings. The chapter will also discuss the use of NaFl on all patients.

Chapter 3:
Measurement of the number of symptomatic/asymptomatic patients & findings seen on Slit Lamp & white light and with NaFl & blue light

3.1 Introduction

Following gaps in the literature review, a study was designed to examine the efficiency of using the slit lamp and NaFl on every patient. While articles describe the proper use of the slit lamp, there is no research on the efficiency of its use. There is very little data on the use of NaFl in general optometric practice. There are articles on how corneal staining is proposed to work. One would expect the frequency of the use of NaFl to be high when optometrists are seeing contact lens patients, but there is little information for non-contact lens patients. It will be reviewed if NaFl should be used on every patient, and it is worthwhile in terms of patient management.

Extensive literature searches were performed using The Cochrane Library website [331], The Cochrane Eye and Vision Group website[332], Centre for Evidence-Based Medicine website[333], Turning Research in Practice website, PubMed website[334] and the Google Scholar website.

There are no matching research articles on the use of the slit lamp for an external eye examination. In addition, keywords used, such as slit lamp/biomicroscope, effectiveness, specificity, sensitivity, usefulness, and external eye examination, did not produce relevant articles.

The keywords "anterior eye examination" came up with two articles discussing using the slit lamp in a routine eye exam, the previously mentioned article from Davies and Veys[124] and one from Blakeney[335]. The article by Blakeney[335] discusses the efficiency of the eye examination to detect pathology even when the patient is asymptomatic but does not discuss the use of the slit lamp in an eye exam.

3.2 Methodology

Ethical approval was granted from the Campus Research Ethics Committee, the University of the West Indies (UWI) and the Ethics Committee, Aston University. The research followed the principles of the Declaration of Helsinki.

The study was done in the UWI Optometry Clinic, St. Augustine, Trinidad & Tobago. This clinic is attached to the BSc Optometry programme offered by the UWI. Patients who attend the clinic pay fees for the services provided. These fees are on average 20% less than privately run practices. Patients are seen by 3rd and 4th-year optometry students whom qualified optometrists supervise. The patient demographics range from a paediatric to a geriatric population. The UWI Optometry clinic also has speciality clinics for binocular vision, contact lenses and low vision.

The inclusion criteria for the study were:

- All patients over the age of 18 years old.
- All patients without cognitive impairment.
- All patients attending the UWI Optometry clinic for only an eye exam were invited to participate.
- Any patients who wore contact lenses previously but had not worn any contact lenses for the last six months.

The exclusion criteria for the study were:

- Any patient who was currently wearing or had worn contact lenses within the last six months[149, 154].
- Any patient referred to the clinic for further testing, such as visual field testing, glaucoma screening, and other clinics.

A planned pilot study was done over one working week to examine the feasibility of the methodology. The main project was conducted over three months.

Every patient was booked as a regular patient in the UWI optometry clinic. Each patient was booked for one hour for an appointment assigned to the investigator. When booking the appointment, the patients were not made aware of the research. Upon arrival, the nature of the project was discussed with them. The patients were invited to take part in the research study.

The patient was given time to read the participant information sheets (Appendix 4) from the two universities, Aston University and the University of the West Indies.
The patient was allowed to ask the investigator any questions they may have had concerning the research study. Any patient who agreed to participate in the study was asked to sign the informed consent forms from both universities. The patient was given copies of the participant information sheets.

In the consulting room, history & symptoms were taken. Each patient was asked their main reason for wanting an eye examination, that is, their chief complaint. This reason was noted.

Even if the patient's chief complaint did not seem to be related to the anterior eye, all patients were asked if they were symptomatic to the following in a yes/no manner:

- "Do you have dry eyes?"
- "Do you have gritty eyes?"
- "Do you have sore, uncomfortable eyes?"
- "Do you have burning eyes?"
- "Do you have itchy eyes?"
- "Do you have watery eyes?"

These questions were chosen following the review in Chapter 1, table 1.4. These six questions will be known as the "six symptom list" throughout this chapter.

The questions were printed and laminated, so the investigator would have them by his side as a reminder to ask every patient the same six questions.

Then the following parts of the eye examination were performed: unaided/aided visual acuity, pupils, cover test, motility, IOPs, objective refraction, subjective refraction, muscle balance and ophthalmoscopy.

Examination of the external/anterior eye was performed using a designated Haag Streit slit lamp, model BQ 900 (Haag Streit Ag, Köniz, Switzerland). Slit-lamp biomicroscopy was performed on all patients, whether the patient was symptomatic or not for any anterior eye problems.

The slit lamp examination was performed systematically as suggested by many authors[16-22].

- Eyelids & Lashes
- Conjunctiva & Sclera
- Tear Film & Meniscus
- Cornea
- Anterior Chamber
- Iris and Pupil
- Lens
- Anterior Vitreous

Firstly, using magnification 10x and using the attached diffuse filter, the eye and eyelids were examined. Next, magnification was changed to 16x, where the superior & inferior lids and lashes were examined. Any signs of blepharitis, blocked meibomian glands, concretions, ectropion, entropion, lid hyperaemia, lid lesions, lid position, stenosis of the puncta and trichiasis were recorded. This was followed by an examination of the conjunctiva (bulbar and palpebral). Any signs of conjunctival hyperaemia, conjunctival naevus, conjunctivochalasis, follicles, papillae, pinguecula and pterygium, were recorded. The tear film was examined for any debris or makeup, and this was recorded. Then the cornea was examined. Any signs of arcus, epithelial/stromal opacity, endothelium pigment/opacity and corneal vascularisation were recorded. The anterior chamber was examined for any cells and flare. The Iris and pupil were examined for any irregularity and lesions. The lens was examined for any lenticular opacity or post capsule opacification if any IOL was present. The anterior vitreous was examined for any pigment cells or "tobacco dust". Any further findings were assessed using higher magnification as needed.

A grading scale was used to give the recorded slit lamp data consistency and accuracy. From Chapter 1, the Efron grading scale was chosen as it is one of the most popular scales used in routine practice.[100, 20] The Efron Scale is shown in Appendix 5.

Any clinical sign seen with white light and graded 1.0 or higher on the Efron scale was taken as clinically significant and recorded as “yes”.[97, 100] There are numerous signs not listed on the Efron scale. These signs were recorded as “yes” once visible on the slit lamp with white light as they could not be graded in the same way as the Efron Scale.

The clinical signs that were recorded are given in Table 3.1

Arcus	Blepharitis	Blocked Meibomian Glands
Concretions	Conjunctival Hyperaemia	Conjunctival Naevus
Conjunctivochalasis	Corneal Opacity	Endothelium Opacity / Pigment
Lenticular Opacity	Lid Hyperaemia	Lid Lesion
Lid Position	Make-up in Tear Film	Pinguecula
Post Capsule Opacification	Pterygium	Stenosis
Other		

Table 3.1 Clinical signs recorded using the Slit Lamp

Ocular surface disease signs were also recorded and are given in Table 3.2

Blepharitis	Blocked Meibomian Glands	Concretions
Conjunctival Hyperaemia	Conjunctivochalasis	Lid Hyperaemia
Lid Lesion	Lid Position	Make-up in Tear Film
Pinguecula	Pterygium	Stenosis
Other		

Table 3.2 Ocular surface disease signs recorded using the Slit Lamp

The patient's cornea was then examined using a circular polarising filter (Chapter 4).

NaFl was instilled in every patient. A standard operating procedure for the instillation of fluorescein was used. The routine discussed by Peterson et al.[148] was followed. First, a strip of NaFl, GloStrips® (Amcon Labs, St. Louis, Missouri, USA) was moistened with saline, Sensitive Eyes Plus (Bausch & Lomb, Rochester, New York, USA), and any excessive saline was shaken off. Then, it was instilled into the lower fornix. The investigator waited one minute before examining the cornea, as recommended by Peterson et al.[148]. The cornea was examined using the cobalt blue filter and then enhanced using a Wratten #12 filter in front of the observation oculars. Any sign seen with NaFl and graded 1.0 or higher on the Efron scale was taken as clinically significant and recorded as yes[97, 100]. However, numerous signs can be seen using NaFl that are not listed on the Efron scale. These signs were recorded as "yes" once visible with NaFl as they could not be graded in the same way as the Efron Scale.

A tear break up time test (TBUT) was performed. The patient was asked to blink softly three times and then the time taken for a break to be seen in the tear film was recorded[336-338]. A low TBUT was taken as any break seen in the tear film within 10 seconds[339, 16, 340, 338, 341, 95, 342].

The tear prism height was measured at the lower lid directly under the pupil using the height of the slit lamp beam as a guide. The illumination and observation system was set at 0°. The patient had to blink once and was asked to look directly ahead. Any patient with a tear prism height of <0.1mm was recorded as having a thin tear prism[343-345].

The signs recorded as visible with NaFl are given in Table 3.3

Conjunctivochalasis	Epiphora	Low TBUT
Superficial punctate keratitis	Thin Tear Prism	

Table 3.3 **Signs visible with NaFl recorded using the Slit Lamp**

After reviewing patient questionnaires in Chapter 1, the Ocular Surface Disease Index (OSDI) (Allergan Inc, California, USA) questionnaire was chosen as the most suitable patient questionnaire for the research. The patient was handed the OSDI questionnaire. The investigator explained how to fill it in. The investigator then left the testing room to avoid any potential bias on the patient filling in the OSDI and returned in 10 minutes. Any patient that could not read (due to a lack of spectacles) had an optometry student read out the questions for the patient. The patient then placed the OSDI in an envelope that was locked in a desk at the clinic reception.

The investigator was masked to the filled-in OSDI questionnaires until the end of the research. This process was done to prevent any bias on the investigator when reviewing the history, slit lamp with white light findings and slit lamp with NaFl findings.

The patient was then advised of any exam findings, be it refractive or medical, and the patient was managed accordingly. A referral letter was written if the patient needed a referral to an ophthalmologist or another professional for other management. The clinical care was not affected by participating in the study nor by the results found. The study was a single visit study, and the patient was not required to return concerning the research.

Every patient was seen by the same optometrist (NF) for consistency in the eye examination and grading of any conditions seen on a slit lamp and NaFl. The first subject visit was in December 2017, and the last subject visit was in July 2018.

A sample size of 96 patients was calculated using a margin of error of 10%, confidence level of 95%, and 9,000 as the university clinic patient population. The sample size calculations are shown in Appendix 6. Data analysis was done using IBM SPSS 25.0 software. The Chi-square test of independence was used to investigate any associations between the grouped responses. A p-value of less than 0.05 from the two-tailed Chi-square test was taken to be statistically significant. For the analysis of the clinical signs of signs seen, yes or no, a single proportion test, Binomial Test, was used, with an expected proportion of 50%. It was tested at the 0.05 level of significance.

3.3 Results

For the planned pilot study, twenty patients were booked in over one week (4 each day). Fifteen patients were seen; the other five did not appear for their appointments at the University Clinic.

The planned pilot study showed that obtaining ethical approval from the patient, doing a comprehensive eye examination including slit-lamp examination on every patient, instilling NaFl in every patient and viewing with blue light and the Wratten filter, using the circular polarising filter (Chapter 4), and getting the patient to fill in the OSDI questionnaire could be achieved with most patients during the one hour allotted. The planned pilot study also showed that the existing university record card was sufficient to record all the data needed. A summary of the results is given in Appendix 7.

Two areas of the study that needed to change were: 1) to obtain a new Wratten filter as the one used in the pilot study was too scratched to get a clear view; 2) the circular polariser used during the pilot study was too small in diameter.

For the main study, 105 patients were asked to take part in the research. However, three patients refused consent immediately due to concerns about the study procedures and the use of personal data.

Six patients were ineligible for the research after they signed the consent forms. Two were ineligible as it was discovered after obtaining ethical approval that they currently wear or had worn contacts within the last six months. Another patient was ineligible when they produced test in the consulting room a referral letter from an ophthalmologist requesting only a visual field. Two were excluded as it was impossible to get a sharp, focussed view on the slit lamp either due to the patient's size or inability to keep their eyes open long enough to make a proper assessment. Finally, a patient was discontinued as they changed their mind and withdrew consent after history & symptoms were taken.

Patient Age:

The age range of patients seen was from 20 to 85 years, with 76.0% of the patients over 40 and 63.5% being over 50. The mean was 54.5 + / - 17.1. The mode was 60 years of age. The ages were then grouped for statistical analysis.

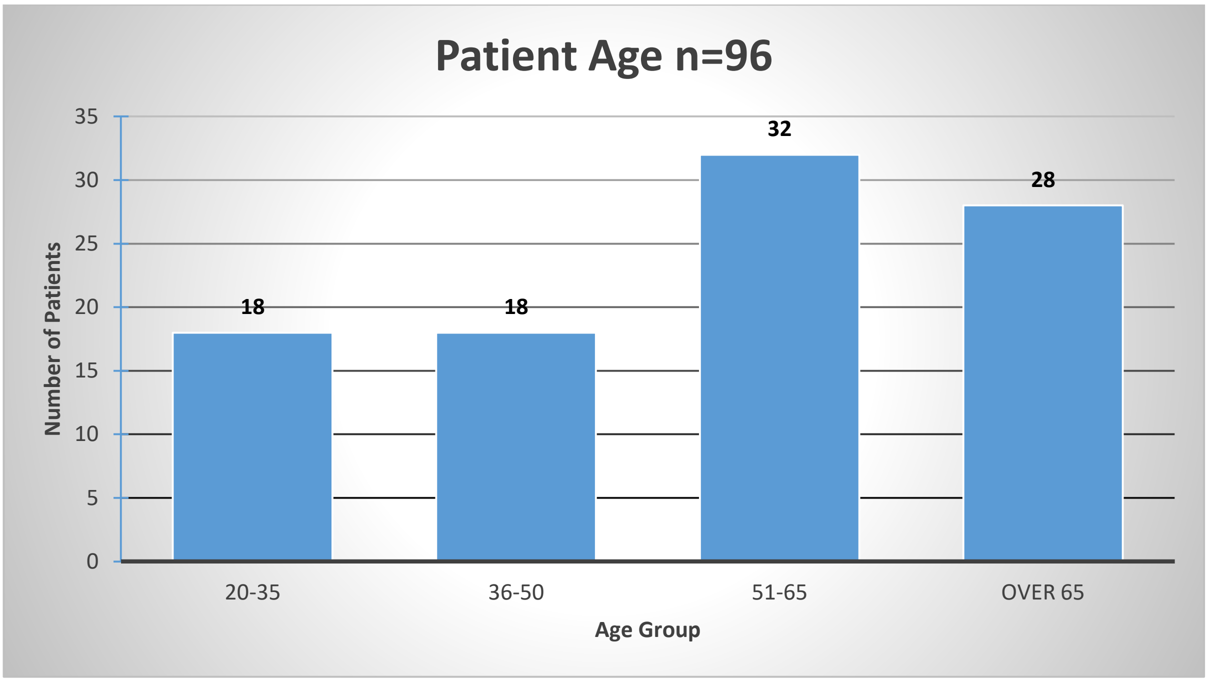

Figure 3.1 Patient age grouped into four categories

Patient Gender:

Females accounted for 64.6% of the patients seen, whilst males accounted for 35.4%.

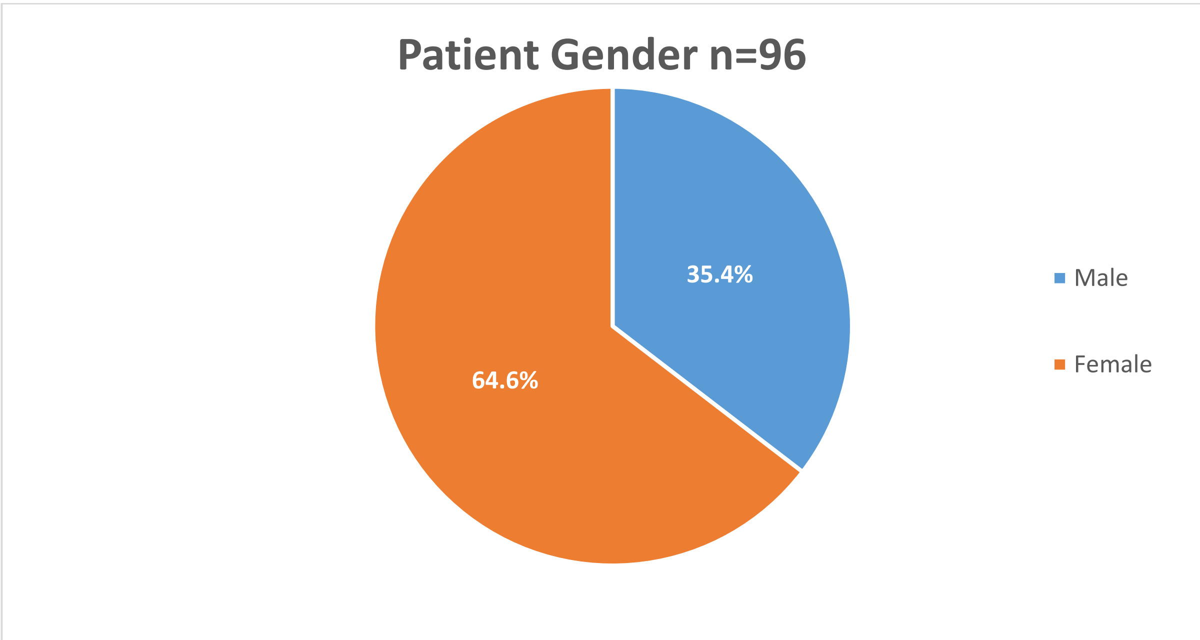

Figure 3.2 Patient Gender

Reason for Visit:

The most common reason for the patient to visit the university clinic was blurry vision, that is, problems with distance & near (23 patients). One patient reported having sore eyes as their reason for the visit. Seven patients only reported watery eyes or sore eyes as their reason for the visit. These were two of the symptoms from the six symptom list.

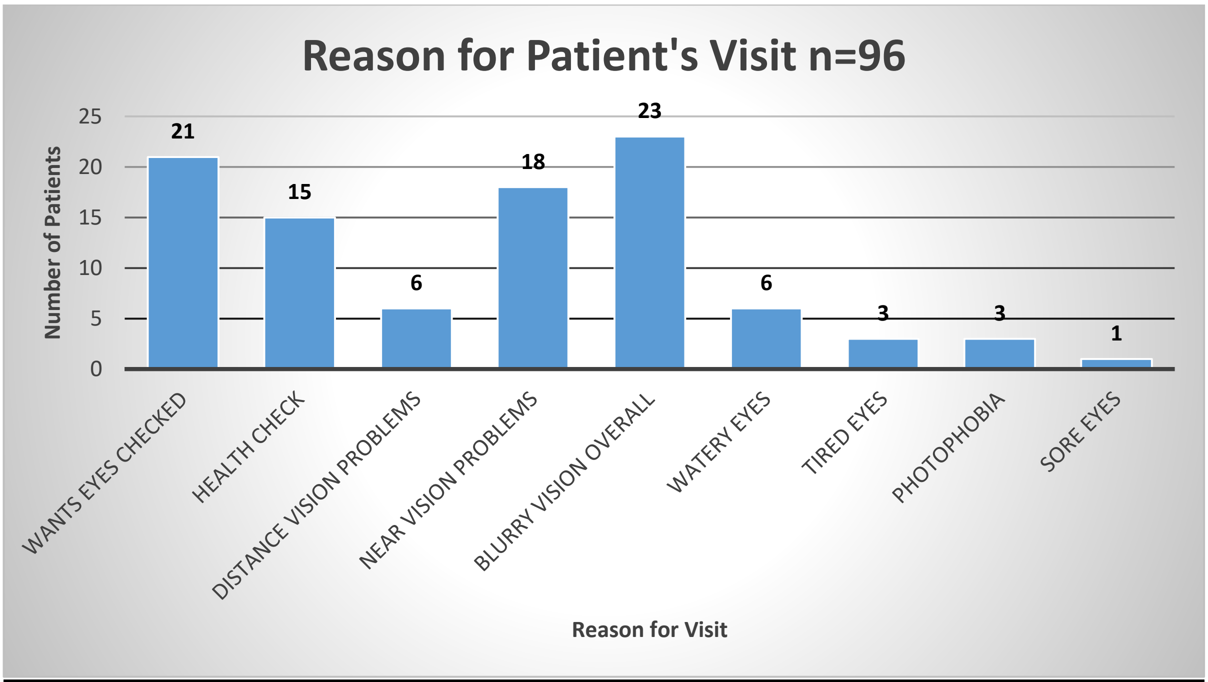

Figure 3.3 Reason for Patient's Visit

Symptoms reported from six symptoms list:

As discussed in the methodology, every patient was then asked the same six questions about possible symptoms. Just over 50% of the patients answered "no" to all six questions. The most common symptom was itchy eyes, and the least common was sore eyes. The number of symptoms reported is 111, as patients could answer yes to more than one symptom. Figure 3.4 shows the reported symptoms.

Figure 3.5 shows a breakdown of the number of symptoms answered "yes" by the patients. As shown in figure 3.6, these were then grouped for statistical purposes to create four groups having a similar number of groups as the OSDI score groups.

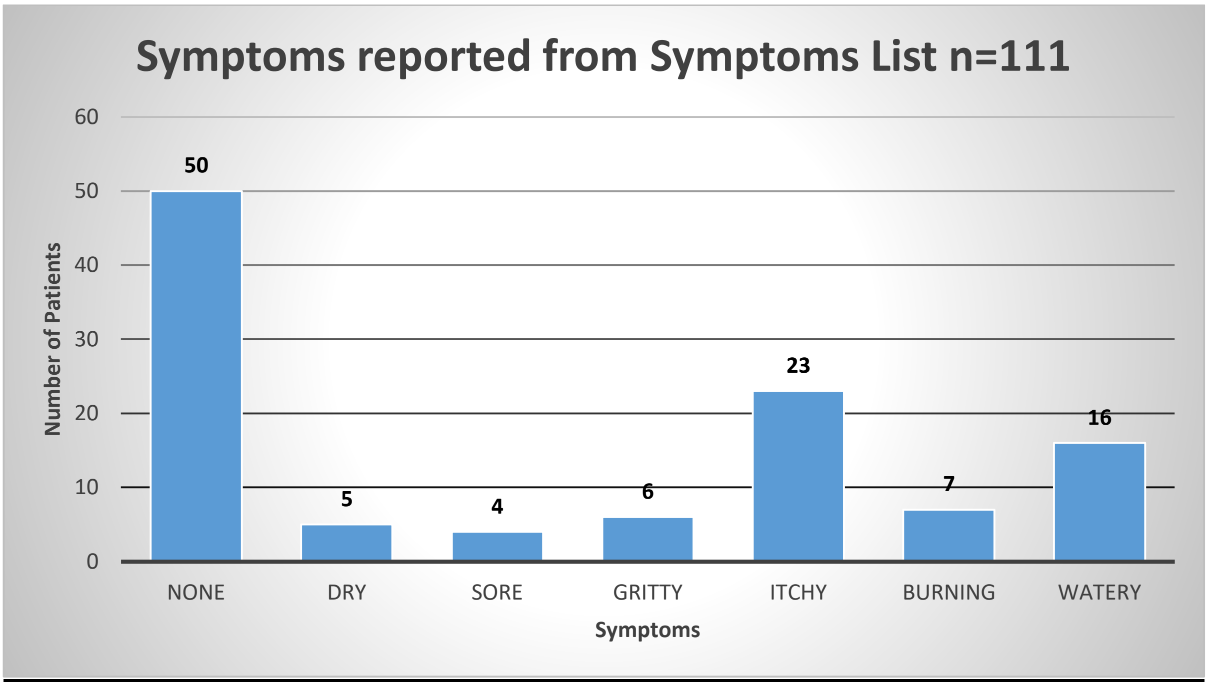

Figure 3.4 Symptoms reported from Symptoms List

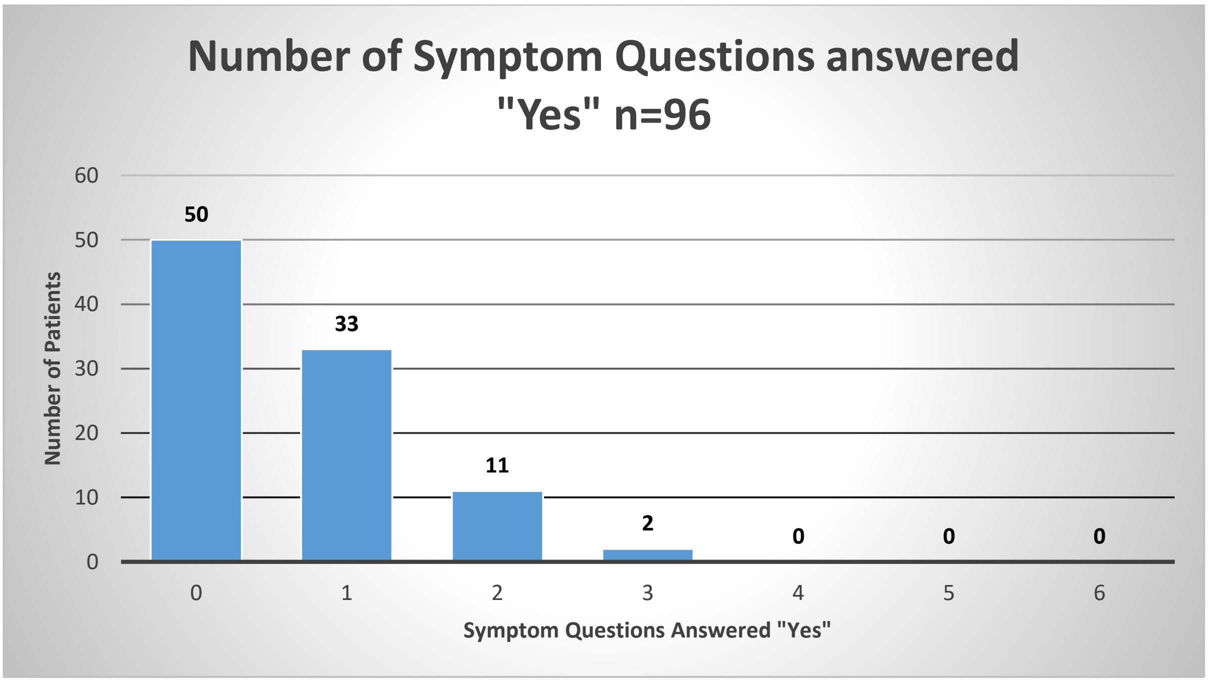

Figure 3.5 Number of Symptom questions answered "Yes"

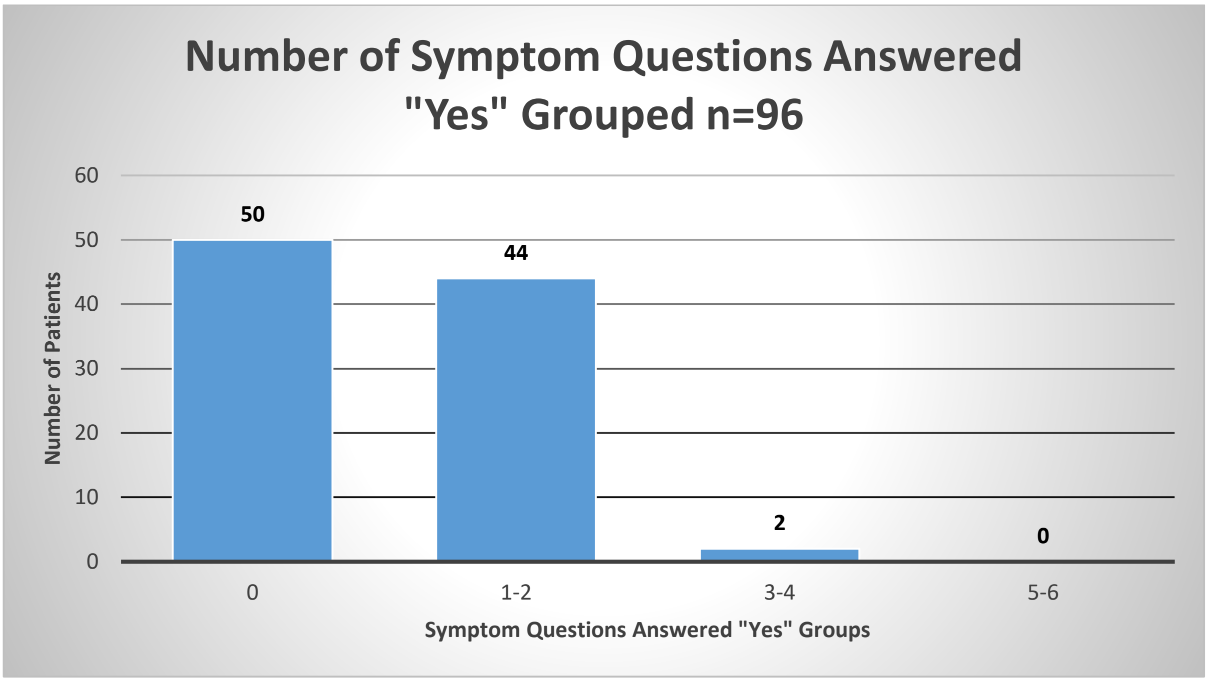

Figure 3.6 Number of Symptom Questions Answered "Yes" Grouped

OSDI levels:

The OSDI questionnaire suggests a range of values to group patients: normal (0-12 points), mild (13-22 points), moderate (22-32 points) and severe (33-100 points).[178, 346] Any patient with a score over 12 can be labelled "symptomatic"[178, 179, 346].

The mean OSDI score was 22.5 + / - 16.2. Figure 3.7 shows the classification of the patients in the study. The largest group of patients seen was those that scored in the normal group.

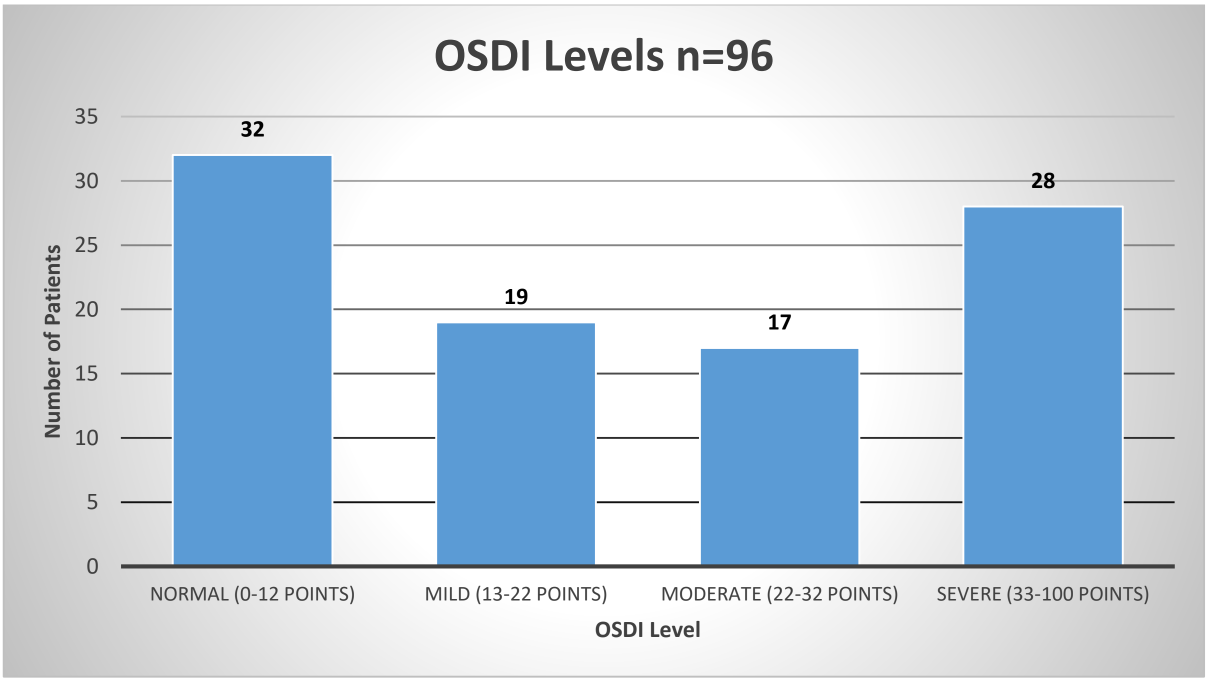

Figure 3.7 OSDI Levels

Ocular Symptoms Subscale:

Schiffman discusses the different subscales of the OSDI[178], with one of them being the Ocular Symptoms Subscale. Figure 3.8 shows the classification of the patients using the OSDI ocular symptoms subscale.

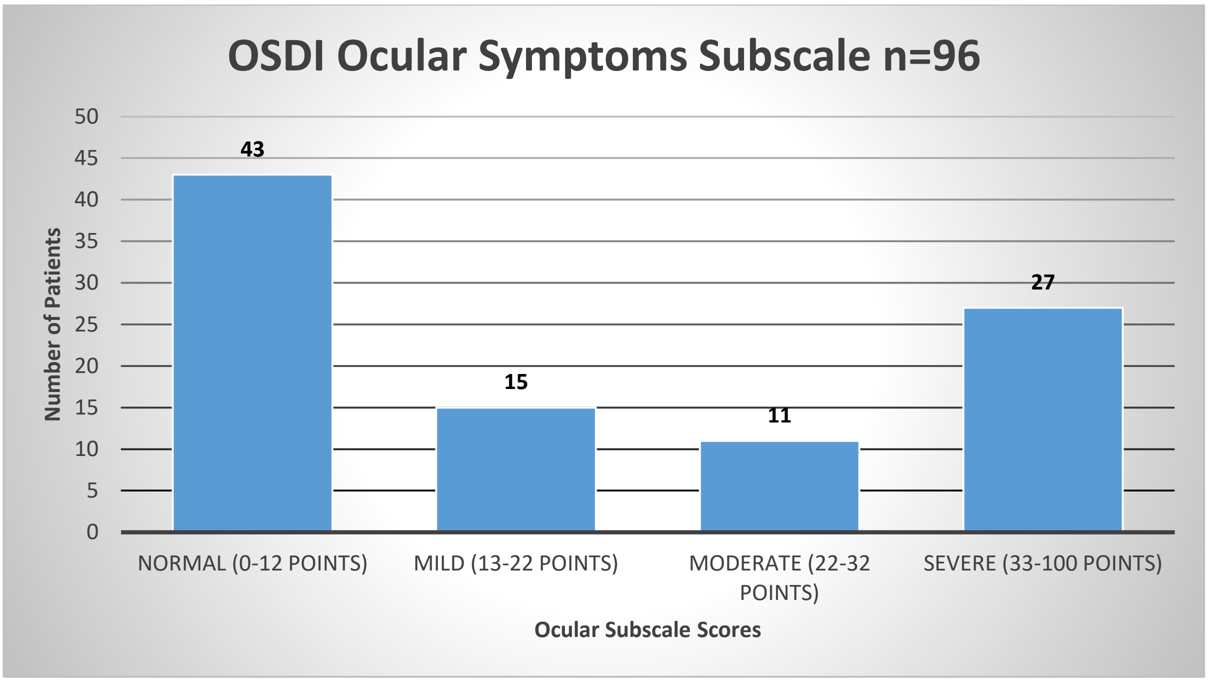

Figure 3.8 OSDI Ocular Symptoms Subscale

Signs seen on Slit Lamp and white light:

Of the 96 patients seen for an eye examination, 91 had signs when using the slit lamp and white light. These signs were categorised as seen in figure 3.10. The most common sign seen using the slit lamp was corneal arcus which was seen in 47 patients. An average of 3 signs was seen per patient.

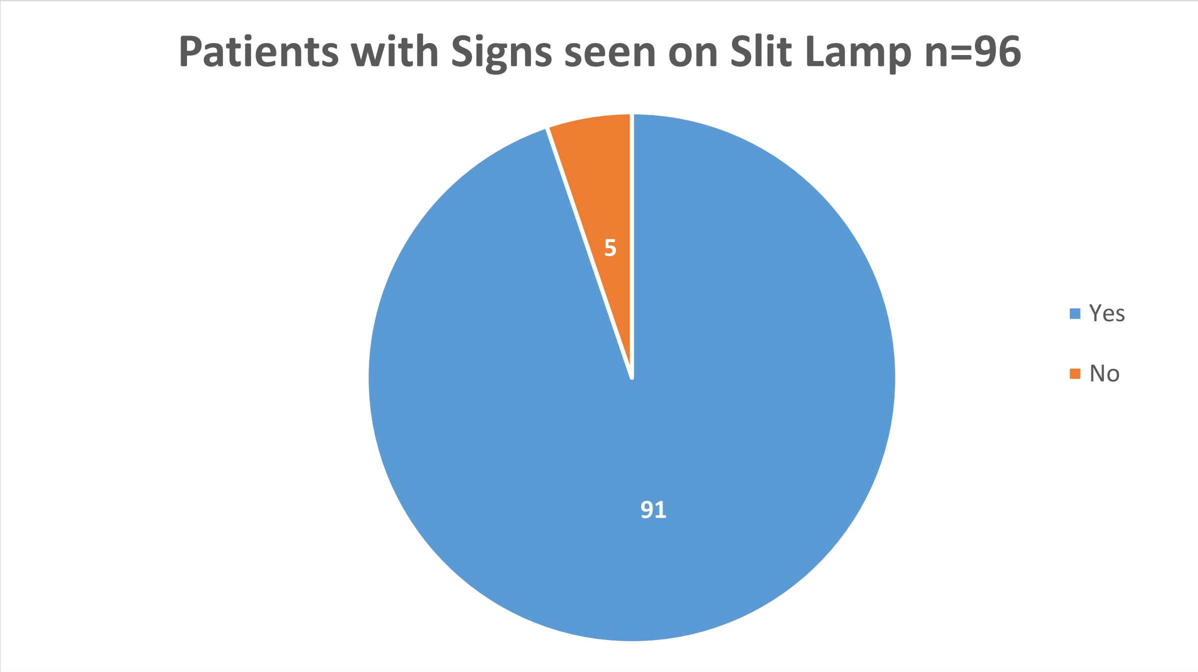

Figure 3.9 Patients with Signs seen on Slit Lamp

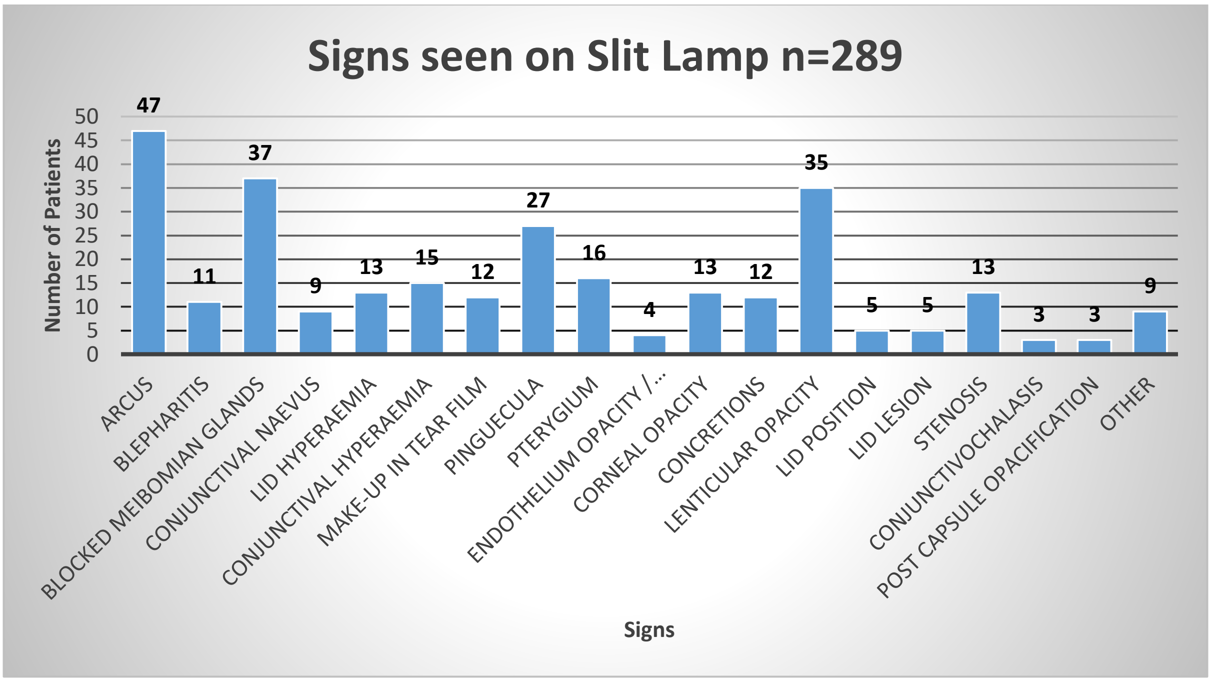

Figure 3.10 Signs seen on Slit Lamp

However, many of these signs, such as corneal arcus, corneal or lenticular opacities and conjunctival naevus, would not be associated with ocular surface disease(OSD). Hence the patient would not report having, for example, itchy eyes due to these signs. Therefore, to compare with the OSDI questionnaire and the six symptom list, a subsection of signs seen on the slit lamp was produced and called "OSD signs".

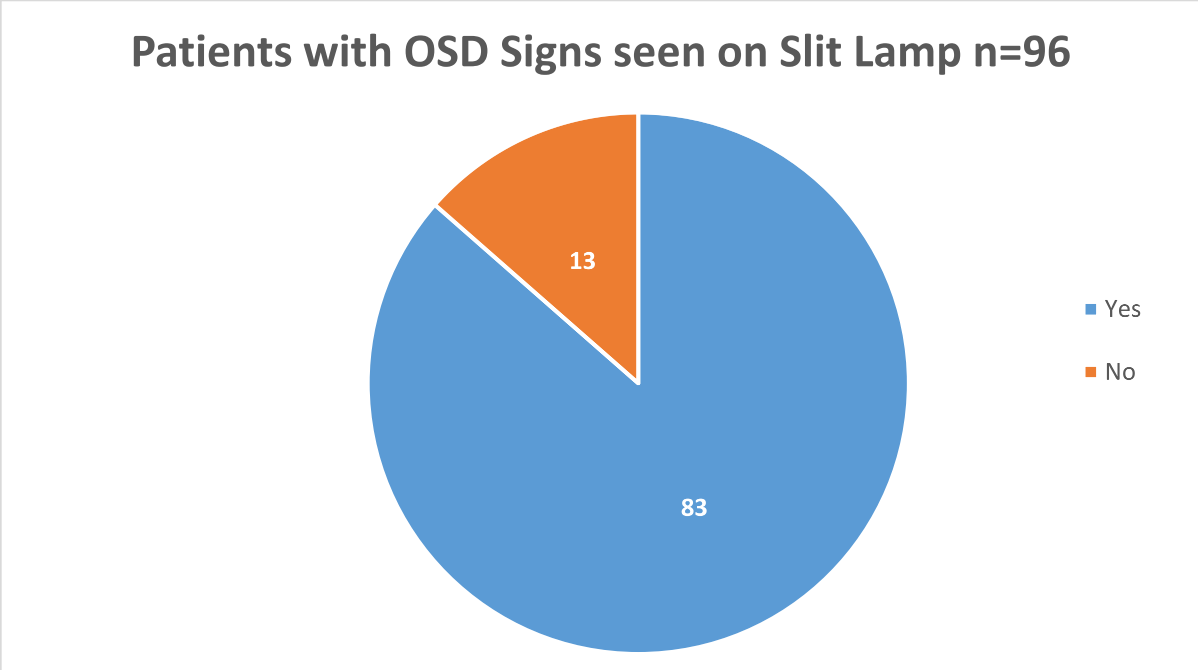

Figure 3.11 Patients with OSD signs seen on Slit Lamp

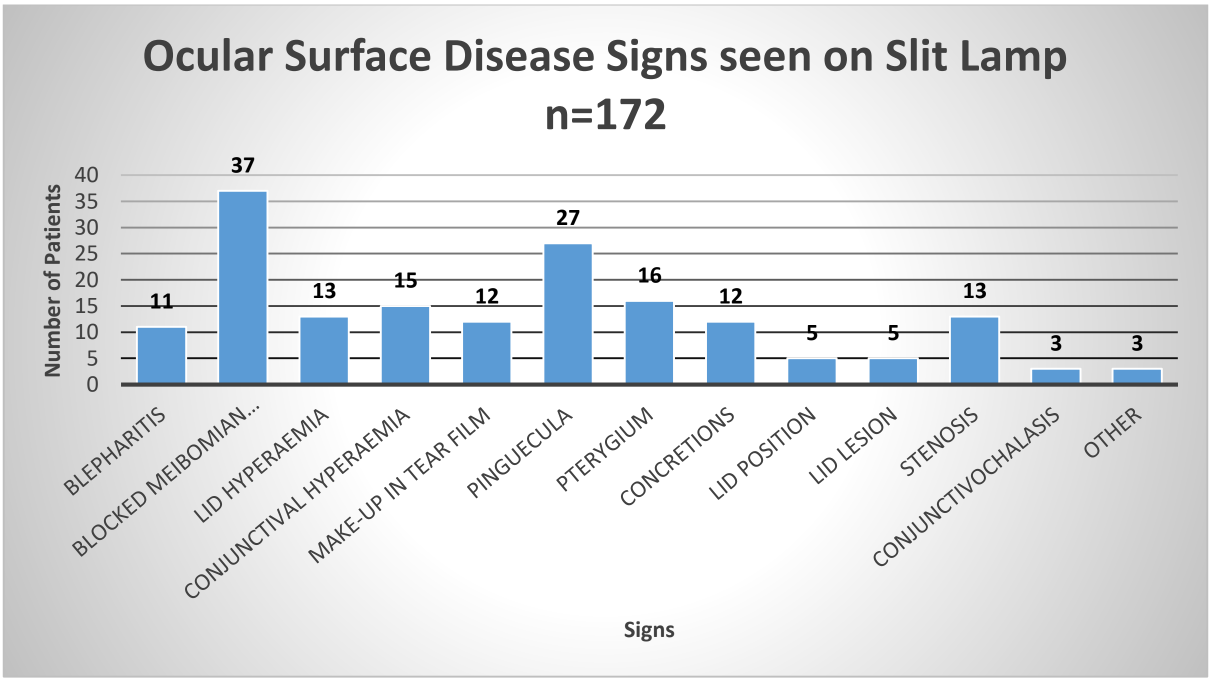

Figure 3.12 OSD Signs seen on Slit Lamp

Signs seen with NaFl:

When NaFl was instilled, 52 patients had clinical signs visible using NaFl whilst 44 patients did not. Figure 3.14 shows the breakdown of the signs visible when using NaFl.

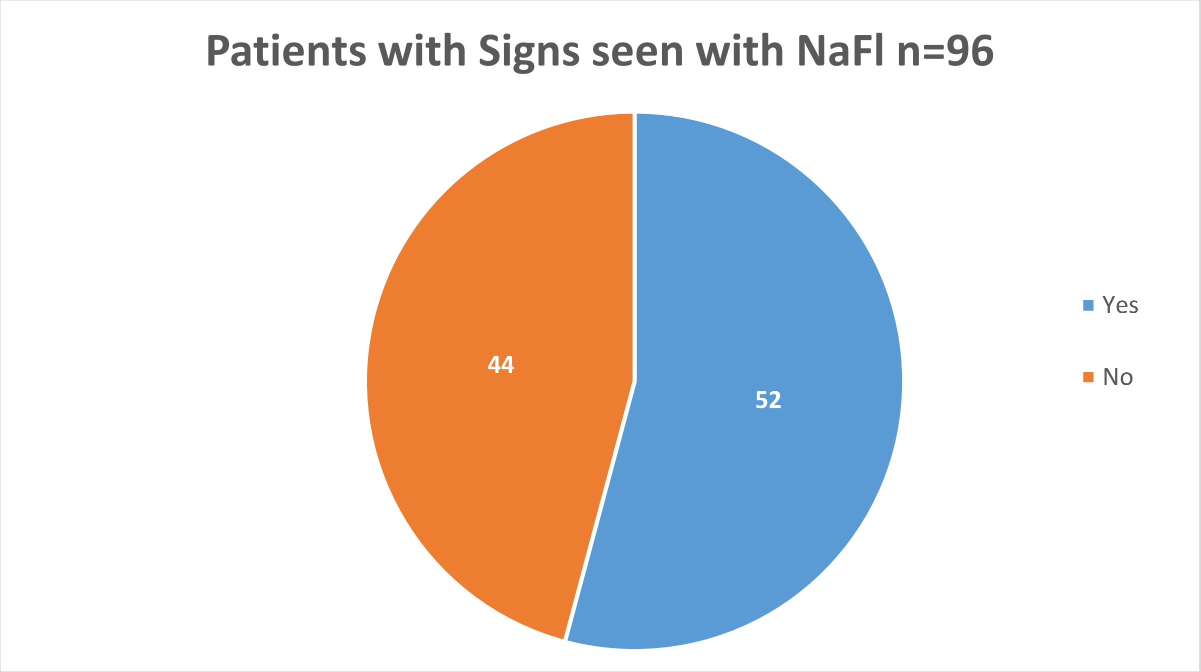

Figure 3.13 Patients with Signs seen with NaFl

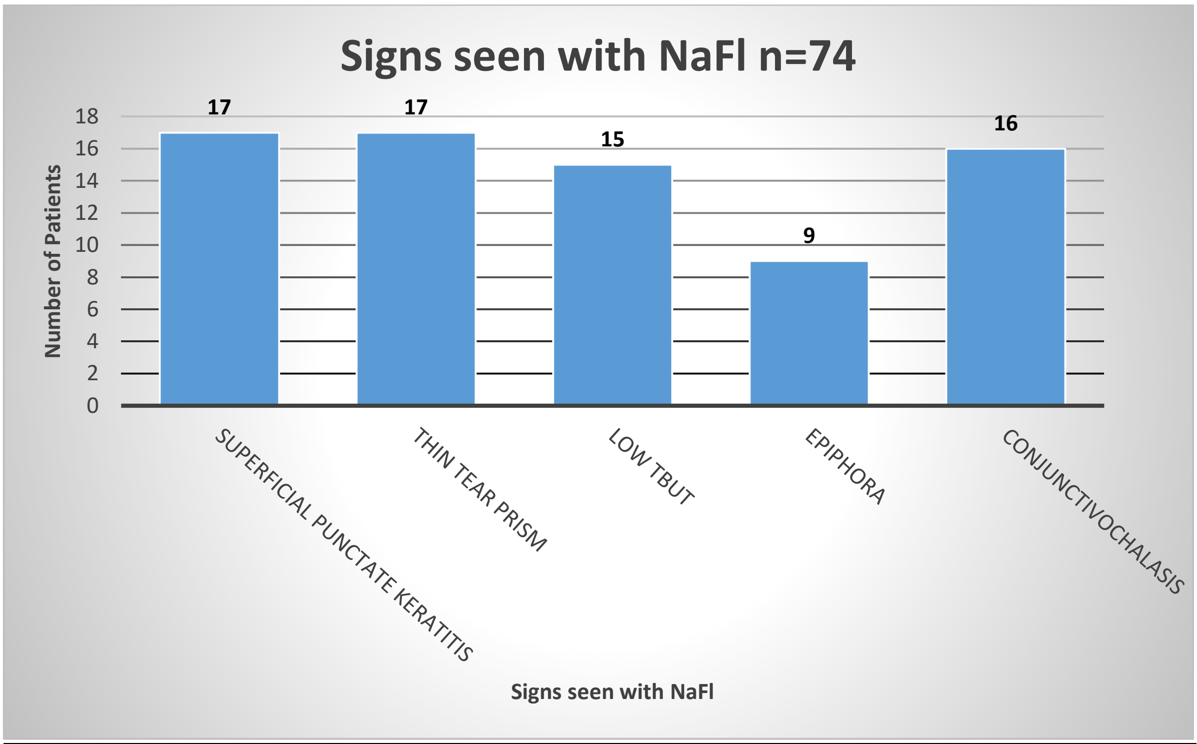

Figure 3.14 Signs seen with NaFl

Signs seen with the Wratten Filter:

When the Wratten filter was placed in front of the slit lamp, after the instillation of NaFl, the filter gave an enhanced view of all the visible signs seen with NaFl in 52 patients and made no difference to the 44 patients who did not have any signs visible with blue light.

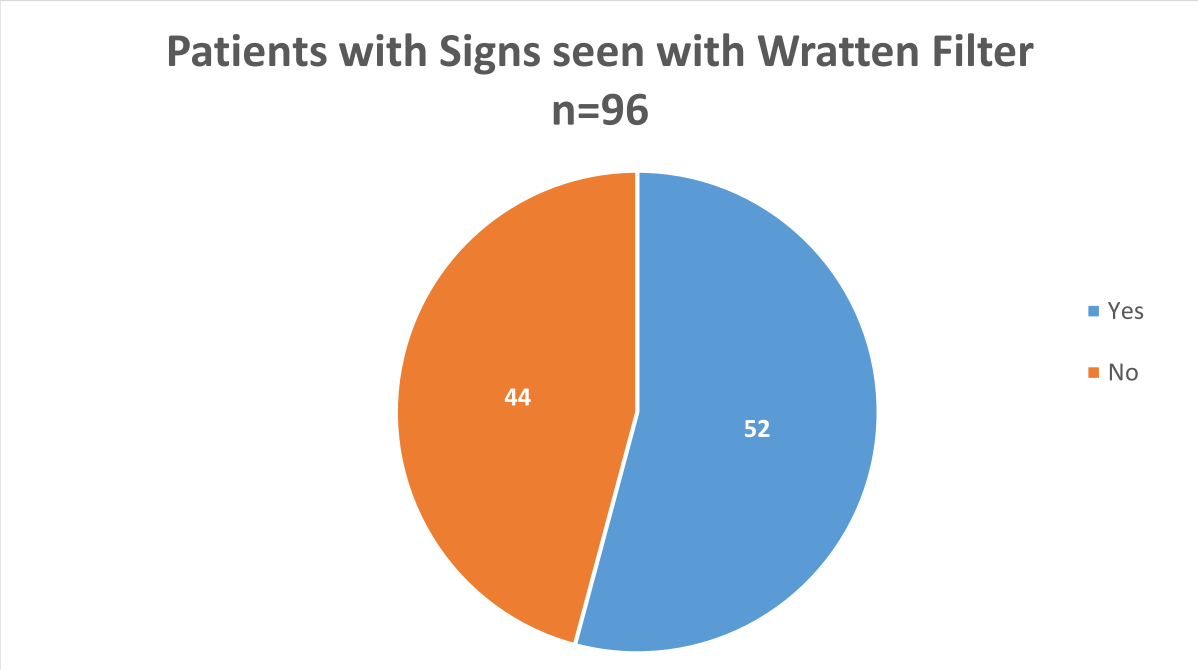

Figure 3.15 Patients with Signs seen with Wratten Filter

Two flow charts were designed to represent the overall results (Figures 3.16-17). They were designed to give a breakdown of each step in the process to highlight those patients who attended for an eye examination asymptomatic. Figure 3.16 shows the asymptomatic patients using the OSDI but had OSD signs on the slit-lamp using white light and/or findings using NaFl and the Wratten Filter #12. Figure 3.17 shows the patients that were asymptomatic on history using the six symptom list but had OSD signs on slit-lamp using white light and/or findings using NaFl and the Wratten Filter #12

The steps of the process were:

Step 1: Was the patient symptomatic using the OSDI questionnaire? Or did the patient report any symptoms of itchiness, grittiness, burning, soreness, dryness, wateriness? Yes or No

Step 2: Were any OSD findings seen on the slit lamp using white light? Yes or No

Step 3: Did the instillation of Sodium Fluorescein show any additional findings? Yes or No

Step 4: Did the use of the Wratten Filter #12 show any other findings? Yes or No

Patients who were deemed asymptomatic either by the OSDI questionnaire or the six symptom list and yet still had OSD signs on the slit-lamp and NaFl are the patients of significance in this research. Therefore, they are highlighted in both figures 3.16-17.

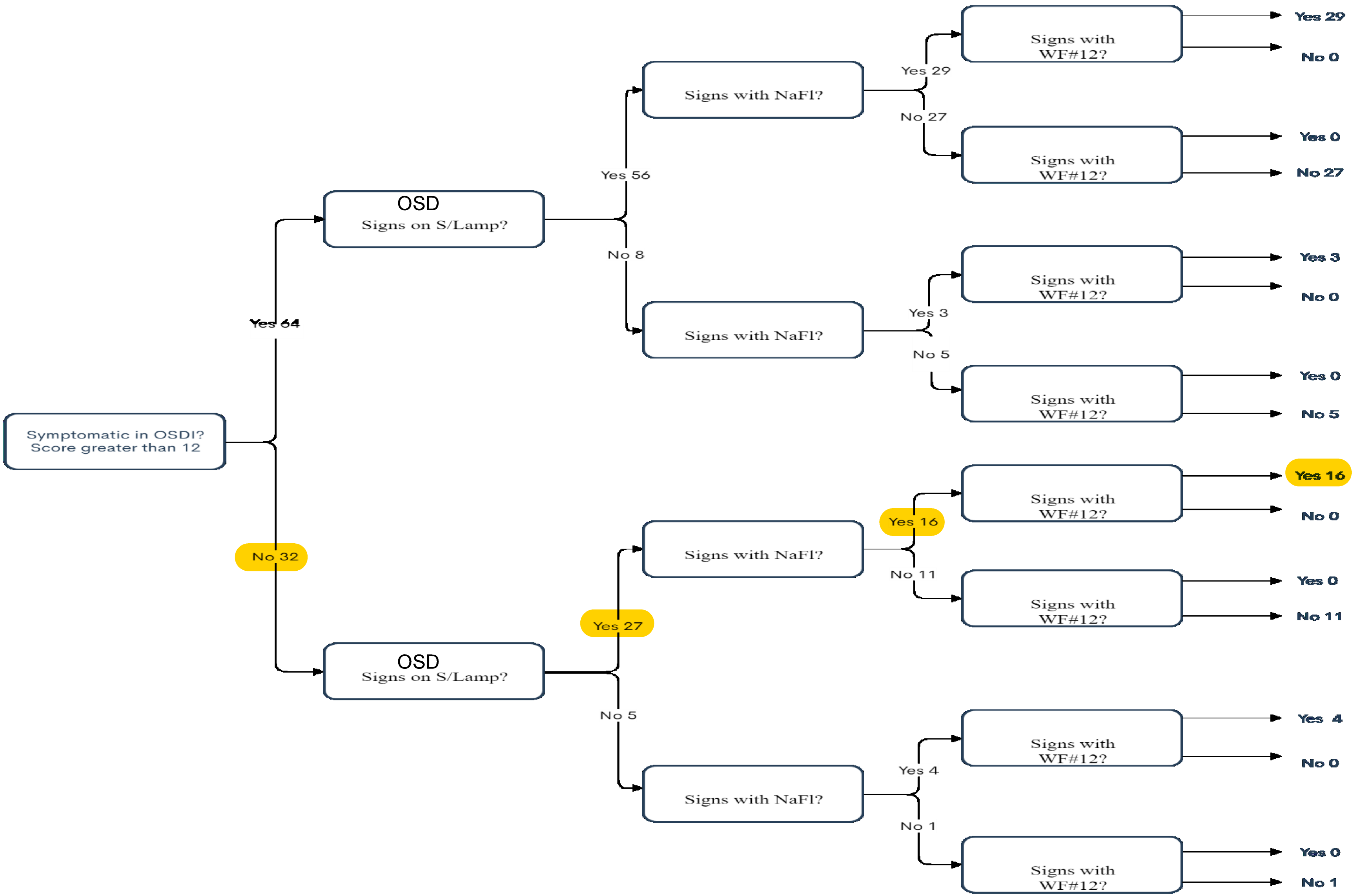

Figure 3.16 Flow chart representing OSD findings seen on slit lamp with asymptomatic OSDI patients

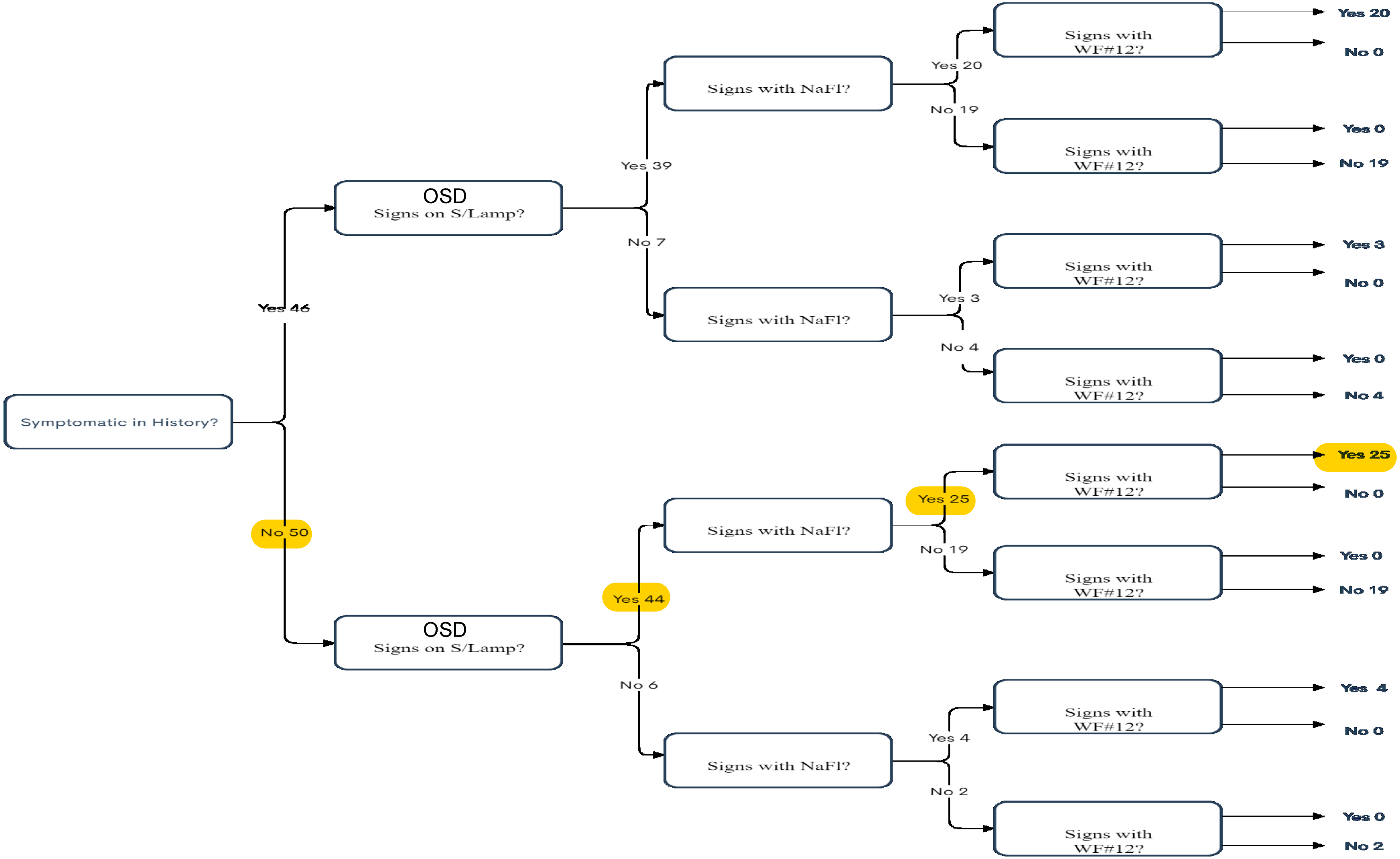

Figure 3.17 Flow chart representing OSD findings seen on slit lamp with asymptomatic patients on history

3.4 Analysis

Appendix 8 lists all the contingency tables used in the analysis

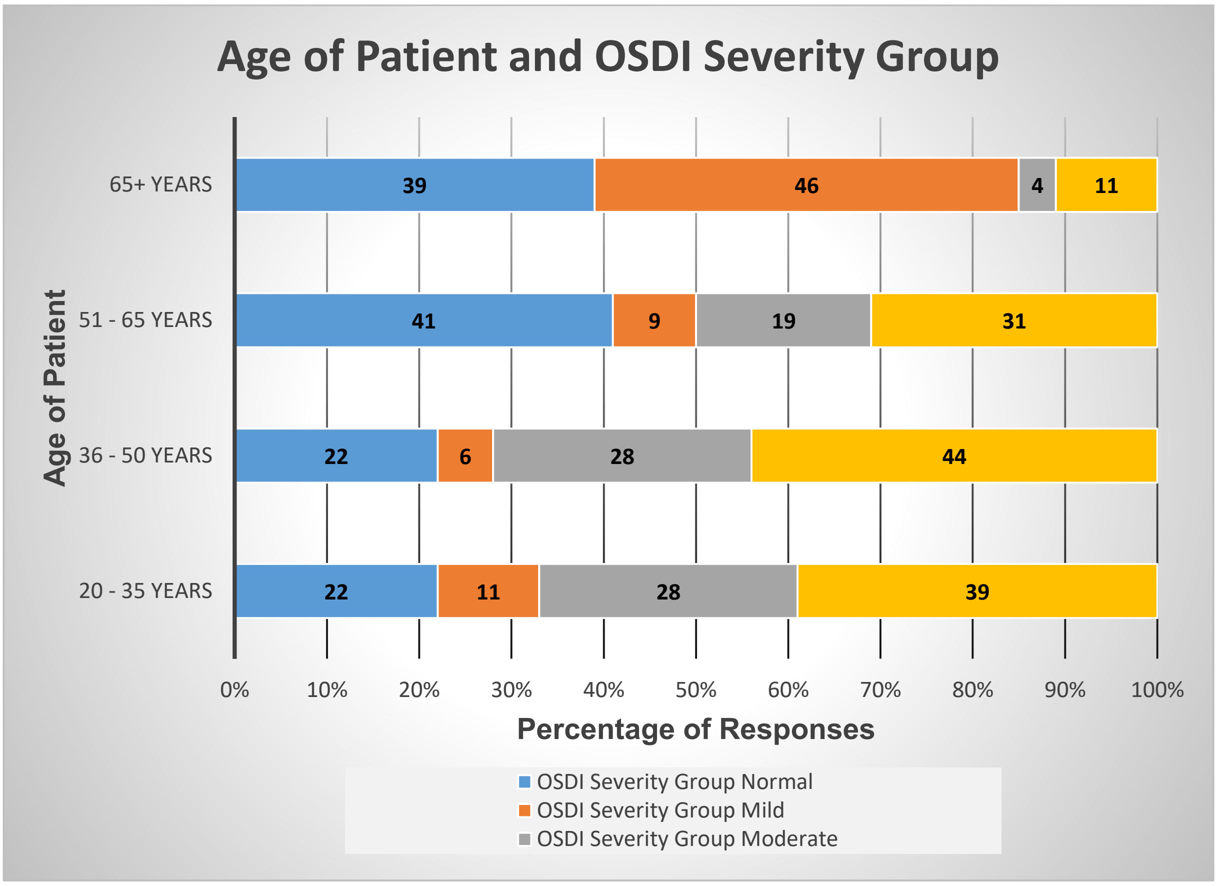

Figure 3.18 Age of patient and OSDI Severity Group

For this sample population, the over 65-year group had a tiny proportion of patients scoring moderate or severe in the OSDI questionnaire. The majority of the over 65-year group scored mild in the OSDI questionnaire. The 20-35 and 36-50 year groups had most of their scores in the moderate and severe range. The 51-65 year group scores were spread across the four ranges but reduced in the mild score category. Overall, the patients below 50 reported more moderate and severe scores, while those over 50 reported more scores in the normal and mild groups.

The Chi-square test of independence gives a p-value of **0.001**, stating that age and the OSDI severity group are dependent. Cramér's V gives a strong association, .306. Post hoc analysis shows that compared to the 36-50 year group and the 51-65 year group, the over 65-year group had significantly more patients reporting the Mild severity level on the OSDI questionnaire. P **< .001**

Females and males have similar proportions for the normal, moderate and severe OSDI groups. Males only scored higher in proportion than females in the severity level of Mild in the questionnaire. However, chi-square analysis showed no significant relationship between the patient's gender and the severity group scored on the OSDI questionnaire. p = .376.

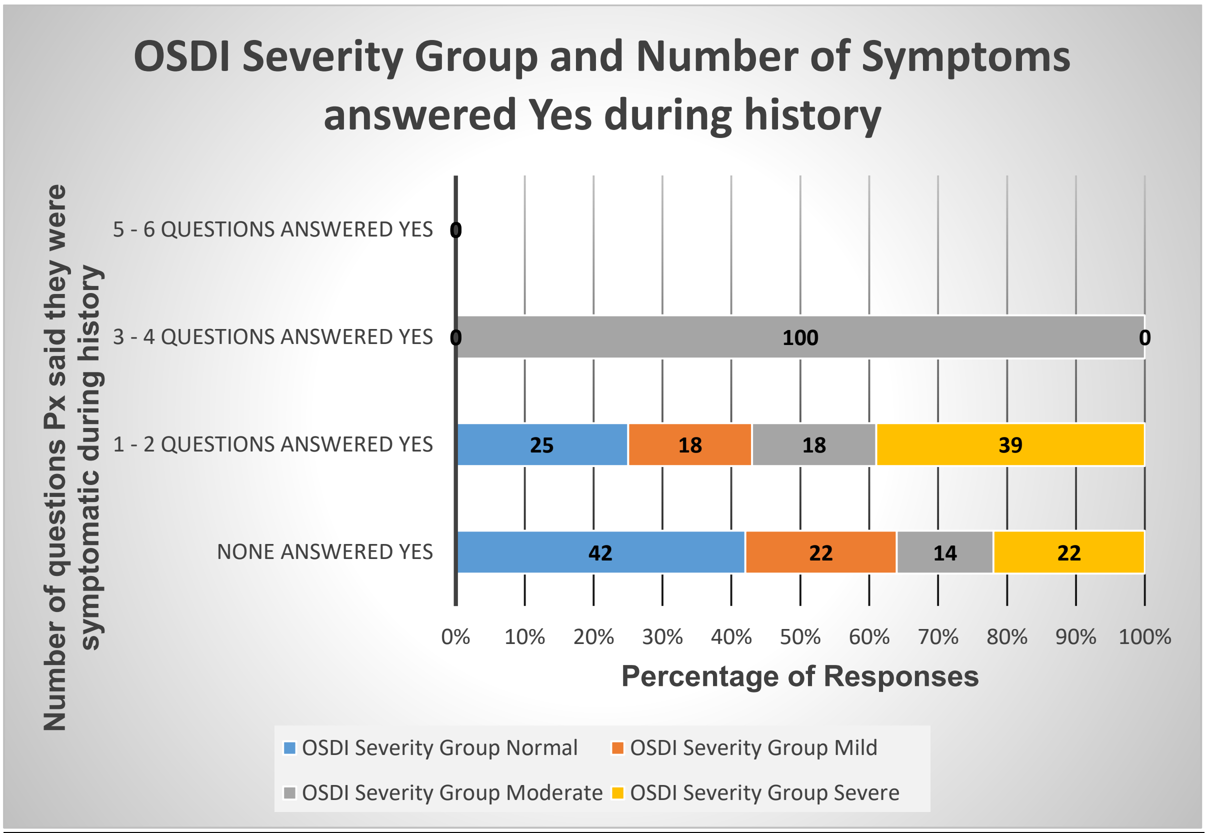

Figure 3.19 OSDI Severity Group and Number of Symptoms answered Yes during history

Twenty-one patients (42.0%) who did not report any symptoms when using the six symptom list also scored normal using the OSDI questionnaire. Chi-square analysis gives a p-value of **0.028**, showing a significant link between the OSDI severity group and the number of symptoms reported using the six symptom list. Cramér's V gives a moderate association, .271.

From figure 3.20, it can be seen that as the patient answered yes to more of the symptoms in the six symptom list, the trend is towards a higher OSDI score. Spearman's Rank Correlation Coefficient test was run, and there is a weak, positive correlation between the OSDI score and the number of symptoms answered yes, r_s=.271. This result was statistically significant, **p= 0.008.** These results will be discussed in Chapter 5.

Figure 3.20 OSDI Severity Group and Number of Symptoms answered Yes during history

Whilst 56.0% of patients who did not report any symptoms using the six symptom list also scored normal in the OSDI ocular subscale, there is no significant difference between the scores using the ocular symptom subscale and the six symptom list. The proportions between the two scores are not significantly different. The Chi-square test gives a p-value of 0.213.

The Spearman's Correlation test showed no correlation between the OSDI ocular subscale and the number of symptoms answered yes, r_s=-0.032

For the slit lamp examination, signs were taken as visible or not visible. Before a patient is asked to put their chin on the slit lamp, it can be taken that there is a 50% probability of finding any signs. The null hypothesis is that there is no difference between the proportion of patients with signs seen using the slit lamp and an expected proportion of 50% of patients. The binomial test indicates that for this sample of patients, the proportion of patients who had signs seen using the slit lamp, .95, was significantly higher than the expected .50, p **< .001**.

Some clinical signs were grouped as Ocular Surface Disease(OSD) signs for analysis from the overall results. The total amount of signs associated with OSD were analysed again using the binomial test. A 50% probability of finding any signs was again taken. The binomial test indicates that the proportion of patients who had OSD signs seen using the slit lamp, .86, was significantly higher than the expected .50, p **< .001**.

These results were compared to the OSDI scores. Even though 26 out of the 32 patients who scored within the normal range on the OSDI questionnaire had OSD signs seen on the slit lamp, the proportions remain approximately the same for all four levels of the OSDI questionnaire. There is no significant relationship between scoring normal on the OSDI questionnaire and having OSD signs on the slit lamp. Chi-square test, p= 0.604.

The subset of patients who scored normal on the OSDI, asymptomatic patients, was further examined. OSD signs were taken as visible or not visible, and the 50% probability of finding any OSD signs was used. The binomial test indicates that the proportion of patients who scored normal on the OSDI, that is asymptomatic, and had OSD signs seen using the slit lamp, .81, was significantly higher than the expected .50, p = **0.001**.

The subgroup of patients who scored more than 12 on the OSDI, that is, symptomatic[178, 179, 346], was examined for the absence of OSD signs on the slit lamp. There were only 7 out of 64 symptomatic patients who showed no OSD signs with a slit lamp. With the 50% probability of finding any OSD signs on the slit lamp, the binomial test indicates that the proportion of patients who had no OSD signs seen using the slit lamp and had a symptomatic score on the OSDI, .11, was significantly lower than the expected .50, p **< .001**.

There were 43 out of 50 asymptomatic patients using the six symptom list who showed OSD signs with the slit lamp. However, a similar proportion of symptomatic patients had the same result. The chi-square test independence indicates no significant relationship between non-symptomatic using history questions and showing OSD signs with a slit lamp, p= 0.851.

With the expected proportion of 50% of the patients examined, the proportion of asymptomatic patients using the six symptom list and who had OSD signs was examined. The binomial test indicates that the proportion of patients with OSD signs seen using the slit lamp and asymptomatic on the OSDI, .86, was significantly higher than the expected .50, p **< .001**.

The subgroup of patients who answered yes to one or more questions on the six symptom list was examined for the absence of OSD signs on the slit lamp. There were 6 out of 46 symptomatic patients who showed no OSD signs with a slit lamp. It was taken that there is a 50% probability of finding any OSD signs on the slit lamp. The binomial test indicates that the proportion of patients who had no OSD signs seen using the slit lamp and symptomatic, .13, was significantly lower than the expected .50, p **< .001**.

When NaFl was instilled, signs were taken as visible or not visible when staining was seen / not seen. Before adding the NaFl, it can be taken that there is a 50% probability of finding any signs. The binomial test indicates that the proportion of patients who had signs seen with NaFl using the slit lamp, .54, was not significantly different from the expected .50, p= 0.475

There were 20 out of 32 patients who scored normal on the OSDI who showed signs with NaFl. The same proportions are seen overall for all groups of the OSDI questionnaire. The chi-square test of independence did not indicate a significant relationship between the OSDI Normal Severity group and showing signs with NaFl, p-value= 0.693.

The subset of patients who scored normal on the OSDI was further examined. NaFl signs were taken as visible or not visible, and it was accepted that there is a 50% probability of finding any signs. The binomial test indicates that the proportion of patients who had signs seen with NaFl using the slit lamp and scored normal on the OSDI, .63, was not significantly different from the expected .50, p = 0.215.

The subgroup of patients who scored more than 12 on the OSDI, that is, symptomatic[178, 179, 346], were examined for the absence of NaFI signs on the slit lamp but were symptomatic on the OSDI questionnaire. There were 32 out of 64 symptomatic patients who showed no signs using NaFI. It was taken that there is a 50% probability of finding any NaFI signs on the slit lamp. The binomial test indicates that the proportion of patients who had signs seen with NaFI using the slit lamp and was symptomatic using the OSDI, .50, was significantly the same as the expected .50, p = 1.000.

Twenty-nine out of 50 patients were asymptomatic using the six symptom list who showed signs with NaFI. The same proportion was also seen with symptomatic patients. The chi-square test independence did not indicate a significant relationship between non-symptomatic using history questions and showing signs with NaFI with a p-value of 0.256.

The proportion of patients who were asymptomatic using the six symptom list was also examined. Again, the expected proportion of patients with NaFI signs seen using the slit lamp is 50% of patients. The binomial test indicates that the proportion of patients with signs seen using the slit lamp of .58 was not significantly higher than the expected .50, p = 0.322.

There were 23 out of 46 symptomatic patients using the six symptom list who showed no signs with NaFI. It was taken that there is a 50% probability of finding any NaFI signs on the slit lamp. The binomial test indicates that the proportion of patients with signs seen using NaFI of .50 was significantly the same as the expected .50, p = 1.000.

Corneal arcus was the most common sign seen on the slit lamp. Chi-square analysis gives a p-value **< .001** with a Cramer’s V of .622, showing a very strong association between age and corneal arcus in the sample of patients seen.

Several cases of pinguecula and pterygium were seen in the patients examined. There is a relationship between age and seeing a pterygium using the slit lamp in the patients seen. Chi-square gives a p-value of **0.029** and a Cramer’s V of .306, showing a strong association between age and pterygium in the patients seen.

In the patients examined for the study, a relationship was also seen where females had a significantly higher proportion of low TBUT than males. The Chi-square test gives p = **0.011,** with Cramér’s V giving a moderate association, .259.

In the study, no one under 50 had any signs of Conjunctivochalasis even with NaFl, with the over 65 group having the highest proportion. Chi-square analysis gives p = **0.002** with Cramér's V giving a strong association, .390.

There were no patients that showed any new signs when the Wratten filter was used. Every time the filter was used, it enhanced viewing a sign that was previously seen using NaFl alone. p= **< .001**

Since the Wratten filter is usually only used alongside NaFl, the one-sample binomial test was not conducted because its results would be dependent on the results of using NaFl.

3.5 Discussion

One of the critical elements of the research was finding patients who are asymptomatic to possible anterior eye concerns yet have clinical signs seen on the slit lamp and/or with NaFl. Only 7.3% of the patients reported possible anterior eye symptoms (the six symptom list) as their main reason for their visit. However, after asking the patient if they were symptomatic using the six symptom list, a further 40.6% reported more symptoms. This result is significant because if the optometrist decides to perform slit-lamp biomicroscopy on a patient only when symptomatic, they would have only completed it on 7.3% of their patients. This further emphasises the importance of expanding the patient's symptoms using further questions and questioning patients on anterior eye symptoms even if they initially appear asymptomatic. Even if the optometrist did ask the six symptom list and elicited that the further 40.6% were symptomatic, this would still lead to only 47.9% of patients being examined using the slit lamp.

The other patients had visual problems (55.2%), health concerns with their eyes (15.6%) or came to the clinic to get their eyes examined routinely (21.9%). No research could be found exploring the reasons why patients visit for a routine eye examination.

Previous research has discussed that dry eye is more prevalent in the elderly population.[186, 347-356]. However, the result of this study has the younger patients scoring in high proportions in the moderate and severe OSDI groups. This could be due to younger people using more digital devices for a more extended period and more frequently[357-359]. In addition, studies have shown that the use of digital devices is associated with dry eyes[360, 361, 327, 362]. Office workers have been shown to have a higher risk of dry eye[363].

It could also be that Trinidad & Tobago has a tropical climate, where the average daytime highest temperature is 32°C, and the lowest nighttime temperature is 23°C. However, given this range of temperature, the average relative humidity of the country is still 80% which is equal to the United Kingdom. However, most workplaces in Trinidad & Tobago have air conditioning, and it has been shown that low relative humidity environments adversely affects the tear film[364-368].

Casavant et al. has reported that patients in the late stages of dry eye may have significant clinical signs but may be asymptomatic. Others have stated that older patients have reduced corneal sensitivity[369]. This could also explain why the older patients did not report as symptomatic as the younger population[370].

Other studies have shown that the cornea is more sensitive in the early stages of dry eye, hence why the patient may be more symptomatic before OSD signs can be seen[371, 372]. As the dry eye progresses, the cornea becomes less sensitive, and thus, lower patient symptoms are reported[373, 374, 372].

Several research articles show that females are more likely to have dry eyes than males[375-377, 186, 347, 348, 378, 379, 352, 354]. There are no studies showing males are more likely than females. It is unsure why for this sample population, there was an equal grouping of males and females for the majority of the OSDI groups and males having proportionally more in the mild OSDI group.

The results showed a significant link between the OSDI severity group and the number of symptoms reported using the six symptom list. This suggests that asking the same six symptom questions could indicate the OSDI group for some patients, especially if they are asymptomatic for all six questions. In addition, there was a weak positive correlation between the two, with the mean OSDI scores increasing as the number of symptoms answered yes increased. This will be discussed further in Chapter 5.

The results state that from the patients seen in the research, whether they were asymptomatic or symptomatic, there is a 95% expectation to find a sign using the slit lamp and white light on all the patients. In addition, there is an 86% expectation to find an OSD sign using white light on all the patients, with and without symptoms. These results are discussed in Chapter 5.

Most asymptomatic patients using either the OSDI or the six symptom list had OSD signs on the slit lamp. When a patient was asymptomatic on the OSDI, 81% still had OSD signs using the slit lamp; when a patient was asymptomatic using the six symptom list, 86% still had OSD signs.

This further compounds that even though some patients may score normal on the OSDI questionnaire, a high proportion will have some sign of ocular surface disease.

The group of patients who scored symptomatic on the OSDI or stated they were symptomatic using the six symptom list were examined for the absence of OSD signs on the slit lamp. Only 11% of symptomatic patients on the OSDI had no OSD signs on the slit lamp. For the group of symptomatic patients on the six symptom list, only 13% had no OSD signs.

These results correlate that when a patient is symptomatic on the OSDI questionnaire or the six symptom list, a substantial proportion will also have OSD signs on the slit lamp. Thus, these results suggest that neither the OSDI questionnaire nor the six symptom list predicts seeing any OSD signs using the slit lamp and white light.

Several studies have also shown little association between OSD Signs and symptoms[380, 206, 381-387].

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Using NaFl, there is a 54% chance of finding signs visible with NaFl on all patients. The results show that when using NaFl on all patients examined, there is no significant difference in a sign visible with NaFl and by chance. This result will be discussed in Chapter 5.

Comparing the OSDI results and the signs seen with NaFl showed that whichever OSDI severity group a patient scores using the questionnaire, there is no significant difference in the signs being visible with NaFl. Again, the OSDI is not a predictor of if signs will be seen using NaFl.

When a patient is asymptomatic using the OSDI, there is a 63% chance of finding NaFl signs. When a patient is asymptomatic using the six symptom list, there is a 58% chance of finding NaFl signs. This result states that even though some patients may score normal on the OSDI questionnaire, there is no decreased probability of seeing signs using NaFl and the slit lamp.

When a patient is symptomatic using the ODSI, there is a 50% chance of finding NaFl signs. When a patient is symptomatic using the six symptom list, there is also a 50% chance of finding NaFl signs. This analysis correlates that even when a patient is symptomatic on the OSDI questionnaire, there is no increased likelihood of having a sign using NaFl.

Again, several studies have shown that symptoms do not predict a patient having corneal staining[178, 179, 388, 389].

Given that 62.5 % of the patients examined were over 50, it is not surprising that corneal arcus was the most common sign seen on the slit lamp. Corneal arcus is more likely to be seen in an older population base[390]. An article from Macaraeg shows that patients of African origin have corneal arcus more frequently and at a younger age.[391] The population of Trinidad & Tobago comprises approximately 40% of people with African heritage.

Several cases of pinguecula and pterygium were seen in the patients examined. Trinidad & Tobago is located in the tropics with high Ultra Violet light exposure. Several research papers have shown the correlation between UV light and these signs[392-396].

A strong relationship is seen between age and seeing a pterygium using the slit lamp in the patients. This, too, has also been true in the previous research[397-399].

Previous studies have shown that there is no gender difference in TBUT scores[400-404]. However, in the patients examined for this study, a relationship was seen where females had a significantly higher proportion of low TBUT than males. Only one other study could be found with similar results[405].

Conjunctivochalasis is expected with increasing age[406-409]. In this study, the relationship between age and conjunctivochalasis was statistically significant. No one under the age of 50 had any signs of this, even with NaFl. The over 65 group had the highest proportion.

Many textbooks[410, 411, 324, 412] have mentioned the benefits of using a yellow filter with NaFl; no research articles could be found where any possible benefit of the Wratten filter was measured and shown in daily practice with patients. This study shows 100% benefit in enhancing the view using NaFl using the Wratten filter with every patient.

It would be expected that a qualified optometrist, hearing that the patient currently wears or had worn contact lenses within the last six months, would perform a slit lamp examination on the patient. Also, contact lenses and their care products have been shown to cause conjunctival and corneal changes, so including these patients in this study could have increased the likelihood of seeing patients with anterior eye findings and introduce bias in the results.

Another cornerstone of this part of the research was that the patients must present themselves during a regular eye examination appointment in the clinic schedule. It could be thought that those patients presenting themselves in one of the speciality clinic appointments, be it the dry eye clinic, low vision clinic, contact lens clinic or binocular vision clinic, would more likely have ocular changes/findings or be treated for ocular conditions which would shift the results in either direction.

There are many grading scales to grade anterior findings, for example, the CCLRU Grading scale, Annunziato scale, Mandell Scale and Vistakon Scale. There is also a range of grading schemes to measure corneal staining, such as the Oxford Scale, Van Bijsterveld Scale, and the National Eye Institute Scale.

It may be thought that the reluctance from some optometrists to use NaFl could be due to reports that some patients react to NaFl. Few case studies have reported a reaction to NaFl when used topically[127-130]. Some of these reports were linked to patients with existing general health problems. Also, some of the reports relate to minim drops[129, 130] and not the paper strip form as in this study. The fluorescein strip does not contain any preservative agent, which is likely to have caused the reaction in some studies. Other reports of reactions to NaFl, mainly nausea and vomiting, but sometimes fatal reactions, are related to its use intravenously, such as for fluorescein angiography[131, 133, 135, 138].

There is also a risk of the patient obtaining an eye infection from the use of NaFl. However, case studies show this was due to the reuse of minim drops, where Staphylococcus or Corynebacterium bacteria were found,[141] or NaFl from a vial where Staphylococcus, Bacillus, Klebsiella, Pseudomonas, Haemophilus and Bordetella was found with Pseudomonas bacteria the most common. Fungal contaminations were also found in the vial, such as Aspergillus, Penicillium and Cladosporium. The most common fungus was Aspergillus[143].

Using the paper strip form, which was disposed of after every use, prevented the risk of infections.

As seen in Chapter 1, table 1.4, various research articles were reviewed based on their entry criteria or outcome on patient symptoms. The average number of symptoms per article was 6. Photophobia was another common symptom asked by many researchers, but the investigator felt this would be a common symptom given that Trinidad & Tobago is within the tropics. Also, it would not be possible to measure signs of photophobia using the slit lamp.

Schiffman discusses the different subscales of the OSDI[178], with one of them being the Ocular Symptoms Subscale. The ocular symptom subscale asks if the patient experienced any of three symptoms, photophobia, gritty eyes, painful or sore eyes over the last week. Some investigators state that the Ocular Subscale is the first section of the OSDI[413, 414]; however, Schiffman[178] and other investigators[415, 416] state it is the first three questions of the OSDI that is the ocular symptom subscale. It is also scored similarly to the overall OSDI questionnaire[178, 415, 417, 418].

Many studies that have taken place in University optometry clinics are on specific patient demographics or with patients with certain ocular conditions. There are limited studies that have taken place in University optometry clinics based on their general clinical population as this research was[419-425]. The patient's mean age in these studies is similar to the present study and have the same gender distribution as this current study.

Again, limited studies are reporting patient demographics visiting a private optometric practice for a routine eye exam. The studies[173, 426, 427] that are available only refer to the patient's gender. The gender distribution is again similar to the present study. Whilst there could be a concern that if this study was replicated elsewhere, the demographics could be different in terms of gender, previous studies suggest not. There is no evidence available on the age distribution in private practices. From the data, it can be seen that the age range of the patients examined was slightly skewed towards an elderly population. Almost two-thirds of the population in the study were female. This could be expected as females are more likely to seek help when faced with a medical problem[428-431].

3.6 Conclusion

This chapter aims to determine if there is a correlation between the patients' symptoms and the findings on external eye examination using the slit lamp with white light and Sodium Fluorescein and blue light. Also, to measure the number of patients that report any initial symptoms of anterior eye problems, that is, the main reason for their visit is due to these symptoms. Finally, to measure the number of patients who report any anterior eye problems after further questioning.

Of the 96 patients who attended the eye examination, 6 reported watery eyes, and one said sore eyes as their chief complaint. However, after further questioning using the six symptom list, 40 other patients stated they had symptoms. Therefore, it is recommended that optometrists do not use patients initial first symptoms to decide if the patient is symptomatic with ocular surface disease but further question the patients on other ocular surface disease symptoms, for example, using the six symptom list. Using the OSDI questionnaire, 64 patients were stated to be symptomatic.

Using the OSDI questionnaire, 32 patients were asymptomatic. Of these 32 patients, 27 had signs with slit lamp and white light. Using the six symptom list, 50 patients were recorded as asymptomatic. Of these 50 patients, 44 had signs with the slit lamp and white light. Whichever method was used to judge the patient as asymptomatic gave a similar ratio of clinical signs.

Using the OSDI questionnaire, 64 patients scored in the Mild, Moderate or Severe severity range. Of these 64 patients, 56 had signs with the slit lamp and white light. Using the six symptom list, 46 patients were recorded as symptomatic. Of these 46 patients, 39 had signs with the slit lamp and white light. Whichever method was used to judge the patient as symptomatic gave a similar ratio of clinical signs.

Of the 32 patients asymptomatic using the OSDI questionnaire, 16 had signs with NaFl. Of the 50 patients asymptomatic using the six symptom list, 25 had signs with NaFl. Whichever method was used to judge the patient as asymptomatic gave the same ratio of clinical signs using NaFl.

Of the 64 patients symptomatic using the OSDI questionnaire, 29 had signs with NaFl. Of the 46 patients symptomatic using the six symptom list, 20 had signs with NaFl. Whichever method was used to judge the patient as symptomatic gave a similar ratio of clinical signs using NaFl.

It can be seen that using the slit lamp on all patients gives the optometrist more clinical findings on 95% of their patients and ocular surface disease signs on 86% of their patients.

It was also seen that if the patient was asymptomatic, no matter how that was determined, there was a strong probability of having OSD signs on the slit lamp. Whilst the probability was not as strong for NaFl; there was still a 50% chance that an asymptomatic patient would have signs visible using NaFl.

From Chapter 2, it was found that optometrists either commit to using the slit lamp on most of their patients or do not. Therefore, with the results from this chapter, the advice is that all optometrists should use their slit lamp on 100% of their patients.

It was also found in Chapter 2 that even fewer Optometrists use NaFl on their patients. This chapter recommends that even if the patient is asymptomatic, NaFl should still be instilled, given the visible signs in the study.

The null hypothesis for this Chapter is that no increase in clinical signs will be found when all patients are examined using a slit lamp biomicroscope to perform the external eye examination. This is rejected as more signs were seen than expected by chance. Furthermore, using Sodium Fluorescein shows no increased likelihood of signs being present; hence the null hypothesis holds.

In Chapter One, it was discussed that Weymann in 1929 stated that Bulter wrote in a textbook that those who are not already using the slit lamp would find themselves in difficulty should they end up in court[302]. Interestingly, in 2019 an optometrist registered with the GOC had conditions imposed on their practice for six months for various reasons: the failure to perform a slit lamp examination on a patient being one of them[432].

Chapter 4: Measurement of the number of findings seen on slit-lamp using a circular polarising filter

4.1 Introduction

The function of the slit lamp has not changed over the last century; however, different tools can be used with the slit lamp to enhance its usefulness. For example, presently, most slit lamps use white linearly polarised light to illuminate the external eye. If this light was modified, there is the possibility that more clinical signs could be observed using the slit lamp.

Polarisers have already been used in the slit lamp. By placing a linear polariser in front of the illumination system in the slit lamp, polarised light can decrease the brightness of the light perceived by the patient. This system is already an option available for some slit lamps models.

By using polarisers during biomicroscopy, polarised biomicroscopy has also been tried before. Polarised microscopy can be performed by using linear polarised light. A linear polarised filter can be attached to the illumination system of the slit lamp, and another linear polarised filter, with its axis at 90° to the first filter, can be attached to the observation system. This method would make any birefringence of the anterior ocular tissue visible and allow the observer to visualise changes in the tissue not seen with normal white light. Nevertheless, this method is not practical in general optometric practice as time would be spent attaching and then removing the filters every time for each patient. It would be easier to have a device that could be placed between the illumination and observation system and then taken away when not needed.

Furthermore, there would be no extra expense to the optometrist in modifying the internal workings of the slit lamp. Using a circular polarising filter could be a way to perform polarised biomicroscopy with ease. A circular polariser filter is one that has a linear polariser combined with a quarter wavelength retarder attached to it.

A cross-like image can be seen when linear polarisers are used to view the cornea. Cope called these areas isogyres[253]. In addition, colour rings in a diamond pattern called isochromes can also be seen near the limbal area when linear polarisers are used to view the cornea[217]. These rings are thought to be an area of equal corneal birefringence for a particular wavelength of light.

When using circular polarisers, the Isogyres discussed by Cope are not visible, but the Isochromes are always visible[259]. In addition, Misson states that using a circular polariser also makes two small dark areas near the pupil area visible, and he termed these areas Isotropes[260]. These areas are thought to be areas of no birefringence or low birefringence. Figure 4.1 shows the Isochromes and Isotropes on a patient's cornea.

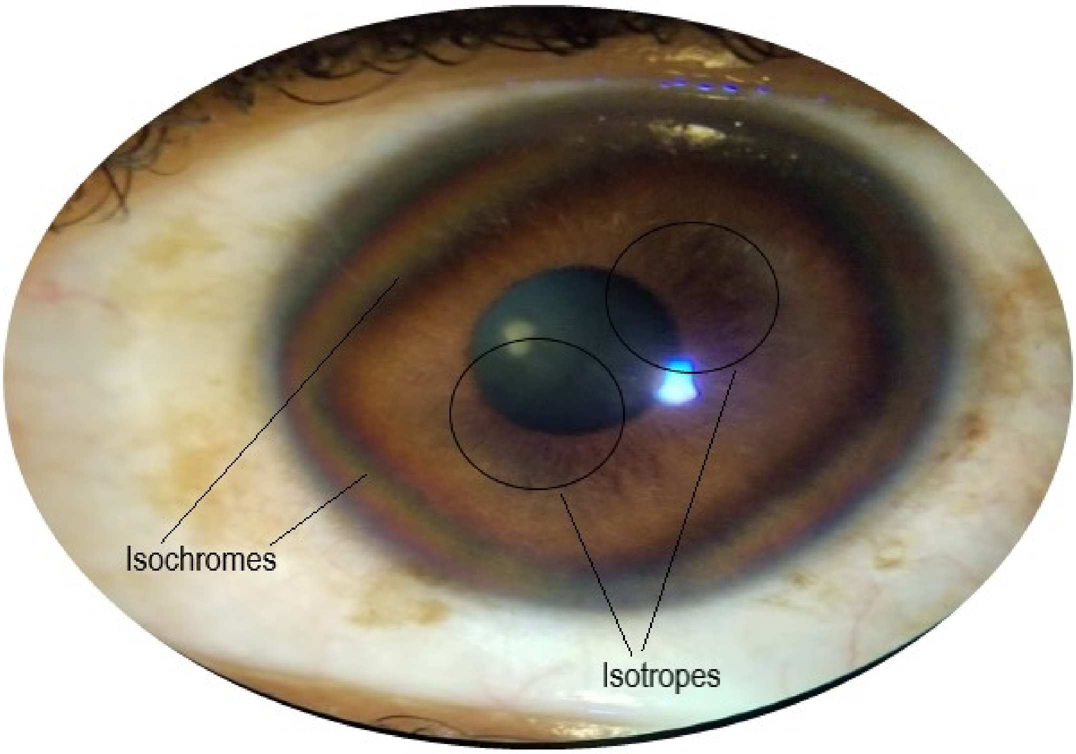


Figure 4.1 Photo demonstrating Isochromes and Isotropes.

Peli listed several uses of circular polarisers: to reduce the glare from computer screens, reduce the reflections when examining the cornea, improve the endothelium's visibility during specular reflection and 3D cinema spectacles[433]. Peli also used an unknown circular polariser filter to enhance viewing of the endothelium[256].

Misson used a readily available circular polariser to determine the structure of the stroma in vivo[264]. However, there are no studies on using a circular polariser for polarised biomicroscopy in routine clinical practice. It is important to study the use of circular polarised biomicroscopy as any ocular changes that could be identified in earlier stages are beneficial to the patient's management. If changes could be seen before they are visible in white light, this could enhance patient management.

This chapter will focus on if there is any benefit to using circular polarisation biomicroscopy on patients or if circular polarisation biomicroscopy is solely a tool for research. The effectiveness of having a circular polarising filter attachment built onto the slit lamp will also be examined. Currently, there is a cobalt blue filter built into all slit lamps. Some advanced slit lamps have the Wratten #12 filter built-in. In addition, some slit lamps have a linear polarising filter to cut down on the glare perceived by the patient.

4.2 Methodology

The patient had an external eye examination as discussed in chapter 3 using the designated Haag Streit slit lamp, model number BQ 900 (Haag Streit Ag, Köniz, Switzerland), first using white light. Then, a circular polariser filter was placed by hand between the illumination and observation systems. The filter was placed as close to the eye as possible[256]. Peli also states that the retarder layer should always face the patient to improve visibility. The magnification used was 10x, then 16x, and any higher magnification as needed. Any findings not seen previously in the patient with white light but now visible using the circular polariser were noted. Also, any findings previously seen with white light but subjectively perceived to be easier to visualise using the filter was recorded.

When one looks through the circular polariser using the slit lamp, one is expected to see the colour fringes (Isochromes) and the two dark areas (Isotropes) near the pupils. For the planned pilot study, a 52mm circular polarising filter (Brand Insignia) was used. The planned pilot study allowed the researcher to experience the diamond pattern, the isochromes, as explained above and in the various research articles discussed in Chapter 1.
It also enabled the researcher to determine the best placement of the filter. When using the filter, it was noted that brighter illumination was needed. In addition, it was noted that the filter used in the planned pilot study was too small for practical use behind a slit lamp.

For the main study, an 86mm filter (Brand AGFA) was used. This filter worked exactly like the previous filter but being bigger allowed for better handling when used with a slit lamp.

Figure 4.2 Photo of the two circular polarisers used. The smaller filter, 52mm, was used in the planned pilot, the bigger filter, 86mm, was used in the study.

Figure 4.3 Photo of the retarder in the circular polariser. White oval indicates the retarder which should be facing the patient.

Figure 4.4 **Photo of the circular polariser in use from the optometrist's point of view. The filter needs to be aligned with both the illumination system and the observation system.**

(Patient on the slit lamp is a work colleague who gave consent and not a participant of the study)

Figure 4.5 **Photo of the circular polariser in use from the side with the retarder side of the filter nearer the patient.**

An improvement in the viewing of the various components of the anterior segment was examined. The improvement was evaluated subjectively. The presence of the Isochromes is feedback to the optometrist that the polariser is facing the correct way and located correctly. The regularity of the Isochromes was observed as they are thought to change with any steeping of the cornea. This regularity was also evaluated subjectively.

Data analysis was done using IBM SPSS 25.0 software. The Chi-square test of independence was used to investigate any associations between the grouped responses. A p-value of less than 0.05 from the two-tailed Chi-square test was taken to be statistically significant. For other analyses, clinical signs were taken as seen, yes or no. A single proportion test, Binomial Test, was used, tested at the 0.05 level of significance.

4.3 Results & Analysis

As in chapter 3, 96 patients had an anterior eye examination using the slit lamp. Using the circular polariser filter always gave a subjectively clearer image for all patients. This is similar to the experience using a linear polariser as the reflections from the cornea are reduced. The cornea, iris and crystalline lens were easier to visualise. It was possible to use the circular polariser with all 96 patients. The isochromes near the limbal area were always visible in every patient. The two small dark areas called Isotropes by Misson were not always visible.

From the 96 sample patients, whether they had signs on the slit lamp with white light or had no signs previously visible, the circular polariser gave an enhanced view of the cornea, iris or crystalline lens for 28 patients (29.2%). Table 4.1 summarises this breakdown.

<table>
<tr><th rowspan="2"></th><th colspan="2">Signs seen on cornea, iris or crystalline lens</th><th rowspan="2">No signs seen</th><th rowspan="2">Total Patients</th></tr>
<tr><th>No improvement with polariser</th><th>Improvement with polariser</th></tr>
<tr><td>White Light Only</td><td colspan="2">49 (51.0%)</td><td>47 (49.0%)</td><td>96 (100%)</td></tr>
<tr><td>Using Circular Polariser</td><td>21 (21.8%)</td><td>28 (29.2%)</td><td>47 (49.0%)</td><td>96 (100%)</td></tr>
</table>

Table 4.1 Breakdown of results using the circular polariser

Binomial Test

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Enhanced viewing with the polariser on all patients		Yes	28	.29	.50	.000
		No	68	.71		
	Total		96	1.00		

Table 4.2 Binomial Test for enhanced viewing with the polariser on all patients

The null hypothesis is that there is no difference between the proportion of enhanced views in patients with the polariser and the expected proportion of 50% enhanced views.
The binomial test indicates that the proportion of patients whose view of cornea/iris/crystalline lens was enhanced by the circular polariser of .29 was significantly lower than the expected .50, p **< .001**.

A subsection of 49 patients had signs visible using the slit lamp with white light located anywhere between the cornea and the crystalline lens. These 49 patients had 57 signs visible due to some patients having more than one sign visible. Of these 57 signs visible, 30 (52.6%) of these signs were easier to visualise when using the circular polariser. The other 27 signs showed no improvement in visibility with the polariser. There were no signs that became less visible due to utilising the polariser. The results are listed in table 4.2. For example, 31 patients had lenticular opacities visible on the slit lamp with white light. When the circular polariser was used, it was easier to visualise 18 of the 31 lenticular opacities; this gives an enhancement rate of 58.1%.

Slit Lamp Findings	Patients with signs seen with slit lamp and white light	Patients whose signs were easier to see with polariser	Percentage of signs with enhanced viewing
Anterior Corneal Opacities	15	8	53.3%
intrastromal corneal ring segments	1	0	0%
Endothelial Opacities	3	0	0%
High Toric Cornea	1	1	100%
Iris Atrophy	1	1	100%
Iris Naevus	1	1	100%
Iris Strand	1	1	100%
Lenticular Opacities	31	18	58.1%
Post Capsule Opacities	3	0	0%

Table 4.3 Signs seen easier when using a circular polariser

Binomial Test

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Enhanced viewing of clinical signs with polariser		Yes	30	.53	.50	.791
		No	27	.47		
	Total		57	1.00		

Table 4.4 Binomial Test for enhanced viewing of clinical signs with polariser

The null hypothesis is that there is no difference between the proportion of enhanced views in patients with the polariser and the expected proportion of 50% enhanced views. The binomial test indicates that the proportion of patients whose view of cornea/iris/crystalline lens was enhanced by the circular polariser of .53 was not significantly different from the expected .50, p= 0.791.

Chi-square test of independence was used to test for any significance in the performance of the circular polariser with anterior corneal opacities and lenticular opacities.

		Location		Total
		Corneal Opacities	Lenticular Opacities	
Enhanced View?	No	7(46.7%)	13(41.9%)	20
	Yes	8(53.3%)	18(58.1%)	26
Total		15(100%)	31(100%)	46

Table 4.5 Contingency Table for Enhanced View and Location

There is no significant difference between the improvement when using the circular polarisers with patients with corneal opacities and patients with lenticular opacities p = 0.762.

Figures 4.6-4.9 show the appearance of the isochromes in the diamond pattern when using the circular polariser. These eyes had no clinically significant signs visible with white light nor with the circular polariser. Figures 4.10-4.21 show various eyes that have signs more visible when using the circular polariser.

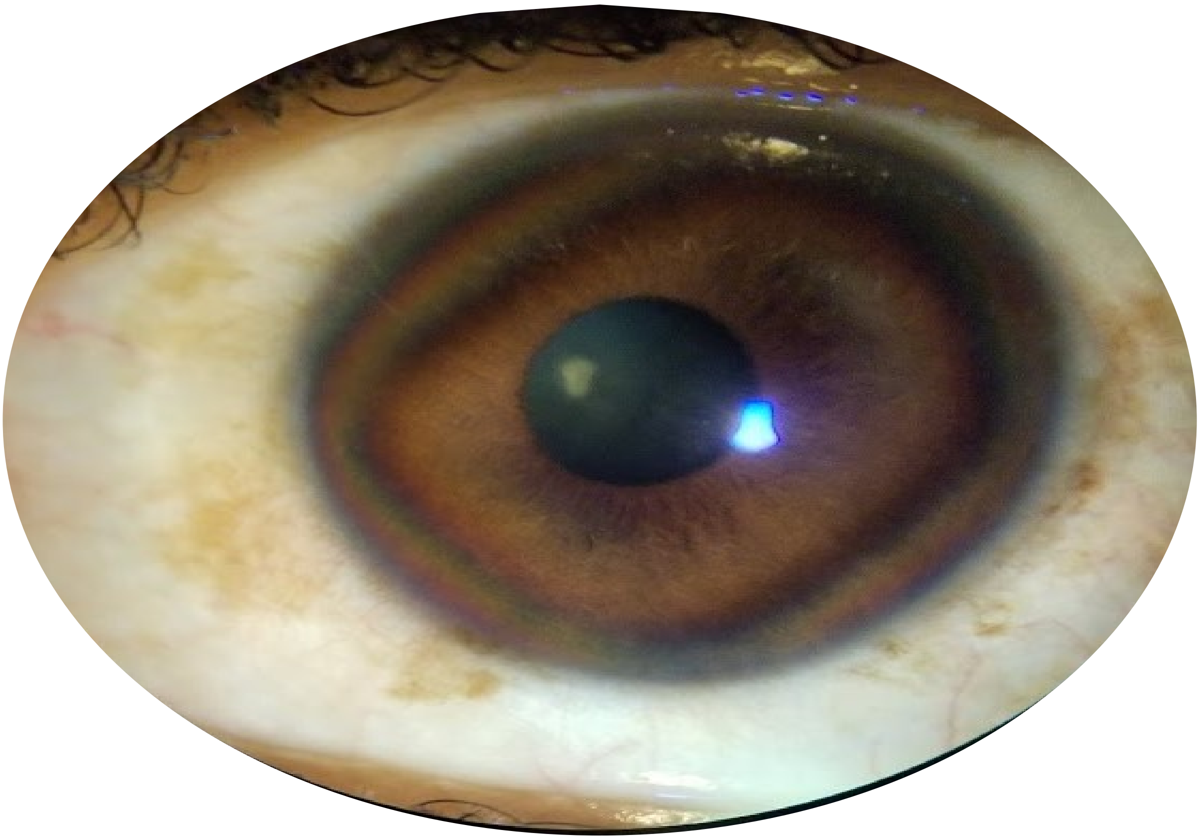


Figure 4.6 Isochromes seen in L Eye of Patient number 8

Figure 4.7 Isochromes seen in R Eye of Patient number 9

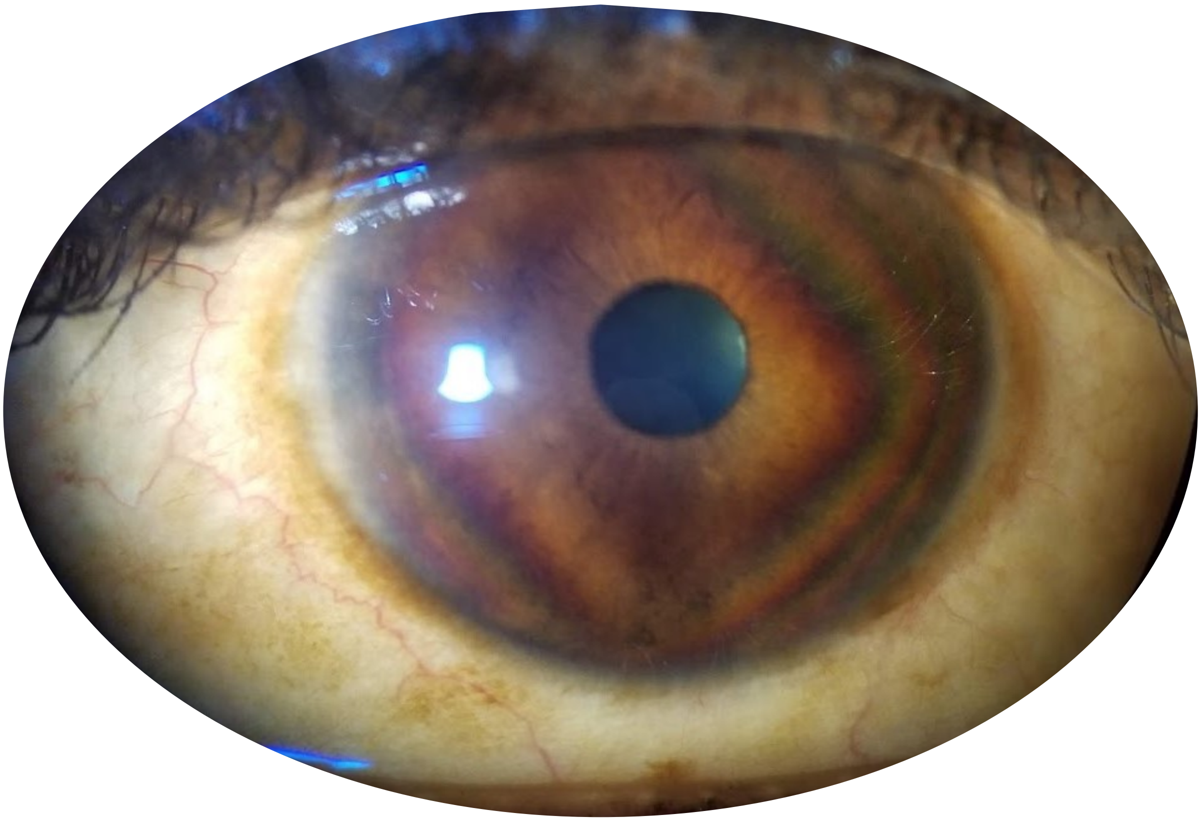


Figure 4.8 Isochromes seen in R Eye of Patient number 82

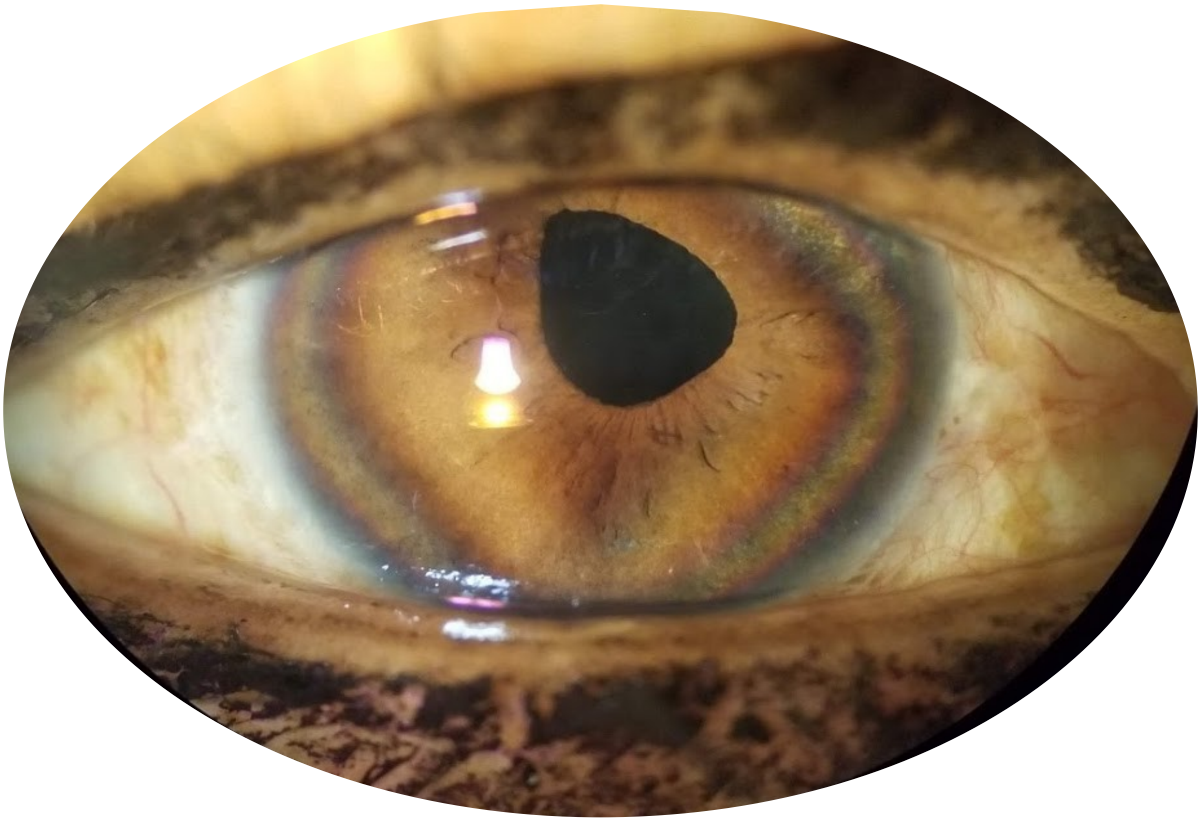


Figure 4.9 Isochromes seen in R Eye of Patient 102

(Pupil distorted due to cataract surgery)

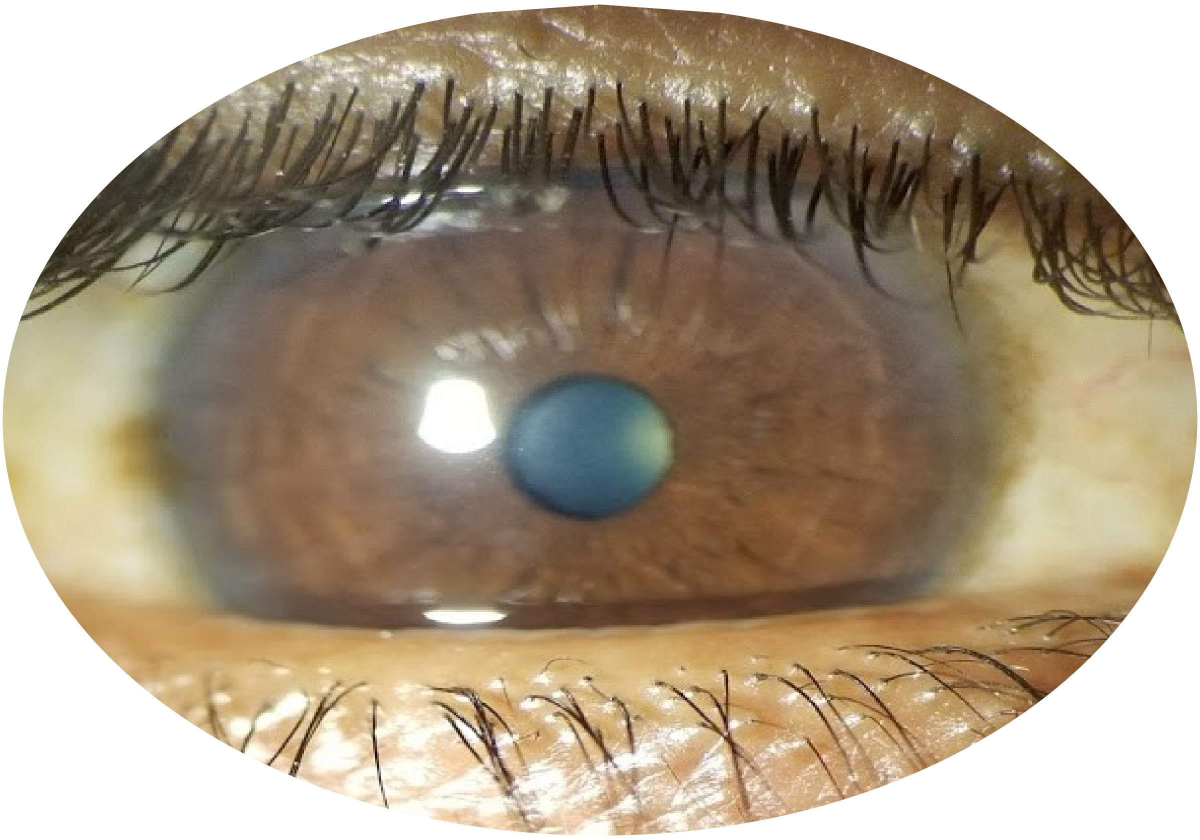


Figure 4.10 Patient 14 Cornea viewed without the Circular Polariser

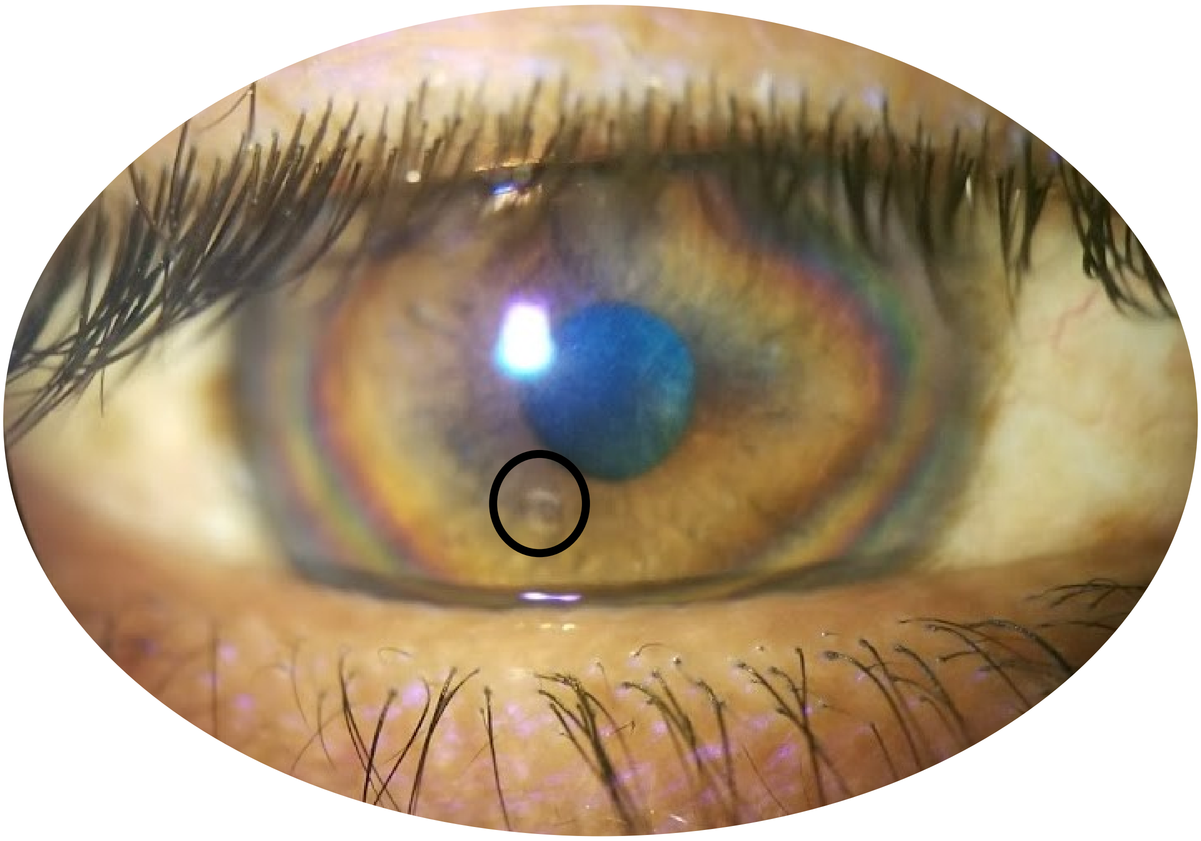


Figure 4.11 Patient 14 Corneal opacity (middle of the black circle) identified easier with Circular Polariser

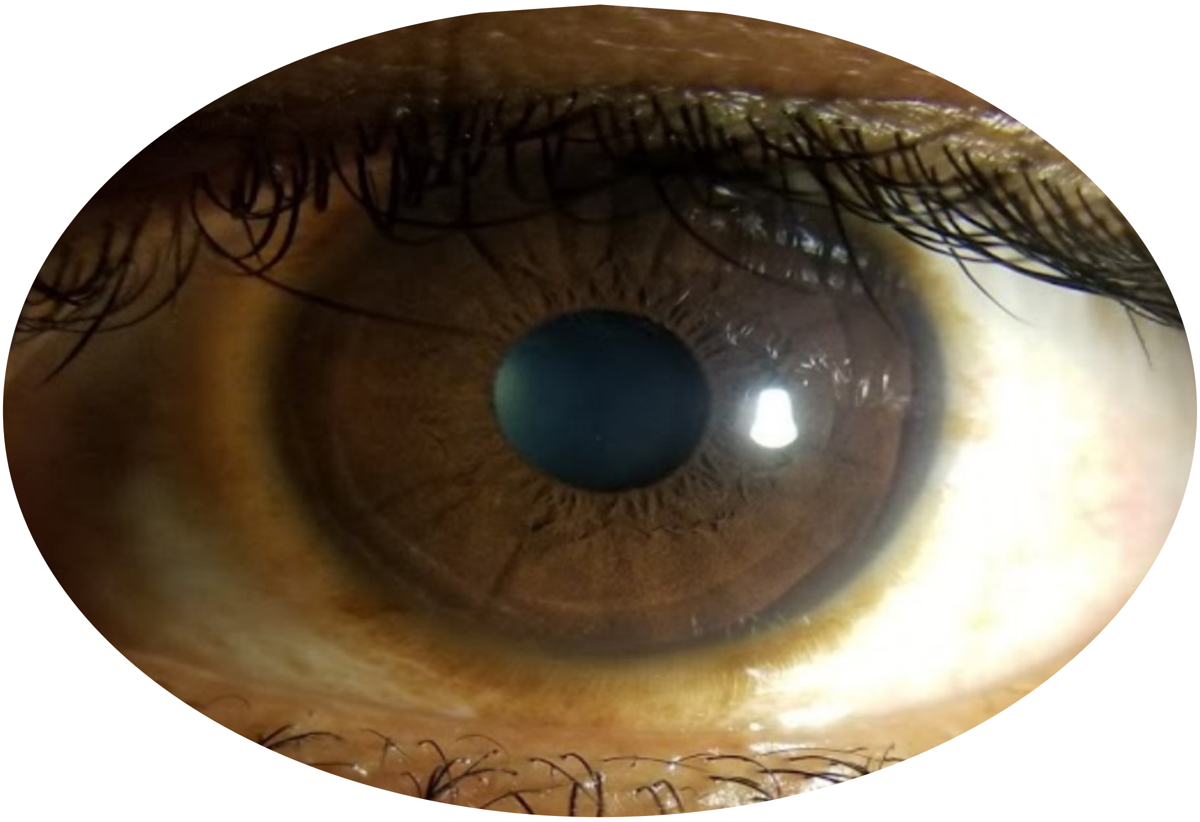


Figure 4.12 Patient 61 anterior eye viewed without the Circular Polariser

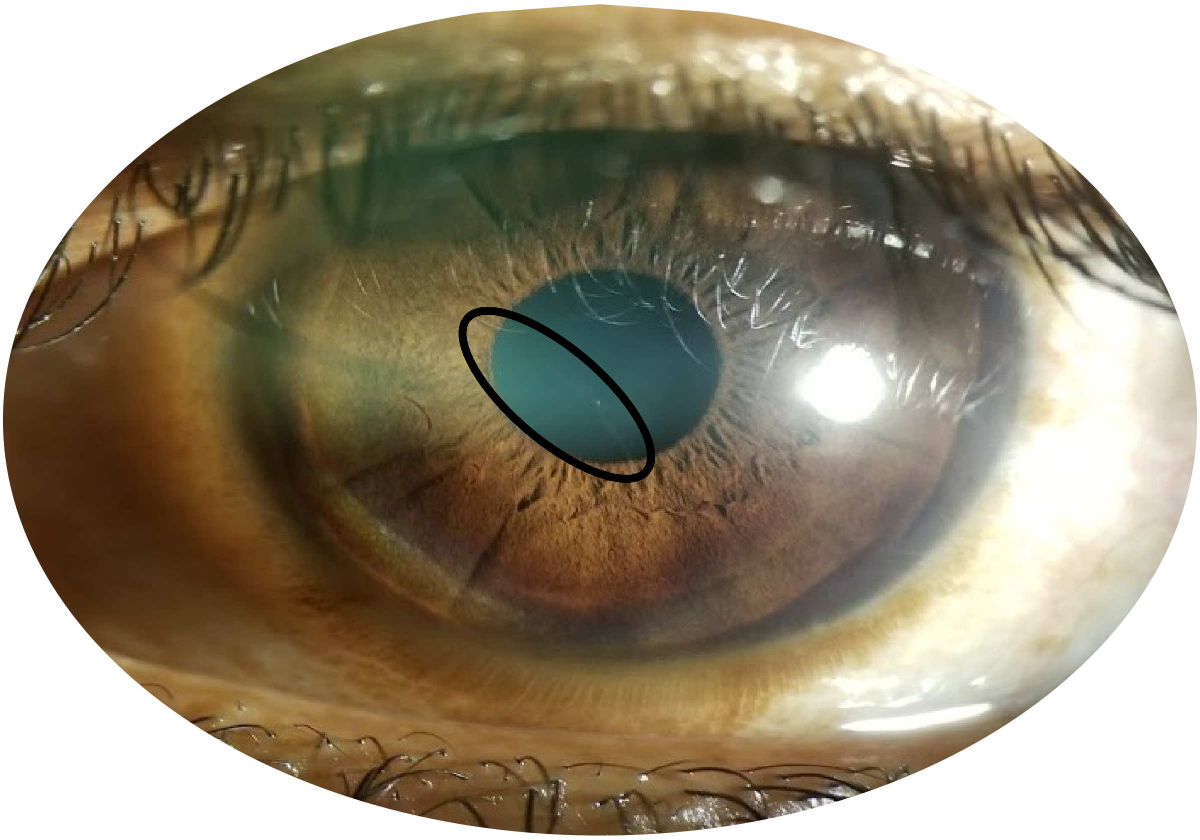


Figure 4.13 Patient 61 Iris strand (within black oval) identified easier with Circular Polariser

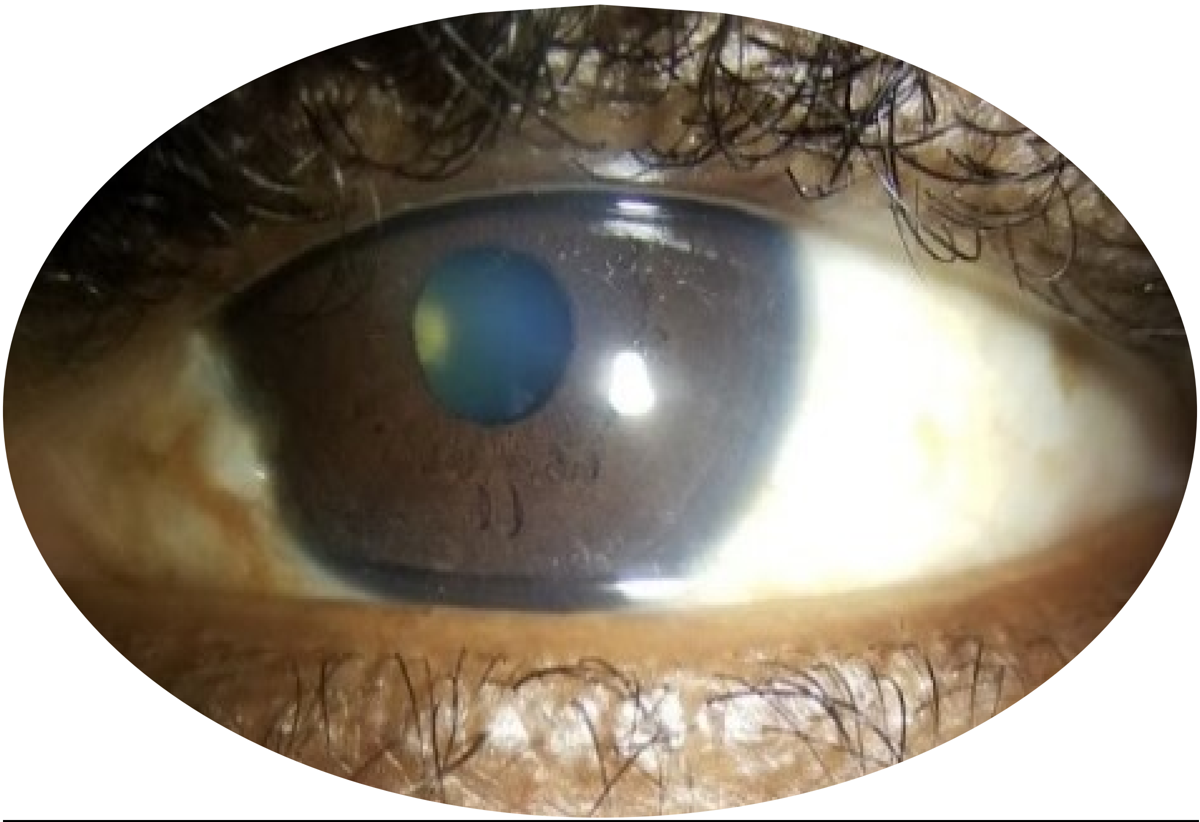


Figure 4.14 Patient 2 Left eye lenticular opacity without the Circular Polariser

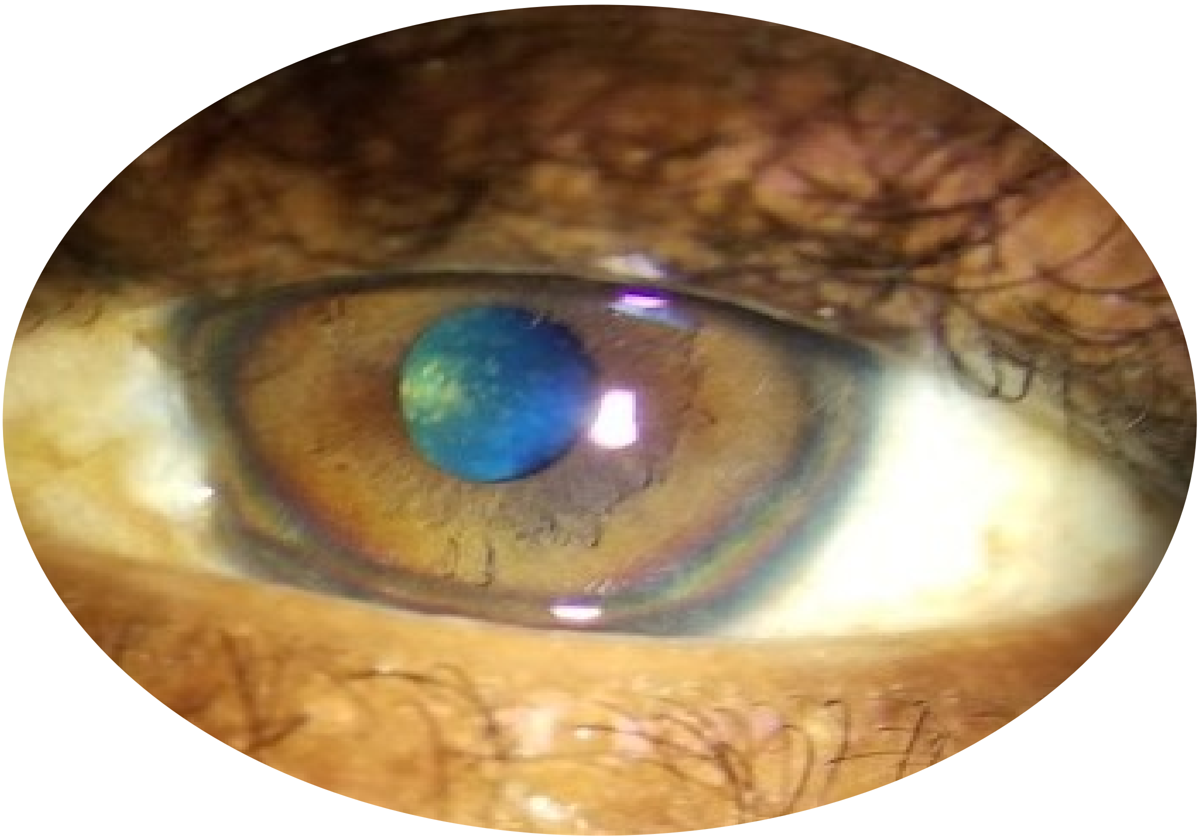
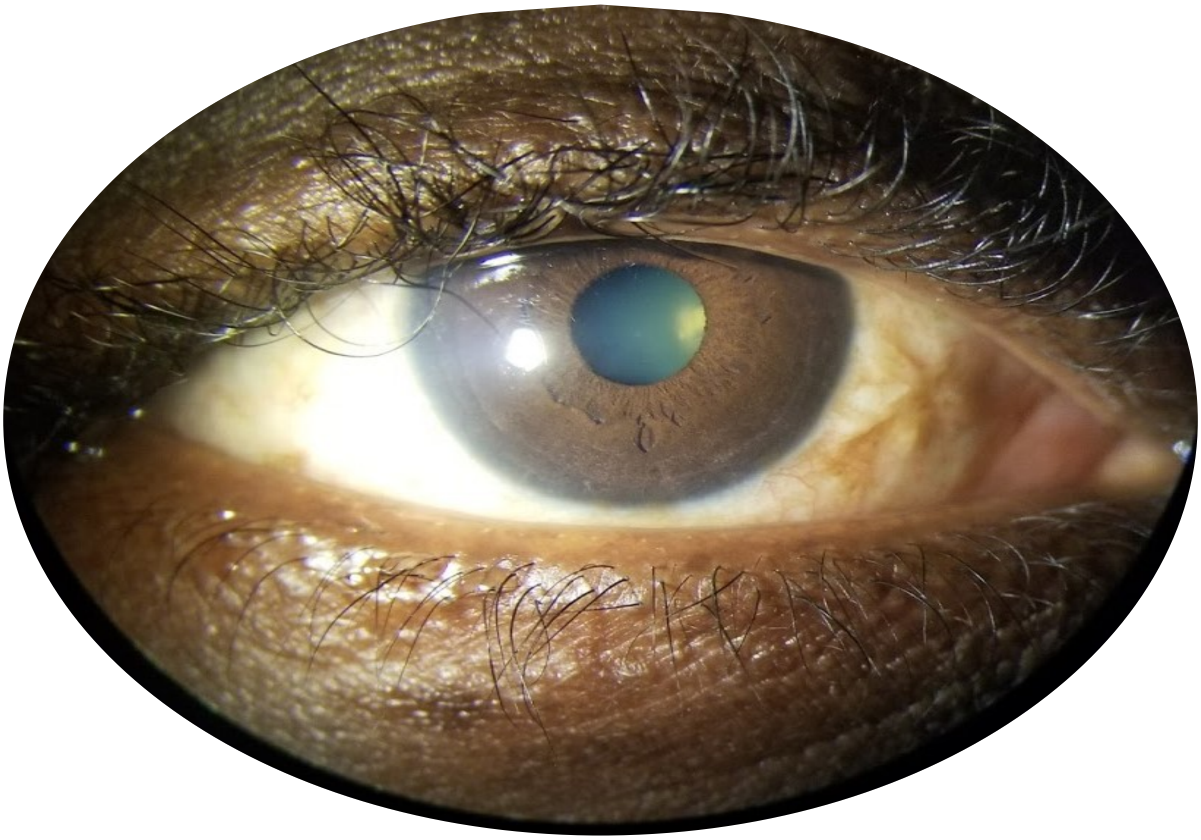
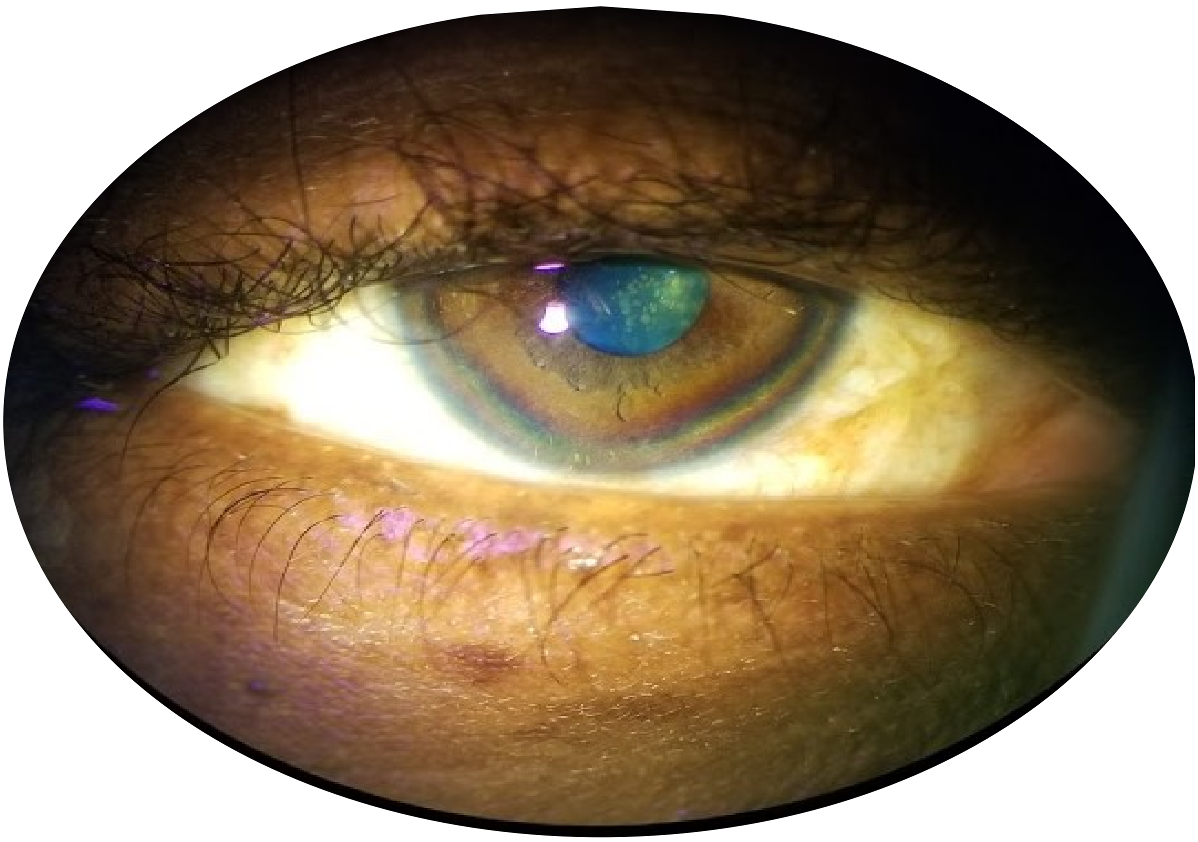


Figure 4.15 Patient 2 Lenticular opacity identified easier with Circular Polariser



<u>Figure 4.16</u> <u>Patient 2 Right eye lenticular opacity without the Circular Polariser</u>



<u>Figure 4.17</u> <u>Patient 2 Lenticular opacity identified easier with Circular Polariser</u>

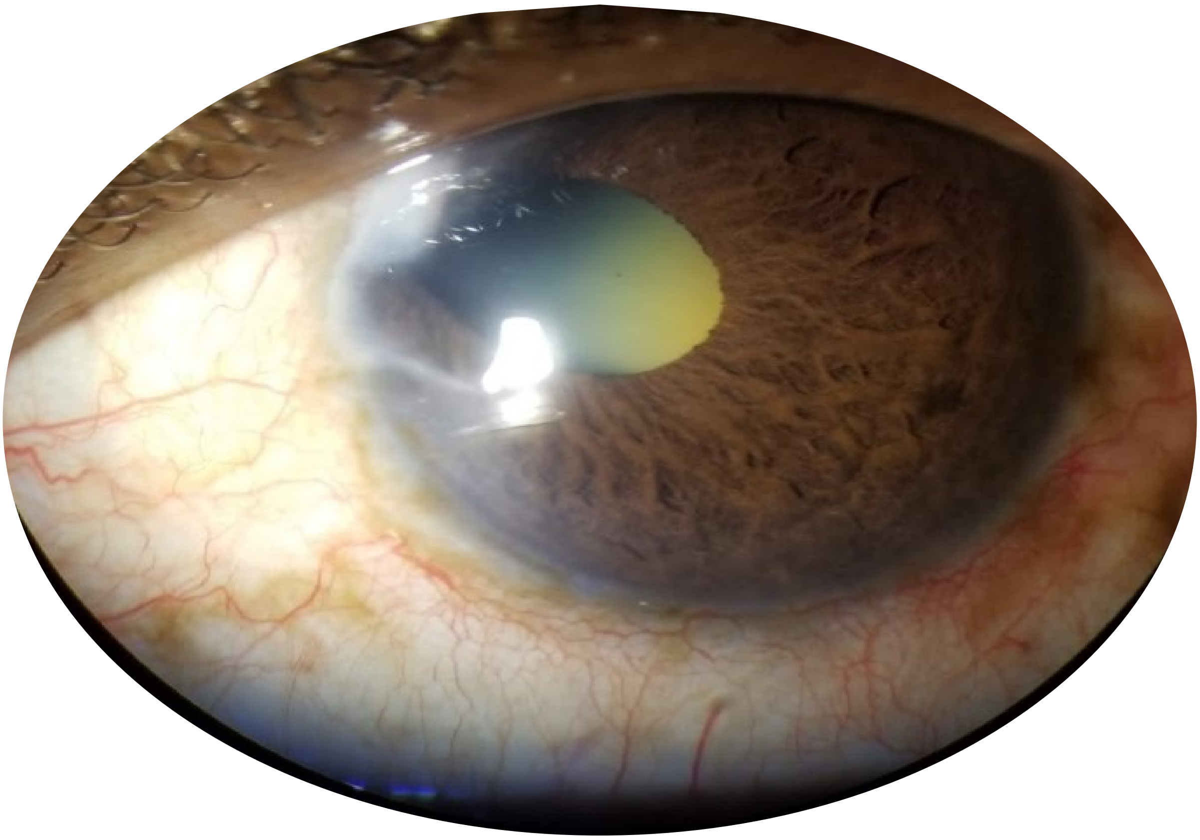


Figure 4.18 Patient 70 Lenticular opacity not easily seen without the Circular Polariser

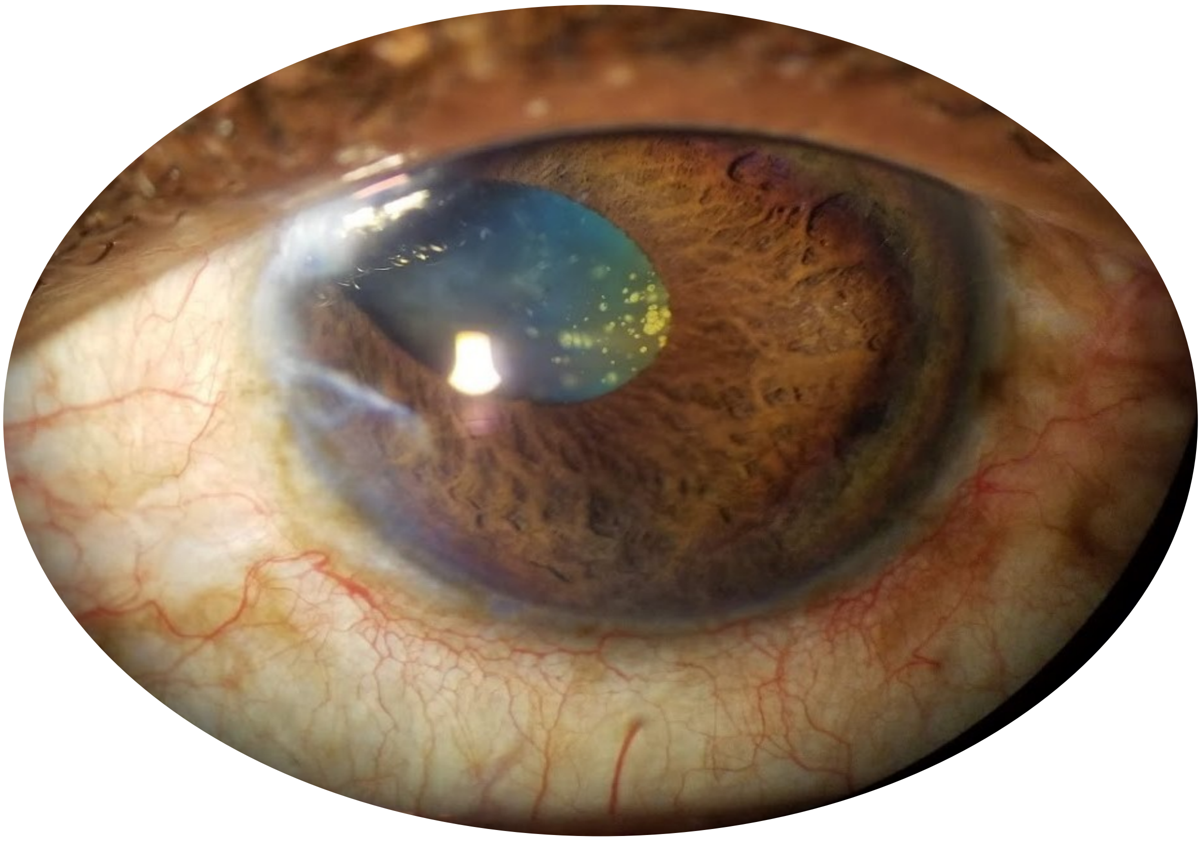


Figure 4.19 Patient 70 Lenticular opacity identified easier with Circular Polariser

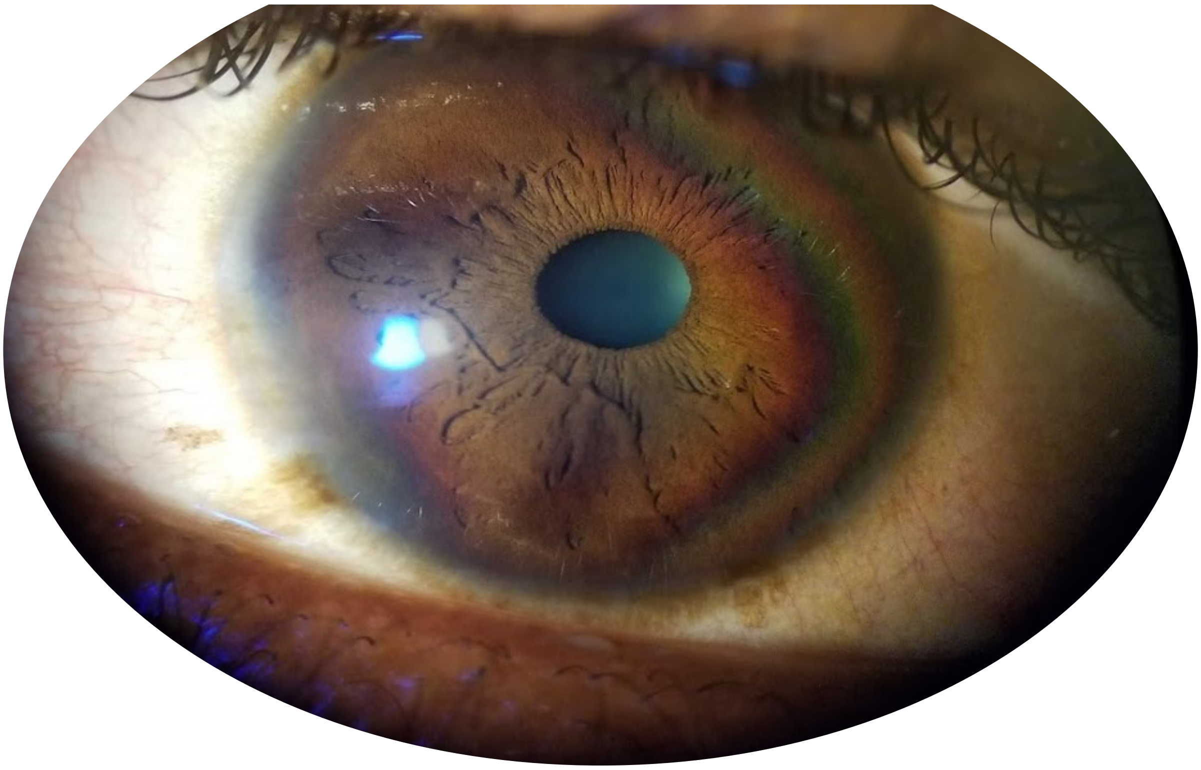


Figure 4.20 Patient 69 Distorted Isochromes in the right eye with high corneal toricity

Figure 4.21 Patient 69 Isochromes in the left eye without high corneal toricity

4.4 Discussion

The mechanism of using the circular polariser was an easy process; one can focus the slit lamp on the area of interest; cornea, iris or crystalline lens and then place the circular polariser as near to the eye as possible, making sure the filter intersects the illumination beam and is also aligned with the observation system. Some small amount of tilting of the filter may be necessary to cut down on any glare from the slit lamp beam. As seen in the results, with all patients, using the filter enhanced the slit lamp view in 29.2% of the patients. Of those who already had signs with white light whilst viewing the cornea, iris or crystalline lens, the circular polariser improved viewing these signs in 52.6% of the signs. However, this varied depending on the ocular tissue viewed using the filter.

When the anterior cornea was examined using the filter, over 50% of the corneal opacities were easier to see. An example of the benefit of using the filter is that the examiner would identify a corneal opacity in a patient; a 2nd-year optometry student not versed in using the slit lamp would be asked to identify the location of the opacity. They would not be able to locate the opacity. However, when the circular polariser filter was placed in the front of the eye, the student could now quickly identify the location of the corneal opacity. This effect was not seen in any patients that had posterior stromal opacities or endothelial irregularities. Using the filter did not make any of these opacities easier to see.

Patient 69, with the possible distorted isochrome in the right eye, was referred internally for topography. The Oculus topographer showed high corneal astigmatism but scored 0 on the topographic keratoconus classification scale (TKC).

Several authors propose that the anterior cornea and posterior cornea are structurally different. They suggest that the fibrils in the anterior cornea are smaller and interlinked, while those in the posterior are larger and in well-defined layers.[434-439] This theory could explain why the polariser was more helpful in viewing anterior corneal opacities. It could also explain why when the polariser was used with a patient with an intrastromal corneal ring segment; there was no difference in visualising it. Thus, whilst Peli[256] had success in increasing the visibility of the endothelium using a filter, he was using the filter as an aid to cut down on the glare during specular reflection.

When used with patients who had lenticular opacities, the polariser made 58.1% of the opacities easier to see and made some opacities visible that were not visible without the polariser.

Weale, in 1986 discusses using polarised light when viewing lenticular opacities[262]. He highlights 10 cases where he found that using polarised light made viewing the crystalline lens easier. However, he does not mention what period or frequency these patients were seen. He also does not offer any explanation for the improvement with the polariser.

Any post capsule opacification with a patient with an Intra Ocular Lens implant was not easier to see with the polariser. There is no literature on using a circular polarising filter for examining post capsule opacification.

4.5 Conclusions

This chapter aims to discover how many patients attending an optometric clinic will have signs on the slit lamp using a circular polariser filter and record how many patients were found with altered corneal structure, such as Keratoconus, LASIK or other refractive surgeries by using the circular polariser filter.

When the filter was used on all the patients, it was shown to subjectively enhance the view in the slit lamp for the researcher in 29.2% of the patients. When the subgroup of patients who had been recorded with anterior corneal opacities, iris changes or lenticular opacities using white light in the previous chapter, the polariser has an effective rate of subjectively enhancing the view in the slit lamp for the researcher in 52.6% of patients.

From the objectives, one patient was seen with intrastromal corneal ring segments (Intacs), but the circular polariser did not change the view of the Intacs. In addition, one patient was seen with high corneal toricity, and the isochromes normally visible using the filter appeared distorted in the eye with the high corneal toricity. However, no patients were seen that had confirmed Keratoconus nor any patients who had had refractive surgery.

The null hypothesis for this chapter is that there will be no benefit in using a circular polariser filter on every patient attending the University Optometry Clinic. Statistically, the null hypothesis holds; however, clinically, the filter is advised in routine practice.

Chapter 5: Conclusions

5.1 Impact of this Study

Chapter 2

As a result of this study, the optometric community has data on when and why optometrists use the slit lamp. In addition, the frequency of NaFl use, lid eversion and a detailed examination of the lids is now also known.

While most optometrists stated they used the slit lamp on more than 75% of their non-contact lens patients, these numbers drop dramatically when discussing the use of NaFl and lid eversion.

The majority of optometrists use their slit lamp for many reasons. The slit lamp is used often for both the examination of the anterior eye and the posterior eye. When optometrists examine their patient's lids, most of them view the meibomian glands and for blepharitis.

Data was also collected on the number of non-contact lens patients seen each day.

Chapter 3

A significant finding from Chapter 3 is the relationship between asking a fixed list of six symptoms with each patient and the scoring groups from the OSDI questionnaire. Of those patients who scored Normal in the OSDI questionnaire, 65.6% also answered no to all six symptoms questions. Of those patients who scored Severe in the OSDI questionnaire, 60.7% answered "yes" to 1-2 questions on the six symptom list.

Another significant finding is that 95% of all the patients examined had at least one clinical sign seen on the slit lamp and white light. Taking away signs not associated with ocular surface disease still showed 86% of all the patients having at least one clinical sign seen on the slit lamp and white light. This result means that if using a slit lamp on every patient, the optometrist is highly likely to pick up a clinical sign.

The use of NaFl on all patients in the study did not find any clinical signs in a more significant proportion than chance. The proportion of patients who had a clinical sign using NaFl was 54%.

The study also confirmed the usefulness of the Wratten filter in enhancing the view of any clinical signs highlighted by NaFl. Furthermore, every use of the Wratten filter gave an improved view.

It was found that both the OSDI questionnaire and the six symptom list cannot be used as a predictor of if a patient will have an OSD sign using the slit lamp and white light nor NaFl.

Chapter 4

This chapter investigated the use of a circular polariser when viewing the anterior eye of non-contact lens patients. When used on all patients, the polariser gave an enhanced view of the anterior eye in only 29% of the patients. However, when a patient already has a clinical sign, the percentage of enhanced views using the polariser increases to 53%. While these results were not statistically significant, the investigator feels that the circular polariser still has some value in daily clinical practice. Furthermore, using the polariser with experience does not add considerable time to the eye examination.

When the polariser enhances a clinical sign, it makes the clinical sign much clearer to see. Therefore, the investigator would strongly recommend using the circular polariser in routine practice and also suggests its usefulness for optometry students to help them visualise signs within the cornea/iris/crystalline lens.

An attachment could be manufactured to hold the circular polariser so that the polariser could be placed into and out of position as needed. This could be similar to the Hruby lens attachment seen on some slit lamps. Given the advent of 3D printing, the optometrist could manufacture this at a cost estimated to be less than £20.

5.2 Limitations

Chapter 2

One of the disadvantages of using an online survey is that there is no way to verify how many optometrists received the link but did not press on the link or how many pressed on the link but did not bother to fill in the questionnaire. This factor makes the calculation of the response rate difficult. In addition, the online survey software also does not allow calculating the completion rate, that is, how many started the survey but did not press the submit button.

Also, there is no way of validating that the respondent answered the questions as they practice in their consulting room. This is a possible source of bias; respondents could have responded with higher standards of practice than they do. The respondent may have answered the questions in a manner that they feel is expected of them as they fill in the questionnaire.

There is no easy method to verify that each person responding was an optometrist, as described by the WCO levels of practice and also did not fall into the exclusion criteria.

Whilst, responses were grouped into the different scope of practice groups for some of the analysis, it does not mean that an optometrist who responded is working at that level. This is because the scope of practice defines the maximum level an optometrist can work; it does not necessarily determine their comfortable working level.

It is appreciated that such a questionnaire may not necessarily represent the profession as a whole. Such questionnaires do bring possible bias. As it was a free choice to answer the questionnaire and it did not have any tangible reward, those who answered the questionnaire were probably enthusiastic about the topic of the questionnaire. They may have felt confident in answering the questions. On the other hand, optometrists not aware of the subject nor confident may not have been keen to answer it.

Four of the questions in the questionnaire required the respondent to choose a number or percentage relevant to the questions. It may have been easier for the respondents to visualise their answers using a visual analogue scale.

Question 5(ii) led to respondents also including their use of the slit lamp to examine the posterior eye, 2 out of the top 5 reasons for using the slit lamp. This outcome could have also led them to believe that question 5 asked them the percentage use of the slit lamp on non-contact lens patients for any purpose when the question was ideally asking about the percentage use of the slit lamp for the anterior eye. However, the ambiguity of this question was not picked up by the investigator nor in the focus group.

Each group was only contacted once concerning the questionnaire; perhaps continuous reminders may have gotten more responses from different parts of the world.

The fact that the survey was only in English may have made some optometrists hesitant to fill in the survey in the parts of the world where English is not their first language.

Google Forms is a free software package; it allows unlimited responses, but it has limited features. Dedicated survey software, for example, Survey Monkey, has more options, but its free version has a limited capacity of respondents, currently 40.

Chapter 3

While a significant result was found using the 6 question symptom list, the list did not investigate how often nor to what extent the patient suffered from these symptoms. For example, when the patient was asked, "Do you have itchy eyes?" no indication was given to the patient if it was to be taken itchy eyes today, within the week or a more extended period. Also, the patient was left to decide what does itchy eyes mean to them.

Whilst there could be the expectation that the OSDI questionnaire should be filled in with the optometrist present, Ngo et al. show that there is not a clinically significant difference between the OSDI questionnaire scores when it is filled in with an optometrist present and when it is filled in without the optometrist being there[440].

The use of patient questionnaires also has its challenges in that can any one questionnaire allow a patient to express what symptoms they are experiencing, how often they are experiencing them, the extent they are experiencing them and yet still be able to be filled in fast enough not to disrupt a daily optometric clinic[199]?

As the research was designed to be performed in routine community practice, the existing patient record card was used for the study. Using a dedicated tick box system in the record card could allow more signs to be noted and measured. In addition, more signs may have been seen at the various points on the grading scale to allow fuller data analysis by increasing the sample population.

Previous studies on corneal staining with NaFl have used pipettes to control the volume of NaFl that gets instilled; however, it was taken that this would be impractical for an optometrist in routine practice.

Other studies on corneal staining have stated that more staining is visible with sequential staining[96, 126, 149]. Studies discuss sequential staining over 18 minutes and 21 minutes. However, sequential staining is impractical for an optometrist in routine practice and a patient visiting the practice.

Whilst many signs were seen using the slit lamp, can we be sure that these findings are relevant to the patient's symptoms? Some findings could be incidental and may not affect the optometrist's management of that patient.

The choice of grading scale could have also affected the data. Unfortunately, not enough signs were seen in each grading category to make data analysis possible. For example, all the same clinical signs were grouped whether they scored 1 or 4 on the Efron scale. After data collection had finished, a new scale for recording corneal staining was suggested by Woods et al.[441].

Chapter 4

There is a slight learning curve involved in the proper use of the circular polarizer. It is suggested that the retarder layer should face the patient. When this is not done, the isochromes are still somewhat visible but not as vivid in colour, and an increase of illumination is needed.

Even with the retarder facing the patient, an increase in illumination is necessary, as advised by other investigators[247]. However, this increase in lighting can make the slit lamp examination uncomfortable for some patients and make the examination using the circular polarizer more difficult.

Whilst any visible clinical signs were recorded by either "Yes" or "No" to give quantitative results, the subjectivity of whether there was an enhanced view using the polariser needs to be noted. For example, if optometrists were shown the sample photos shown in Chapter 4, would all optometrists state they felt the filter gives an enhanced view? Even if it was agreed that the filter provides an improved view, does the use of the filter help us manage the patient? What do these enhanced views mean for the management of the patient? The researcher believes that the management of the patient is improved and enhanced with the circular polariser. For example, when one becomes familiar with the expected isochromes, it prompts a further investigation when they are not as expected. Also, the polariser made the observation of some anterior findings easier and quicker.

One of the objectives of the study was to measure and detect patients with altered corneal structure. There is anecdotal evidence of a high prevalence of keratoconus in Trinidad & Tobago; however, none of the patients in the study was diagnosed previously with this condition, and no patients were found to have signs of it during the eye examination.

Due to the ethnic demographics of Trinidad & Tobago, most patients will have dark irides. No patient in the study had blue irides or light irides. A darker iris has been shown to help with the visualisation of the isochromes[260]. The results using the circular polariser with patients with lighter irides may not be the same.

Misson discussed observing two small dark areas near the pupil and termed these areas to be isotropes. These two dark areas were not always seen during the research; however, examining this central corneal area is easier using the crystalline lens's front surface reflection. Dilating the patient would increase the lens's front surface visibility, hence these front surface reflections[260]. However, all the circular polariser measurements were taken before any patient needed to be dilated.

Whilst O'Sullivan discussed using crossed polarisers to enhance the examination of the eyelids[261], it was not easy to use the circular polariser used in the study to examine the eyelids. It was much easier to use the polariser with the slit lamp focussed on the cornea, iris and crystalline lens

Another challenge for this section of the research is that there are significant differences in the corneal birefringence found in each patient[442]. Knighton found that whilst there is some relationship between the amount of corneal birefringence in the two eyes of each patient, there is a wide disparity in the amount of corneal birefringence between different patient's eyes[220].

5.3 Future Studies

Chapter 2

An additional questionnaire should be arranged to supplement the data that already exists with this study. Efforts could be made to reach more optometrists around the world. The questionnaire could be translated into common languages such as Spanish, Arabic, Mandarin, Cantonese, Hindi and French.

The question on using the slit lamp should be changed to stress what reasons optometrists use the slit lamp concerning the anterior eye. A question about why the optometrist does not use NaFl could be asked. Also, a question of what the optometrist constitutes a detailed lid examination could be asked.

Chapter 3

The preliminary result that using a fixed list of six symptoms is associated with the OSDI group should be expanded. As discussed in the limitations, the six symptom list was only yes or no for each symptom. The frequency nor the depth of the symptoms was recorded.

Future studies should be arranged to look at the possibility of an optometrist asking their patients the same six questions and the probability of predicting what severity group the patient would score on the OSDI questionnaire without having to fill in the questionnaire. This list could allow more optometrists to assess patient symptoms in detail if they feel that the OSDI questionnaire takes too long and would slow them down during the eye examination.

From chapter 2, given the low amount (3.41%) of optometrists performing lid eversion on 100% of their non-contact lens patients, further studies should be done to see if more signs would be seen if optometrists everted the lid on all their patients.

While this study focused on using NaFl and clinical signs, it would be interesting to perform a study on using Lissamine green on every non-contact lens patient of a sample population and examine any increase in conjunctival signs.

Chapter 4

The results from chapter 4 give rise to some questions that should be studied further.

Why do some lenticular opacities show better than others? The chapter shows a 50% improvement when viewing these opacities when using the circular polariser. Further studies should be done to examine if there is a relationship between the location of the opacity and the opacity being enhanced, or is there a relationship between the type of lenticular opacity and the opacity being easier to view with the polariser.

None of the cases of post capsule opacification were easier to see with the polariser. Could this result be due to the material of the IOL? The birefringence of IOLs varies considerably to the birefringence of the cornea and also between different manufacturers[443]. Another reason could be that perhaps the post capsule opacification was more posterior than the crystalline lens opacities that were enhanced with the polariser. It should be noted that there were only 3 cases of post capsule opacification. Further studies with more patients would be needed to examine any possible relationship.

All three cases of signs on the iris had an improvement with the circular polariser. This result should also be studied in more detail. Is this because the examined patients had only dark irides, and no patients with blue or lighter irides were examined? Again the number of cases was small and more cases should be studied.

One of the limitations discussed is the subjectivity of whether the view using the circular polariser improves the viewing of the clinical sign. Using image processing software, like Image J, would allow for objective grading of the view in the slit lamp and enable a model to be developed to identify objective enhancement of the view.

With modern photographic software, the use of different filters could be examined to highlight the isochromes or isotropes visible on the cornea.

With the ease of use of the circular polariser, the use of a circular polariser can lead to several future new studies.

The distortion of the right eye isochromes in patient 69 lead the investigator to advise the patient to have topography done another day. When the patient returned, topography showed high corneal astigmatism in the RE but no keratoconus. Future studies could expand on these isochrome patterns; any relationship between the patient's prescription and the isochromes could be examined. In addition, each patient's corneal curvature could be measured using the topographer and photographs of the isochromes taken. Again, this would help discover any relationship between the isochrome patterns and the topography results.

The circular polariser could be expanded into other clinics, for example, the speciality contact lens clinic. In this clinic, patients who are not achieving good visual acuity with their current spectacles or contact lenses are offered to be fitted with speciality contact lenses. There is anecdotal evidence that most of the patients in this contact lens clinic have primary or secondary corneal ectasias. Future studies could be organised to examine any relationship between the isochrome patterns and the degree of corneal ectasia. For example, could the use of the polariser allow an optometrist to become suspicious of a patient having keratoconus?

With orthokeratology becoming more popular and as a reliable technique for myopia management, a study could be organized using the isochrome patterns to examine any differences before a patient starts orthokeratology and the patterns when the patient is deemed a successful orthokeratology wearer.

The use of the circular polariser as a teaching tool should also be examined. While the polariser enhances approximately 50% of any clinical signs present in the cornea and lens, when it does, it makes the clinical sign much more visible. However, if an optometry student is not well-versed in slit lamp use and the demonstrator is describing a clinical sign, there could be a tendency for the student to say yes they see it, yet they have no idea, in reality, the location of the clinical sign. Putting the polariser in front of the patient could allow the student to see the sign easier and enable the demonstrator to describe the features.

Finally, the use of the circular polariser with anterior eye imaging should also be studied. Given that the polariser sharpens the cornea and the Iris image, the polariser may enhance the view using these devices. For example, the anterior chamber angle and/or cataract grading may be easier to calculate.

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APPENDIX 1 WCO Scope of Practice

Scope of Practice Level	Scope of Practice Category	Roles	Profession
1	Optical Technology Services	Management and dispensing of ophthalmic lenses, ophthalmic frames and other ophthalmic devices that correct defects of the visual system	Optician
2	Visual Function Services	Optical Technology Services plus Investigation, examination, measurement, recognition and correction/management of defects of the visual system	Optometrist
3	Ocular Diagnostic Services	Optical Technology Services & Visual Function Services plus Investigation, examination and evaluation of the eye and adnexa, and associated systemic factors, to detect, diagnose and manage disease	Diagnostic Optometrist
4	Ocular Therapeutic Services	Optical Technology Services & Visual Function Services & Ocular Diagnostic Services plus Use of pharmaceutical agents and other procedures to manage ocular conditions/disease.	Therapeutic Optometrist

https://worldcouncilofoptometry.info/wp-content/uploads/2017/03/wco_global_competency_model_2015.pdf

APPENDIX 2 Chapter 2 Questionnaire

Slit Lamp & Fluorescein Use

1. What year did you qualify as an optometrist? *

2. In which country do you work? *

3. What type of practice do you work in for the majority of the week? * Mark only one oval.

- Independent (Single Location)
- Small Sized Multiple (Less than 5 locations)
- Medium Sized Multiple (5 to 30 locations)
- Large Sized Multiple (More than 30 locations)
- Hospital or other surgical clinic (Such as laser clinic etc)
- University
- Locum (work in a mixture of practices as listed above)

4. How many non-contact lens patients do you see a day for an eye exam in your main place of work? *

5 . On what percentage of those patients (non-contact lens wearers) do you use a slit lamp?
*

5. (ii) Why do you use a slit lamp on these patients? (Open Answer) *

6. On what percentage of non-contact lens patients would you use Sodium Fluorescein? *

7. On what percentage of non-contact lens patients would you perform lid eversion? *

8. Do you perform a detailed lid examination on your patient using the slit lamp? * Mark only one oval.

- Yes
- No

8. (ii) What areas/conditions are you looking for/at during the lid examination? (Open answer)
*

Google Forms

Appendix 3

Chapter 2 Data Analysis Contingency Tables

Table A3.1 shows a summary of the Chi-square analysis results for the various questions of the questionnaire. The shaded areas indicate where no analysis was done due to there being no apparent link between the two questions.

	Type of Practice	Number of Patients Seen	% Use of the Slit Lamp	% Use of NaFl	% Performing Lid Eversion	Doing a Full Lid Examination
Year of Qualification			**.006**	.571	.075	.900
Scope of Practice			**< .001**	**.007**	**.004**	**< .001**
Type of Practice		**< .001**	.506	**.002**	**< .001**	.082
Number of Patients Seen	**< .001**		**< .001**	.839	**.006**	.365

Table A3.2 Chi-Square probabilities score for the various questions asked in the questionnaire.

1. Percentage use of the slit lamp:

Year of qualification and Percentage use of the slit lamp:

		Year of Qualification					Total
		1980 and before	1981 - 1989	1990 - 1999	2000 - 2010	After 2010	
Percentage Using Slit Lamp	Less than or equal to 25%	2 (7.7%)	9 (15.0%)	19 (14.5%)	30 (17.7%)	35 (17.6%)	95
	26 - 50%	1 (3.9%)	4 (6.7%)	13 (9.9%)	10 (5.6%)	11 (5.5%)	39
	51 - 75%	4 (15.4%)	2 (3.3%)	1 (0.8%)	2 (1.2%)	4 (2.0%)	13
	More than 75%	19 (73.1%)	45 (75.0%)	98 (74.8%)	128 (75.3%)	149 (74.9%)	439
Total		26 (100%)	60 (100%)	131 (100%)	170 (100%)	199 (100%)	586

Table A3.3 Contingency Table for Year of qualification and Percentage use of the slit lamp.

Scope of practice and Percentage use of slit lamp:

		What Scope of Practice do they work at?			Total
		2	3	4	
Percentage Using Slit Lamp	Less than or equal to 25%	6 (35.3%)	78 (23.5%)	11 (4.6%)	95
	26 - 50%	3 (17.6%)	32 (9.6%)	4 (1.7%)	39
	51 - 75%	0	10 (3.0%)	3 (1.3%)	13
	More than 75%	8 (47.1%)	212 (63.9%)	219 (92.4%)	439
Total		17 (100%)	332 (100%)	237 (100%)	586

Table A3.4 Contingency Table for Scope of practice and Percentage use of slit lamp.

Type of practice and Percentage use of slit lamp:

		What type of practice are they working in							Total
		Hospital or	Independent	Large Sized	Locum (work	Medium Sized	Small Sized	University	
Percentage Using Slit Lamp	Less than or equal to 25%	9 (18.7%)	41 (17.4%)	11 (13.4%)	6 (15.0%)	14 (28.0%)	12 (11.2%)	2 (8.3%)	95
	26 - 50%	5 (10.4%)	13 (5.5%)	6 (7.3%)	4 (10.0%)	1 (2.0%)	7 (6.5%)	3 (12.5%)	39
	51 - 75%	1 (2.1%)	6 (2.56%)	1 (1.2%)	2 (5.0%)	1 (2.0%)	1 (0.9%)	1 (4.2%)	13
	More than 75%	33 (68.8%)	175 (74.5%)	64 (78.1%)	28 (70.0%)	34 (68.0%)	87 (81.3%)	18 (75.0%)	439
Total		48 (100%)	235 (100%)	82 (100%)	40 (100%)	50 (100%)	107 (100%)	24 (100%)	586

Table A3.5 Contingency Table for Type of practice and Percentage use of slit lamp.

Number of non-contact lens patients seen in a day and percentage using slit lamp:

		Percentage Using Slit Lamp				Total
		Less than or equal to 25%	26 - 50%	51 - 75%	More than 75%	
Number of Non-Contact Patients	Less than or equal to 10 patients	69 (72.6%)	25 (64.1%	4 (30.8%)	210 (47.8%)	308
	11-20 patients	21 (22.1%)	13 (33.3%)	9 (69.2%)	215 (49.0%)	258
	Greater than 20 patients	5 (5.3%)	1 (2.6%)	0	14 (3.2%)	20
Total		95 (100%)	39 (100%)	13 (100%)	439 (100%)	586

Table A3.6 Contingency Table for Number of non-contact lens patients seen in a day and percentage using a slit lamp.

2. Percentage use of NaFI:

<u>Year of qualification and Percentage NaFI use:</u>

		Year of Qualification					Total
		1980 and before	1981 - 1989	1990 - 1999	2000 - 2010	After 2010	
Percentage Using NaFI	Less than or equal to 25%	13 (50.0%)	33 (55.0%)	74 (56.5%)	93 (54.7%)	124 (62.3%)	337
	26 - 50%	5 (19.2%)	15 (25.0%)	30 (22.9%)	32 (18.8%)	41 (20.6%)	123
	51 - 75%	1 (3.9%)	3 (5.0%)	7 (5.3%)	7 (4.1%)	10 (5.0%)	28
	More than 75%	7 (26.9%)	9 (15.0%)	20 (15.3%)	38 (22.4%)	24 (12.0%)	98
Total		26 (100%)	60 (100%)	131 (100%)	170 (100%)	199 (100%)	586

<u>Table A3.7 Contingency Table for Year of qualification and Percentage NaFI use.</u>

Scope of practice and Percentage use of NaFl:

		What Scope of Practice do they work at?			Total
		2	3	4	
Percentage Using NaFl	Less than or equal to 25%	10 (58.8%)	207 (62.3%)	120 (50.6%)	337
	26 - 50%	3 (17.7%)	74 (22.3%)	46 (19.4%)	123
	51 - 75%	1 (5.8%)	12 (3.6%)	15 (6.3%)	28
	More than 75%	3 (17.7%)	39 (11.8%)	56 (23.6%)	98
Total		17 (100%)	332 (100%)	237 (100%)	586

Table A3.8 Contingency Table for Scope of practice and Percentage use of NaFl.

Type of practice and Percentage use of NaFl:

		What type of practice are they working in							Total
		Hospital or	Independent	Large Sized	Locum (work	Medium Sized	Small Sized	University	
Percentage Using NaFl	Less than or equal to 25%	22 (45.8%)	132 (56.2%)	61 (74.4%)	26 (65.0%)	25 (50.0%)	62 (57.9%)	9 (37.5%)	337
	26 - 50%	8 (16.7%)	50 (21.4%)	14 (17.1%)	9 (22.5%)	14 (28.0%)	23 (21.5%)	5 (20.8%)	123
	51 - 75%	4 (8.3%)	8 (3.4%)	3 (3.7%)	1 (2.5%)	3 (6.0%)	4 (3.7%)	5 (20.8%)	28
	More than 75%	14 (29.2%)	45 (19.2%)	4 (4.9%)	4 (10.0%)	8 (16.0%)	18 (16.8%)	5 (20.8%)	98
Total		48 (100%)	235 (100%)	82 (100%)	40 (100%)	50 (100%)	107 (100%)	24 (100%)	586

Table A3.9 Contingency Table for Type of practice and Percentage use of NaFl.

Number of non-contact lens patients and Percentage use of NaFl:

		Percentage Using NaFl				Total
		Less than or equal to 25%	26 - 50%	51 - 75%	More than 75%	
Number of Non-Contact Patients	Less than or equal to 10 patients	177 (52.5%)	66 (53.7%)	17 (60.7%)	48 (49.0%)	308
	11-20 patients	147 (43.6%)	55 (44.7%)	10 (35.7%)	46 (46.9%)	258
	Greater than 20 patients	13 (3.9%)	2 (1.6%)	1 (3.6%)	4 (4.1%)	20
Total		337 (100%)	123 (100%)	28 (100%)	98 (100%)	586

Table A3.10 Contingency Table for Number of non-contact lens patients and Percentage use of NaFl.

3. Percentage performing lid eversion:

Year of qualification and Percentage performing lid eversion:

		Year of Qualification					Total
		1980 and before	1981 - 1989	1990 – 1999	2000 - 2010	After 2010	
Percentage Performing Lid Eversion	Less than or equal to 25%	19 (73.1%)	54 (90.0%)	111 (84.7%)	144 (84.7%)	168 (84.4%)	496
	26 - 50%	5 (19.2%)	4 (6.7%)	15 (11.5%)	18 (10.6%)	11 (5.5%)	53
	51 - 75%	0	0	0	0	4 (2.0%)	4
	More than 75%	2 (7.7%)	2 (3.3%)	5 (3.8%)	8 (4.7%)	16 (8.0%)	33
Total		26 (100%)	60 (100%)	131 (100%)	170 (100%)	199 (100%)	586

Table A3.11 Contingency Table for Year of qualification and Percentage performing lid eversion.

Scope of practice and Percentage performing lid eversion:

		What Scope of Practice do they work at?			Total
		2	3	4	
Percentage Doing Lid Eversion	Less than or equal to 25%	9 (52.9%)	282 (84.9%)	205 (86.5%)	496
	26 - 50%	5 (29.4%)	29 (8.7%)	19 (8.0%)	53
	51 - 75%	1 (5.9%)	1 (0.3%)	2 (0.8%)	4
	More than 75%	2 (11.8%)	20 (6.0%)	11 (4.7%)	33
Total		17 (100%)	332 (100%)	237 (100%)	586

Table A3.12 Contingency Table for Scope of practice and Percentage performing lid eversion.

Type of practice and Percentage performing lid eversion:

		What type of practice are they working in							Total
		Hospital or	Independent	Large Sized	Locum (work	Medium Sized	Small Sized	University	
Percentage Doing Lid Eversion	Less than or equal to 25%	37 (77.1%)	196 (83.4%)	80 (97.6%)	35 (87.5%)	45 (90.0%)	89 (83.2%)	14 (58.3%)	496
	26 - 50%	5 (10.4%)	24 (10.2%)	1 (1.2%)	2 (5.0%)	2 (4.0%)	15 (14.0%)	4 (16.7%)	53
	51 - 75%	2 (4.2%)	2 (0.9%)	0	0	0	0	0	4
	More than 75%	4 (8.3%)	13 (5.5%)	1 (1.2%)	3 (7.5%)	3 (6.0%)	3 (2.8%)	6 (25.0%)	33
Total		48 (100%)	235 (100%)	82 (100%)	40 (100%)	50 (100%)	107 (100%)	24 (100%)	586

Table A3.13 Contingency Table for Type of practice and Percentage performing lid eversion.

Number of non-contact lens patients seen in a day and Percentage performing lid eversion:

		Percentage Doing Lid Eversion				Total
		Less than or equal to 25%	26 - 50%	51 - 75%	More than 75%	
Number of Non-Contact Patients	Less than or equal to 10 patients	251 (50.6%)	29 (54.7%)	3 (75.0%)	25 (75.8%)	308
	11-20 patients	230 (46.4%)	22 (41.5%)	0	6 (18.2%)	258
	Greater than 20 patients	15 (3.0%)	2 (3.8%)	1 (25.0%)	2 (6.1%)	20
Total		496 (100%)	53 (100%)	4 (100%)	33 (100%)	586

Table A3.14 Contingency Table for Number of non-contact lens patients seen in a day and percentage performing lid eversion.

4. Performing a detailed lid examination:

Year of qualification and detailed lid examination:

		Year of Qualification					Total
		1980 and before	1981 - 1989	1990 - 1999	2000 - 2010	After 2010	
Do you perform a detailed lid examination on your patient using the slit lamp?	No	3 (11.5%)	12 (20.0%)	23 (17.6%)	32 (18.8%)	38 (19.1%)	108
	Yes	23 (88.5%)	48 (80.0%)	108 (82.4%)	138 (81.2%)	161 (80.9%)	478
Total		26 (100%)	60 (100%)	131 (100%)	170 (100%)	199 (100%)	586

Table A3.15 Contingency Table for Year of qualification and detailed examination.

Scope of practice and detailed lid examination:

		What Scope of Practice do they work at?			Total
		2	3	4	
Do you perform a detailed lid examination on your patient using the slit lamp?	No	5 (29.4%)	81 (24.4%)	22 (9.2%)	108
	Yes	12 (70.6%)	251 (75.6%)	215 (90.7%)	478
Total		17 (100%)	332 (100%)	237 (100%)	586

Table A3.16 Contingency Table for Scope of practice and detailed lid examination.

Type of practice and detailed lid examination:

		What type of practice are they working in							Total
		Hospital or	Independent	Large Sized	Locum (work	Medium Sized	Small Sized	University	
Do you perform a detailed lid examination on your patient using the slit lamp?	No	11 (22.9%)	36 (15.3%)	22 (26.8%)	12 (30.0%)	8 (16.0%)	15 (14.0%)	4 (16.7%)	108
	Yes	37 (77.1%)	199 (84.7%)	60 (73.2%)	28 (70.0%)	42 (84.0%)	92 (86.0%)	20 (83.3%)	478
Total		48 (100%)	235 (100%)	82 (100%)	40 (100%)	50 (100%)	107 (100%)	24 (100%)	586

Table A3.17 Contingency Table for Type of practice and detailed lid examination.

Number of non-contact lens patients and Performing a detailed lid exam:

		Do you perform a detailed lid examination on your patient using the slit lamp?		Total
		No	Yes	
Number of Non-Contact Patients	Less than or equal to 10 patients	53 (49.1%)	255 (53.3%)	308
	11-20 patients	53 (49.1%)	205 (42.9%)	258
	Greater than 20 patients	2 (1.8%)	18 (3.8%)	20
Total		108 (100%)	478 (100%)	586

Table A3.18 Contingency Table for Number of non-contact lens patients and Performing a detailed lid exam

5. Type of practice and Number of non-contact lens patients seen in a day:

<u>Type of practice and Number of non-contact lens patients seen in a day:</u>

		What type of practice are they working in							
		Hospital or	Independent	Large Sized	Locum (work	Medium Sized	Small Sized	University	Total
Number of Non-Contact Patients Per Day	Less than or equal to 10 patients	16 (33.3%)	145 (61.7%)	27 (32.9%)	13 (32.5%)	30 (60.0%)	59 (55.1%)	18 (75.0%)	308
	11-20 patients	26 (54.2%)	83 (35.3%)	54 (65.9%)	25 (62.5%)	19 (38.0%)	45 (42.1%)	6 (25.0%)	258
	Greater than 20 patients	6 (12.5%)	7 (3.0%)	1 (1.2%)	2 (5.0%)	1 (2.0%)	3 (2.8%)	0	20
Total		48 (100%)	235 (100%)	82 (100%)	40 (100%)	50 (100%)	107 (100%)	24 (100%)	586

<u>Table A3.19 Contingency Table for Type of practice and number of non-contact lens patients seen in a day.</u>

Aston University

Investigation of the use of a slit lamp bio-microscope to improve detection of adverse ocular clinical signs

PARTICIPANT INFORMATION SHEET

You are being invited to participate in a research study. Before you decide if you would like to participate, it is important for you to understand why the study is being done and what would be involved. Please take the time to read the information carefully, and discuss with friends and family, if you wish.

Please feel free to ask us about anything that is not clear, or if you would like more information. Take time to decide whether or not you would like to participate.

What is the purpose of the study?

The study is designed to investigate if by using different eye exam techniques consistently on every patient, some eye problems could be more easily picked up than current methods used at present. The beneficial outcome of this study is to seek ways of increasing patient care by using existing equipment already available during the eye examination.

Do I have to agree to take part in this study?

No. It is up to you to decide whether or not you wish to take part.

If you do decide to participate, you will be asked to sign and date a consent form. You would still be free to withdraw from the study at any time without giving a reason. A decision not to take part, or a decision to withdraw at a later date, will not affect the standard of care that you receive or your relationship with the University if you are a member of staff or student.

What will happen to me if I take part?

During your regular full eye examination an examination of the outside of your eye using a machine called a slit lamp bio-microscope will be performed. A slit lamp bio-microscope is a

machine that magnifies the front of your eye which allows the optometrist to examine the front of your eye in detail. You will need to place your chin on a rest and your head against a head rest. It causes no pain.

A drop called Sodium Fluorescein (1mg) will be put in your eyes and a blue light will be used to examine the front of your eye. A special filter will then be used to check the front of your eye. Doing these steps should only add 10 minutes onto the length of the eye exam. Please note if any ocular abnormality is detected then you will be referred for full ocular examination to a medical or ophthalmic practitioner.

What are the possible risks of taking part?

While every opportunity will be taken for you not to get harmed, the only potential for discomfort is the use of a bright light from the slit lamp. The eye drops/ strips used in the study are staining agents (Sodium Fluorescein) used to aid external examination of your eye (When applied to the eye, they may sting for a few moments. Due to their colouring (orange/ yellow) they may cause the vision to take on a coloured appearance, but this will not last long. As soft contact lenses can absorb the dye, you are advised to refrain from wearing your lenses for at least 15 minutes. Sometimes, the eyelids and the skin around the eyes will be coloured by the stain, but this can be removed with cold water.

Will my taking part in this study be kept confidential?
Yes. You will be given a unique study number which will be attached to all measurements taken at study visits (your data). The data will be kept confidential in a locked room or on a password protected computer and only be accessible to the Research Team (the research student Niall Farnon and his supervisors Dr Shehzad Naroo and Professor James Wolffsohn)

To ensure the quality of the research designated individuals from Aston University may need to access your data to check that it has been recorded accurately. If this is required your personal data will be treated as confidential by the individuals accessing your data.

With your permission we will inform your General Practitioner of your involvement with the study.

What will happen to the results of the research study?

It is intended that the results of the research will be presented at scientific meetings, published in relevant clinical and academic journals and disseminated in the student's DOptom thesis We will also produce a lay summary which we can send to you. You will not be identified in any report or publication.

Who is organising and funding the research?

The Ophthalmic Research Group at Aston University are organising this study. Niall Farnon will collect the data and it will be used in his doctoral studies. His supervisors are Dr Shehzad Naroo and Professor James Wolffsohn, who are full time employees of Aston University and are members of the Ophthalmic Research Group at Aston University.

Who has reviewed the study?

This study has been reviewed and given a favourable opinion by the Aston University Research Ethics Committee.

What if I have a concern about the study?

If you have any concerns about anything to do with this study, please speak to Dr Naroo and he will do his best to answer your questions. His contact details can be found at the end of this information sheet.

If they are unable to address your concerns or you wish to make a complaint about how the study is being conducted you should contact the Aston University Director of Governance, Mr. John Walter, j.g.walter@aston.ac.uk or telephone +44 121 204 4665.

Contact details

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Tel: +44121 2044132

Email: s.a.naroo@aston.ac.uk

Thank you for taking time to consider participating in this study.

Farnon Doptom study, PIS 1.4 (04/10/17) Page 2 of 2

Aston University

Investigation of the use of a slit lamp bio-microscope to improve detection of adverse ocular clinical signs

CONSENT FORM

Participant Identification Number: ______

Please initial box

I confirm that I have read and understand the information sheet dated 04/10/17(version 1.4) for the above study. I have had the opportunity to consider the information provided, ask questions and have had these answered to my satisfaction. ☐

1. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason and my legal rights being affected. ☐

2. I understand that my data may be reviewed by authorised individuals from Aston University responsible for ensuring the quality of the research. ☐

3. I agree to my General Practitioner (GP) being informed of my participation in the study. ☐

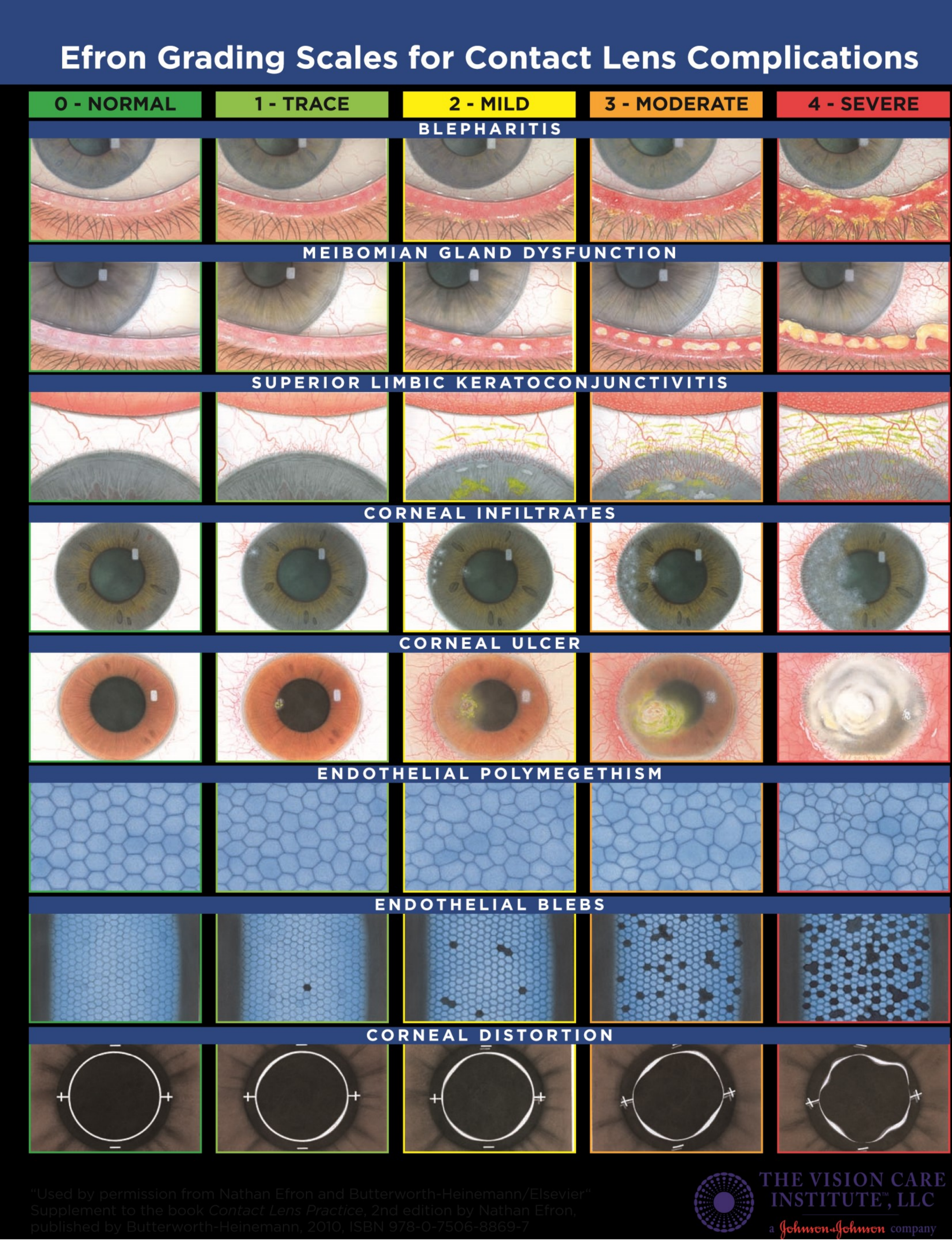
4. I agree to take part in the above study. ☐

Name of Participant	Date	Signature
Name of Researcher	Date	Signature

1 copy for the participant, 1 for researcher site file

Appendix 5 Efron Scale

Available from
https://www.jnjvisionpro.com/sites/default/files/content/us/desktop/pdf/EFRON%20Grading%20Scale%20US%20INSERT.pdf



Efron Grading Scales for Contact Lens Complications
0 - NORMAL
1 - TRACE
2 - MILD
3 - MODERATE
4 - SEVERE
BLEPHARITIS
MEIBOMIAN GLAND DYSFUNCTION
SUPERIOR LIMBIC KERATOCONJUNCTIVITIS
CORNEAL INFILTRATES
CORNEAL ULCER
ENDOTHELIAL POLYMEGETHISM
ENDOTHELIAL BLEBS
CORNEAL DISTORTION
"Used by permission from Nathan Efron and Butterworth-Heinemann/Elsevier"
Supplement to the book *Contact Lens Practice*, 2nd edition by Nathan Efron,
published by Butterworth-Heinemann, 2010, ISBN 978-0-7506-8869-7
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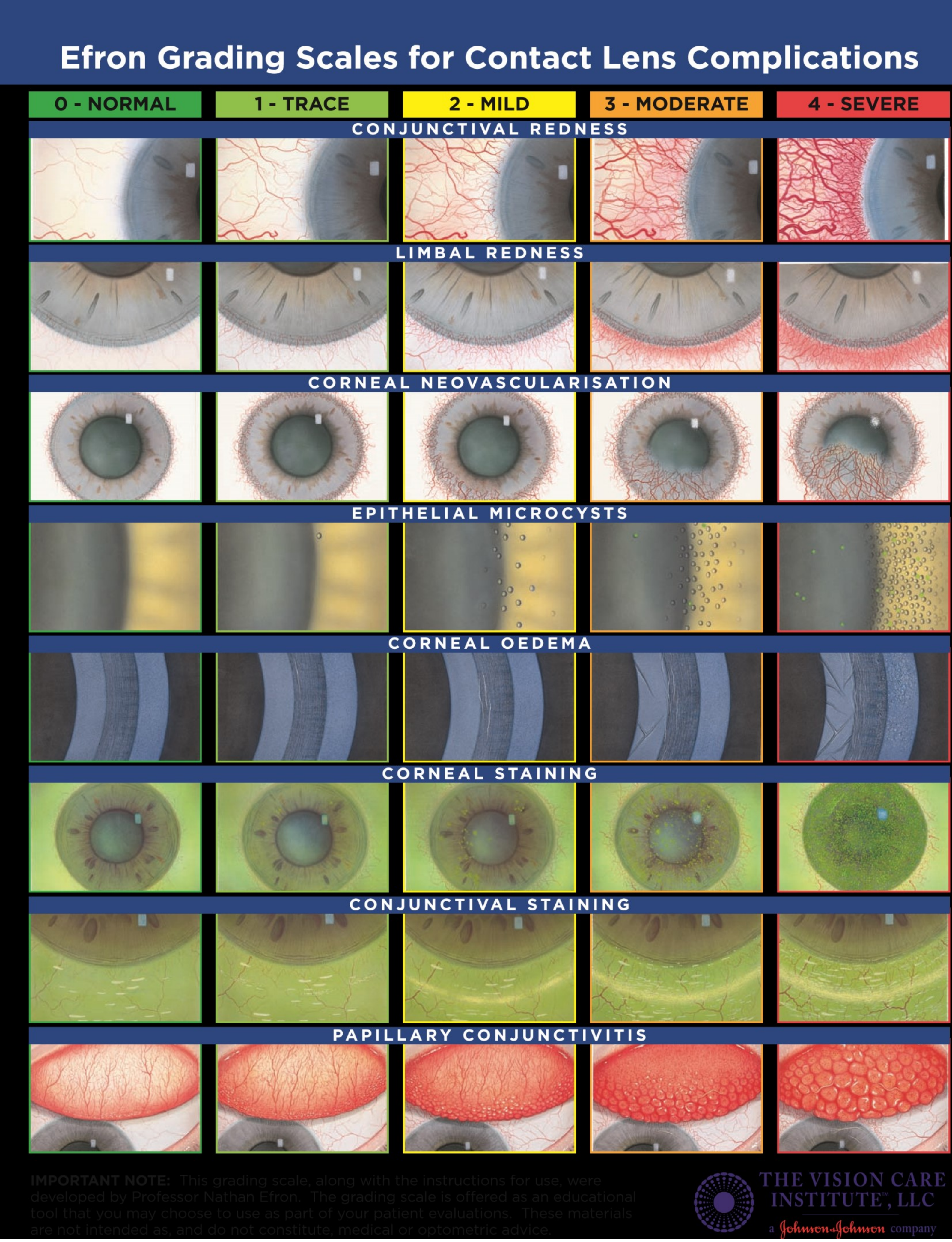
Efron Grading Scales for Contact Lens Complications
0 - NORMAL
1 - TRACE
2 - MILD
3 - MODERATE
4 - SEVERE
CONJUNCTIVAL REDNESS
LIMBAL REDNESS
CORNEAL NEOVASCULARISATION
EPITHELIAL MICROCYSTS
CORNEAL OEDEMA
CORNEAL STAINING
CONJUNCTIVAL STAINING
PAPILLARY CONJUNCTIVITIS
IMPORTANT NOTE: This grading scale, along with the instructions for use, were developed by Professor Nathan Efron. The grading scale is offered as an educational tool that you may choose to use as part of your patient evaluations. These materials are not intended as, and do not constitute, medical or optometric advice.
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Appendix 6

SAMPLE SIZE CALCUATION FOR CHAPTER 3

A sample size of 96 was calculated using a margin of error of 10%, confidence level of 95% and using 9,000 as the university patient population

$$n_0 = \frac{Z^2 pq}{e^2}$$

Where

n_0 is the calculated sample size

Z is the z value found in the Z table for 95% confidence, that is, 1.96

p is the estimated population that will have signs on the slit lamp, taken to be 0.5

q is 1-p

e is the margin of error, taken to be 10%

$$n_0 = \frac{(1.96)^2(0.5)(0.5)}{(0.1)^2}$$

$$n_0 = 96 \text{ patients}$$

APPENDIX 7

Results of the planned Pilot study

Patient Age:

The age range of patients seen was from 32 to 70 years, with 80.0% of the patients over 40 and 66.7% being over 50. The mean was 51.5 + / - 11.4. The mode was 51 years of age.

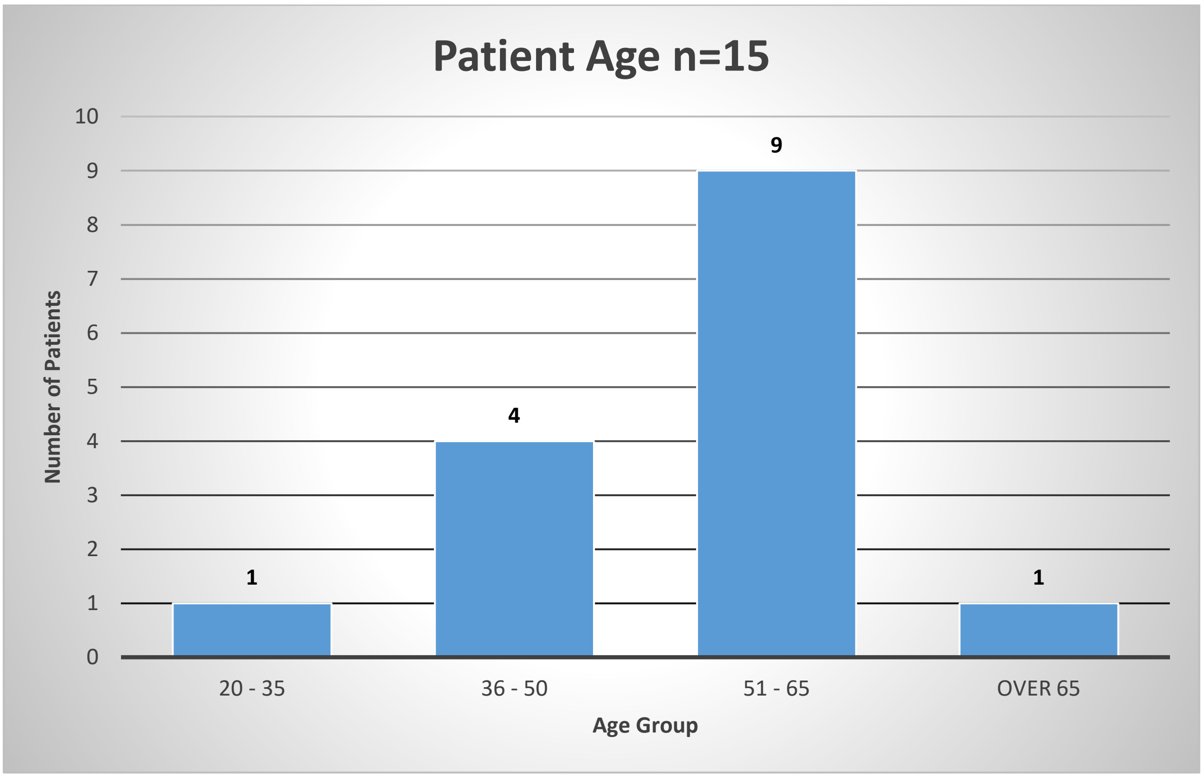

Figure A7.21 Patient age grouped into four categories

Patient Gender:

Females accounted for 73.3% of the patients seen, whilst males accounted for 26.7%.

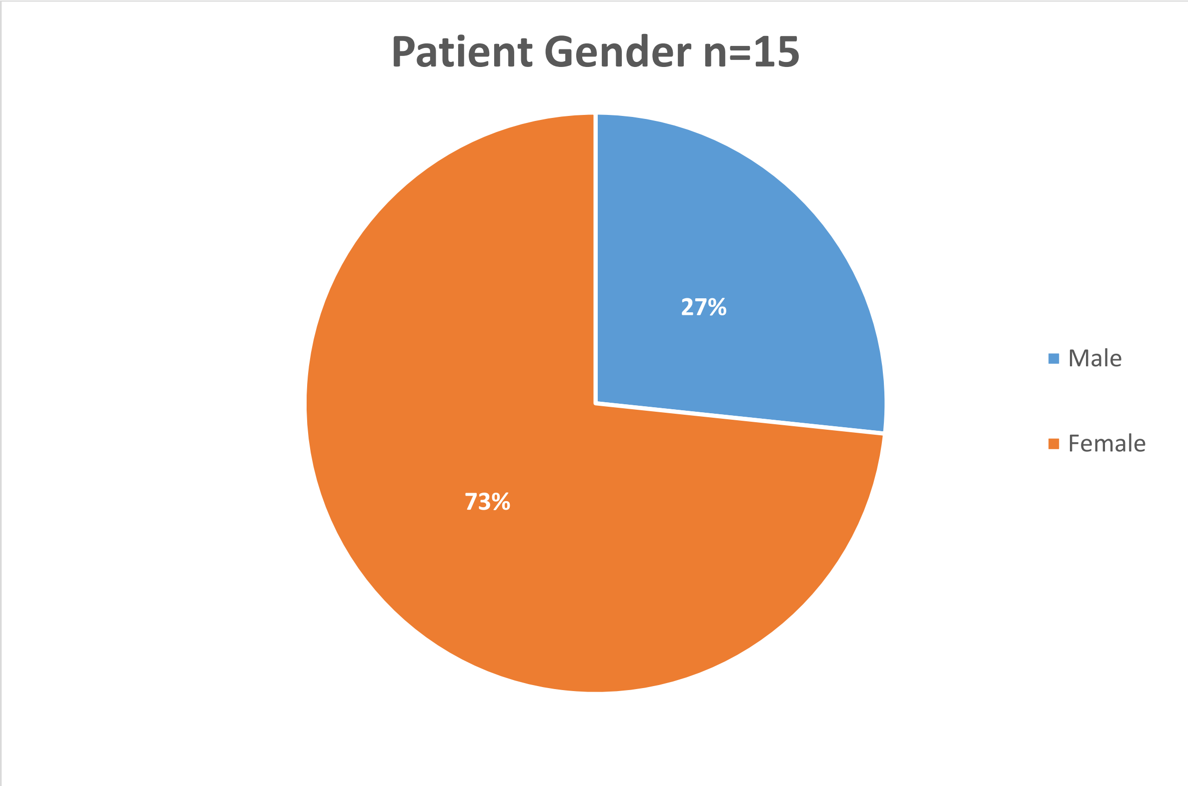

Figure A7.22 Patient Gender

Reason for Visit:

The most common reason for the patient to visit the university clinic was to get their eyes checked (6 patients). Two patients only reported watery eyes or itchy eyes as their reason for the visit. These were two of the symptoms from the six symptom list.

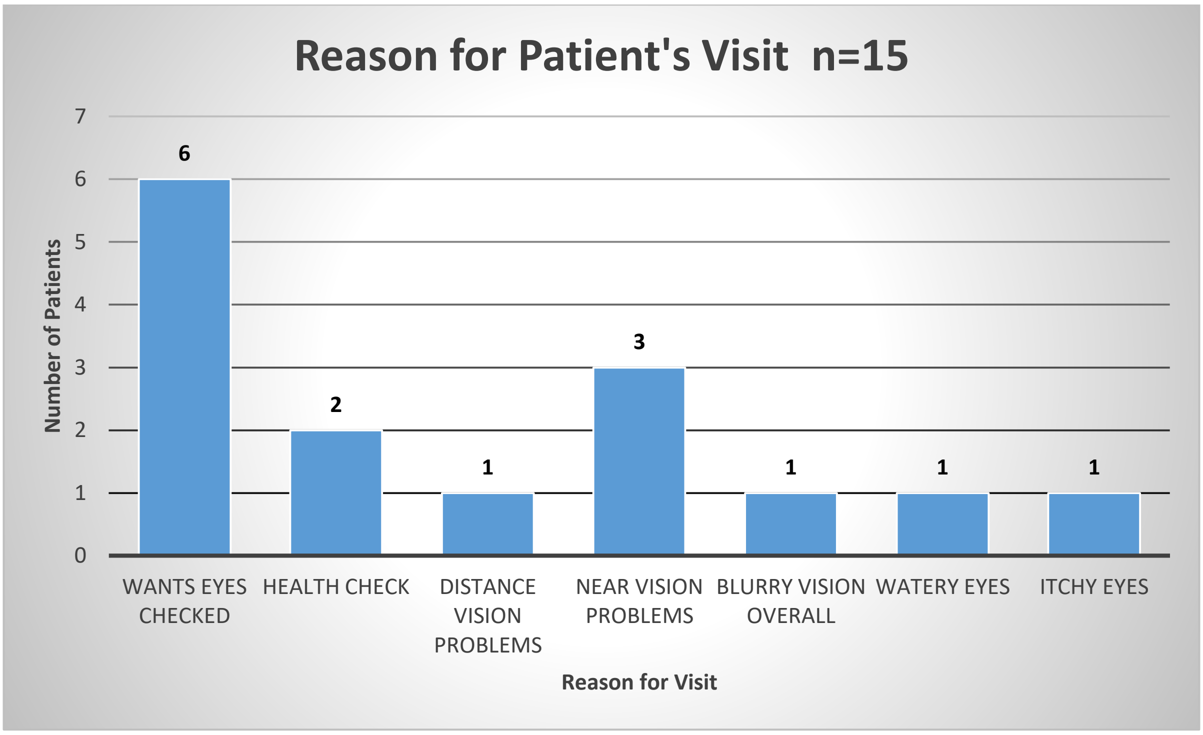

Figure A7.23 Reason for Patient's Visit

Symptoms reported from six symptoms list:

As discussed in the methodology, every patient was then asked the same six questions about possible symptoms. Five (33.3%) of the patients answered "no" to all six questions. The most common symptom was watery eyes, and the least common was sore eyes and burning eyes. The number of symptoms reported is 19, as patients could answer yes to more than one symptom. Figure 3.4 shows the reported symptoms.

Figure 3.5 shows a breakdown of the number of symptoms answered "yes" by the patients. As shown in figure 3.6, these were then grouped to create four groups having a similar number of groups as the OSDI score groups.

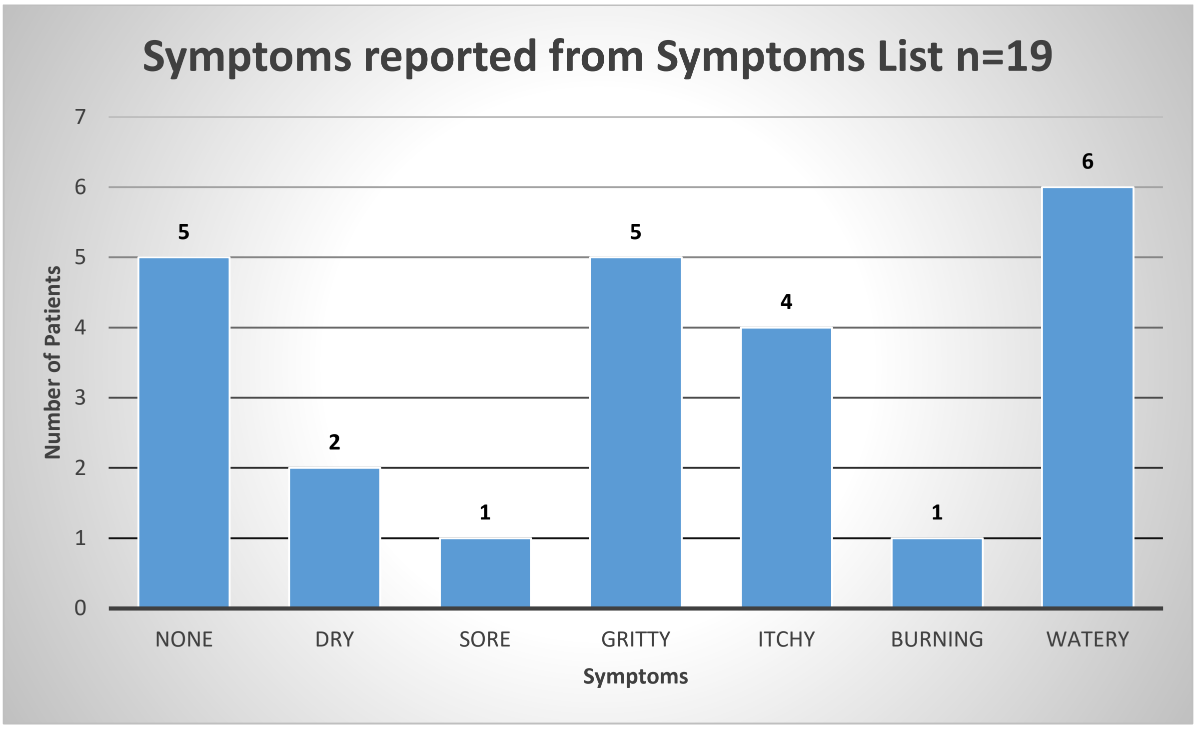

Figure A7.24 Symptoms reported from Symptoms List

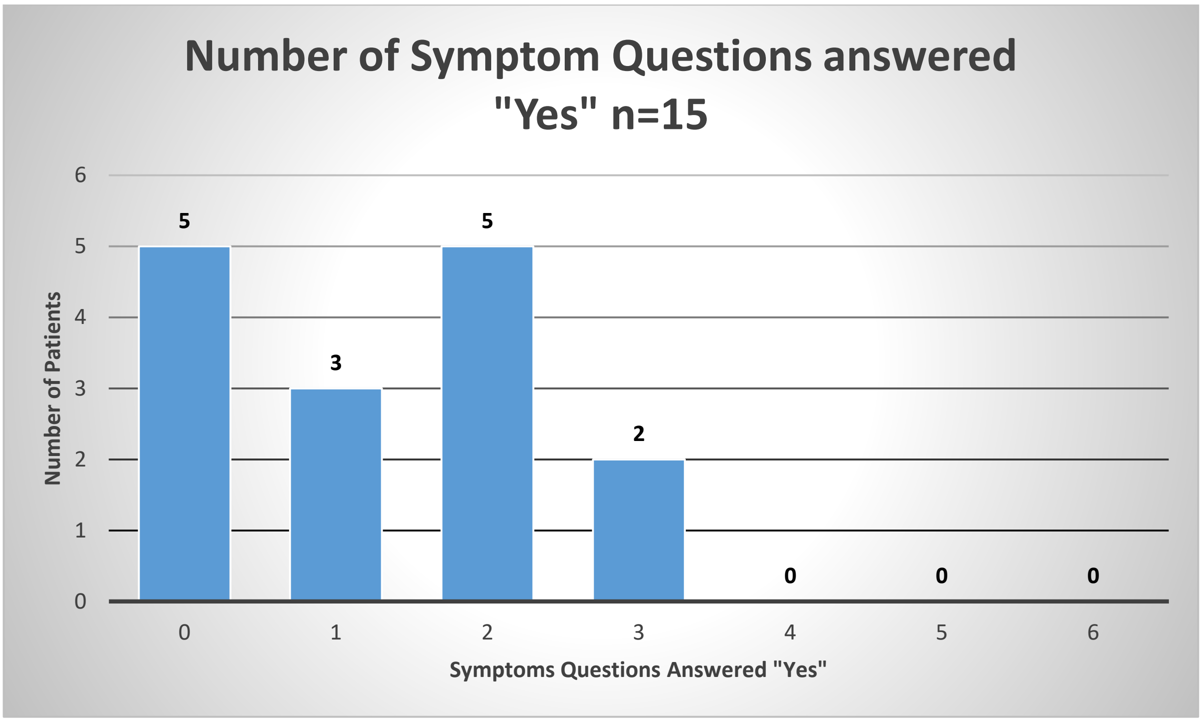

Figure A7.25 Number of Symptom questions answered "Yes"

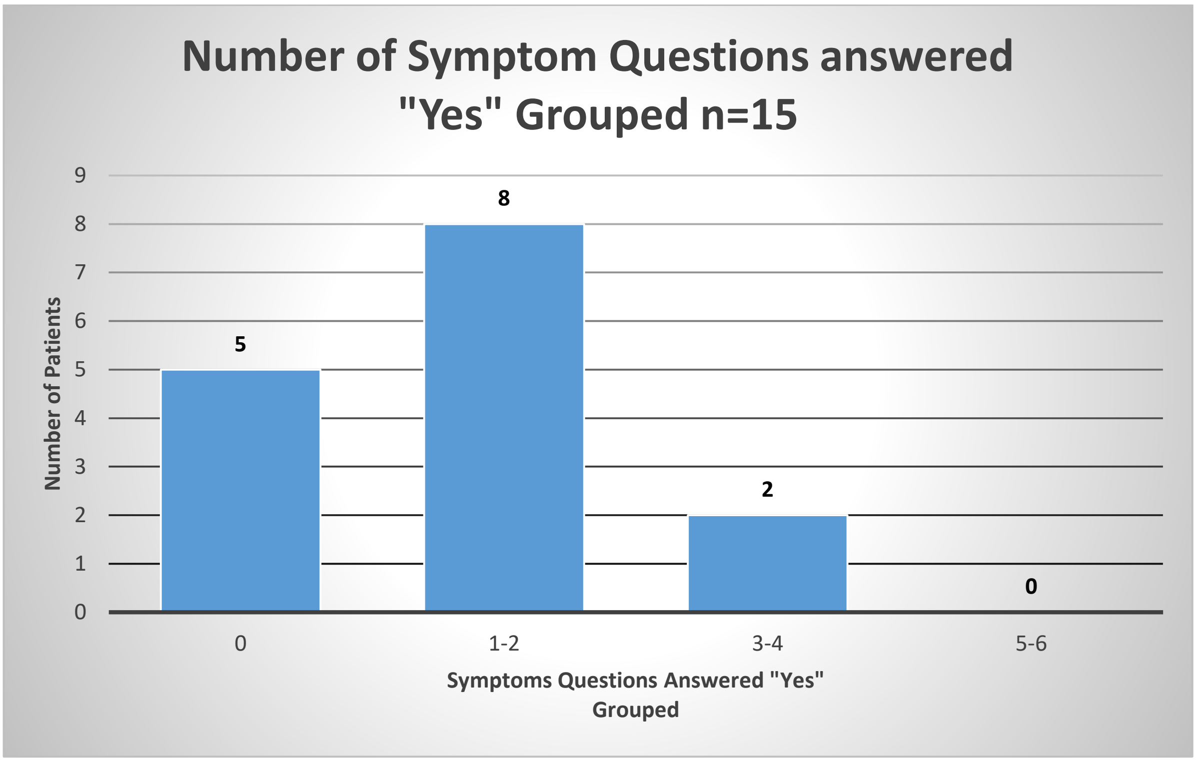

Figure A7.26 Number of Symptom Questions Answered “Yes” Grouped

OSDI levels:

The OSDI suggests a range of values: normal (0-12 points), mild (13-22 points), moderate (22-32 points) and severe (33-100 points). Any patient with a score over 12 can be labelled "symptomatic". Figure A7.7 shows the classification of the patients in the study. The largest group of patients seen was those that scored in the normal group.

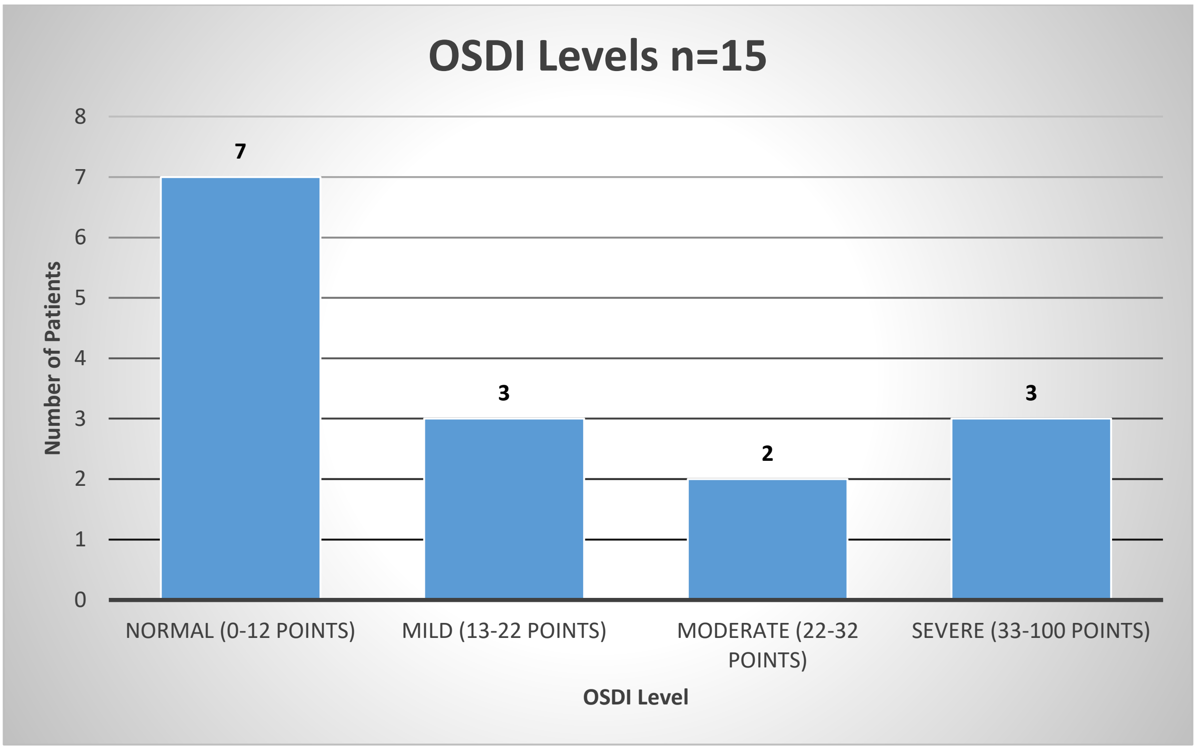

Figure A7.27 OSDI Levels

Signs seen on Slit Lamp and white light:

Of the 15 patients seen for an eye examination, 12 showed signs using the slit lamp and white light. These signs were categorised as seen in figure A7.9. The most common sign seen using the slit lamp was pinguecula which was seen in 9 patients. An average of 2 signs was seen per patient.

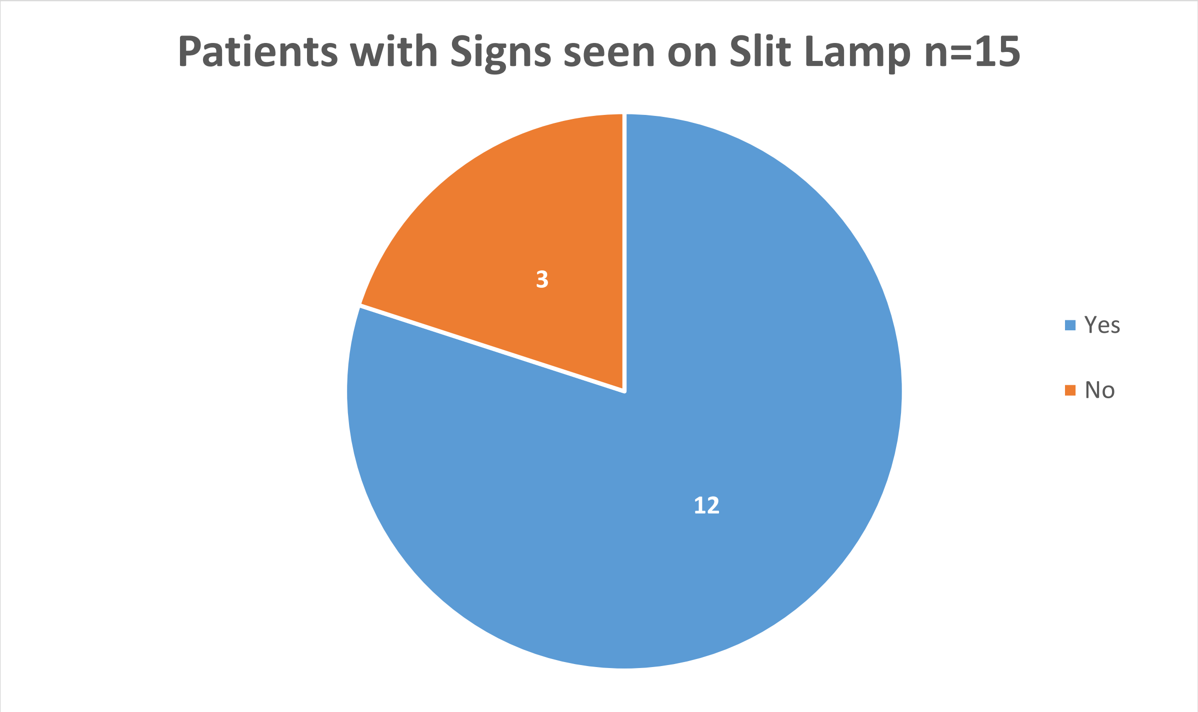

Figure A7.28 Patients with Signs seen on Slit Lamp

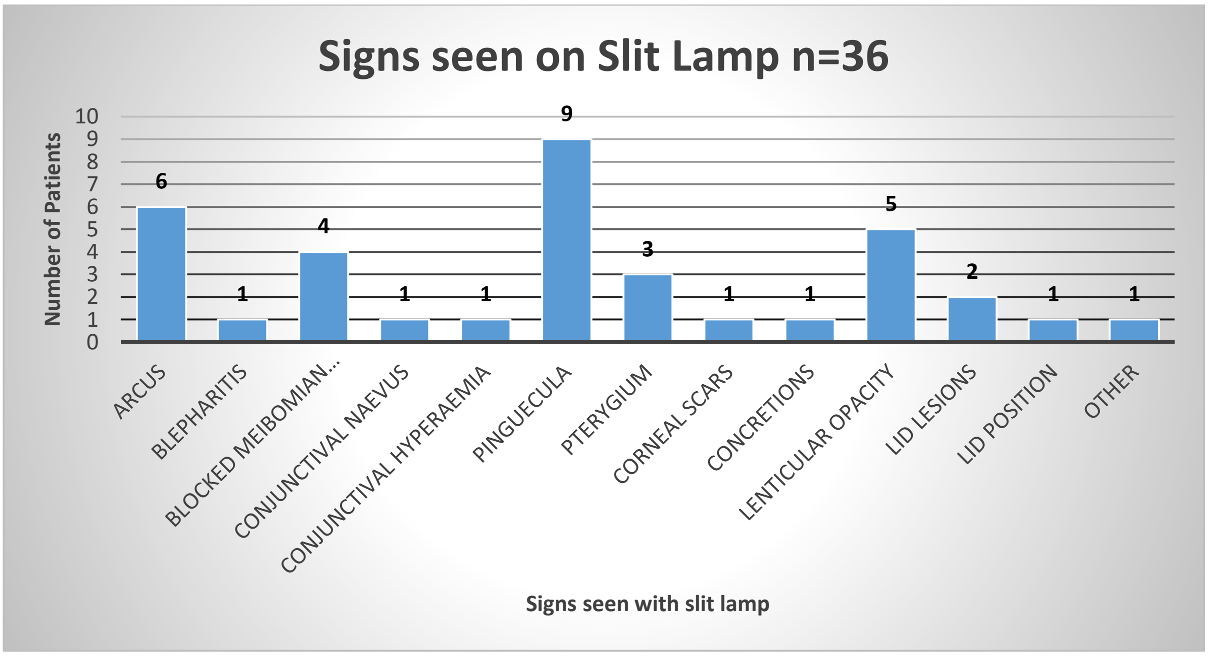

Figure A7.29 Signs seen on Slit Lamp

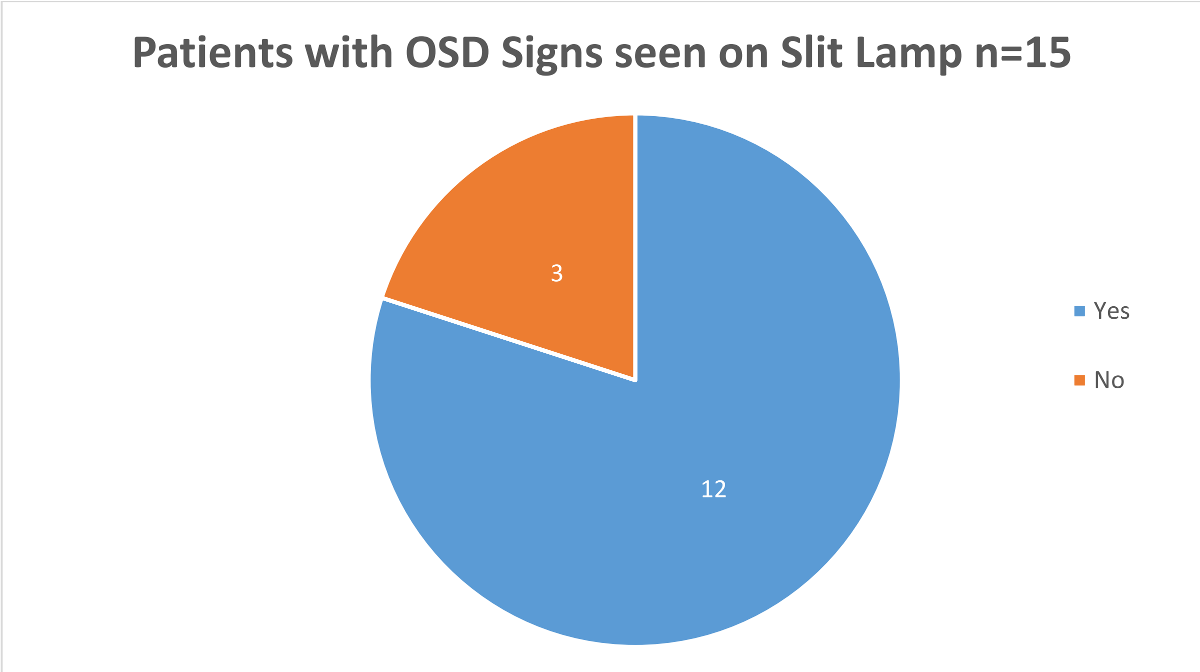

Figure A7.30 Patients with OSD signs seen on Slit Lamp

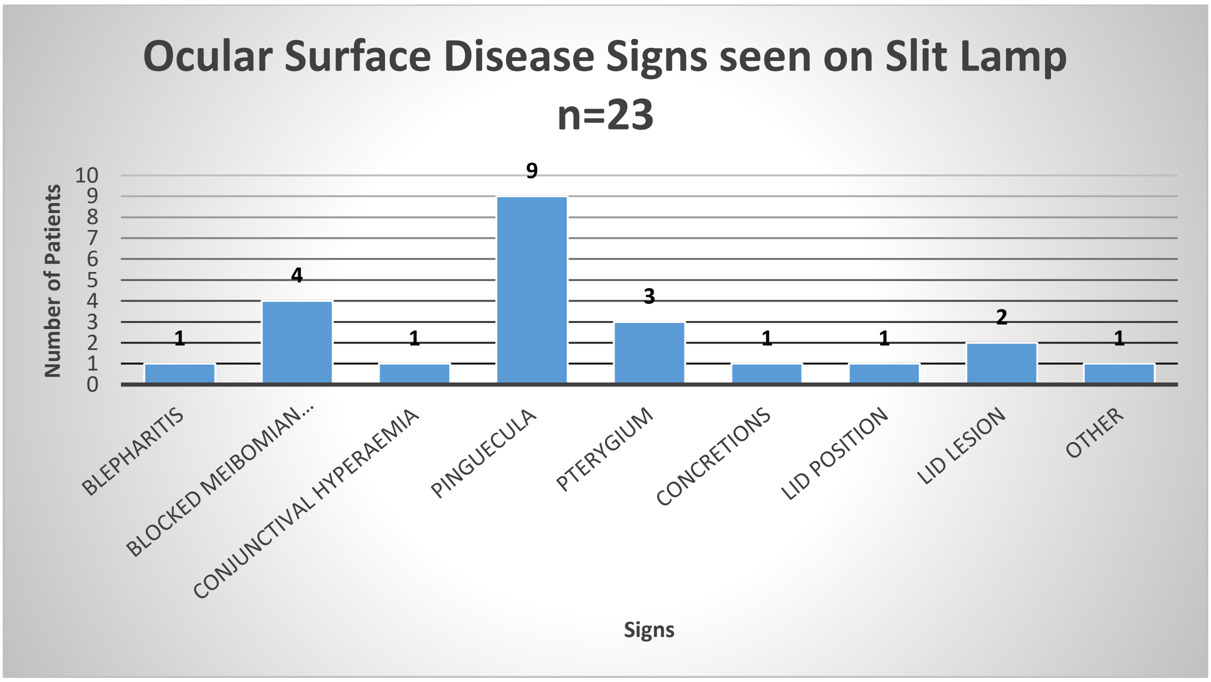

Figure A7.31 OSD Signs seen on Slit Lamp

Signs seen with NaFl:

When NaFl was instilled, 12 patients had clinical signs visible using NaFl whilst three patients did not. Figure A7.13 shows the breakdown of the signs visible when using NaFl.

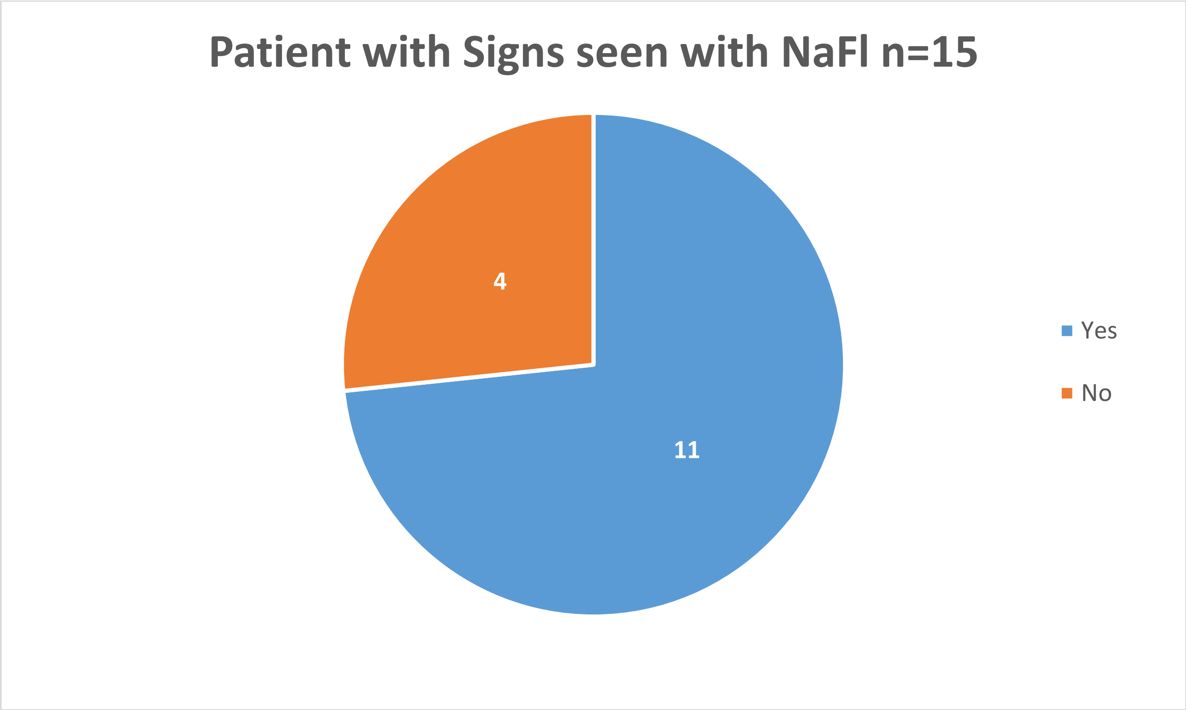

Figure A7.32 Patients with Signs seen with NaFl

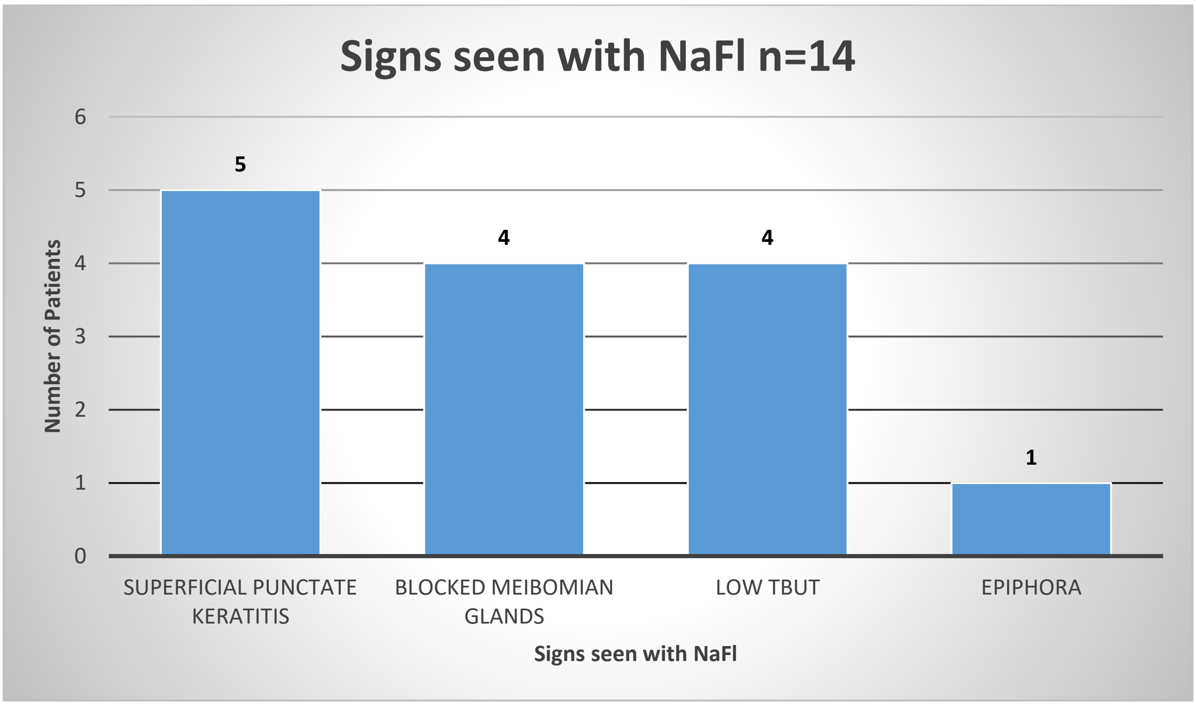

Figure A7.33 Signs seen with NaFl

From the 15 patients seen in the pilot study, 10 (67%) expressed themselves as symptomatic during history taking.
Eight patients (53%) were deemed to be symptomatic using the OSDI questionnaire.

Of the ten patients who were symptomatic during history, 7 (63.5%) were also symptomatic using the OSDI questionnaire.

Of the five patients who expressed themselves to be asymptomatic during history taking, only 1 (20%) was symptomatic using the OSDI questionnaire.

From the five patients who stated they were asymptomatic during history taking, 3 of them had clinical signs when viewed with white light, and all of them had clinical signs when NaFl was instilled.

Of the ten patients who stated they were symptomatic during history taking, 8 (80%) had clinical signs when viewed on the slit lamp with white light. When NaFl was instilled, 7 out of the 8 had further clinical signs.

Appendix 8

Chapter 3 Data Analysis Contingency Tables

OSDI Questionnaire

Is there a link between the age of the patient and the OSDI severity group?

		OSDI Severity Group				Total
		Normal	Mild	Moderate	Severe	
Age of Patient	20 - 35 years	4(22.2%)	2(11.1%)	5(27.8%)	7(38.9%)	18(100%)
	36 - 50 years	4(22.2%)	1(5.6%)	5(27.8%)	8(44.4%)	18(100%)
	51 - 65 years	13(40.6%)	3(9.4%)	6(18.8%)	10(31.3%)	32(100%)
	65+ years	11(39.3%)	13(46.4%)	1(3.6%)	3(10.7%)	28(100%)
Total		32	19	17	28	96

Table A8.4 Contingency Table for Age of the patient and OSDI Severity Group

Is there a link between the patient's gender and the OSDI severity group?

		OSDI Severity Group				Total
		Normal	Mild	Moderate	Severe	
Patient Gender	Female	22(35.5%)	9(14.5%)	12(19.4%)	19(30.6%)	62(100%)
	Male	10(29.4%)	10(29.4%)	5(14.7%)	9(26.5%)	34(100%)
Total		32	19	17	28	96

Table A8.5 Contingency Table for Patient Gender and OSDI Severity Group

Is there a link between the number of symptoms from the six symptom list answered yes during history and the OSDI severity group?

		Number of questions Px said they were symptomatic during history				Total
		None answered yes	1 - 2 questions answered yes	3 - 4 questions answered yes	5 - 6 questions answered yes	
OSDI Severity Group	Normal	21(65.6%)	11(34.4%)	0	0	32(100%)
	Mild	11(57.9%)	8(42.1%)	0	0	19(100%)
	Moderate	7(41.2%)	8(47.1%)	2(11.8%)	0	17(100%)
	Severe	11(39.3%)	17(60.7%)	0	0	28(100%)
Total		50	44	2	0	96

Table A8.6 Contingency Table for OSDI Severity Group and Number of Symptoms answered Yes during history

Is there a link between the number of symptoms from the six symptom list answered yes during history and the OSDI ocular symptom subscale severity?

		Number of questions Px said they were symptomatic during history				Total
		None answered yes	1 - 2 questions answered yes	3 - 4 questions answered yes	5 - 6 questions answered yes	
OSDI Ocular symptom subscale Severity	Normal	28(65.1%)	15(34.9%)	0	0	43(100%)
	Mild	6(40.0%)	8(53.3%)	1(6.7%)	0	15(100%)
	Moderate	6(54.5%)	5(45.5%)	0	0	11(100%)
	Severe	10(37.0%)	16(59.3%)	1(3.7%)	0	27(100%)
Total		50	44	2	0	96

Table A8.7 Contingency Table for OSDI Ocular Subscale and Number of Symptoms answered Yes during history

Signs on slit lamp and white light

By doing a slit lamp examination on every patient in the sample group, was it worthwhile to do the slit lamp examination, that is, were a significant number of signs discovered overall with white light?

Binomial Test

	Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Were signs seen on Slit Lamp and white light?	Yes	91	.95	.50	.000
	No	5	.05		
Total		96	1.00		

Table A8.8 Binomial Test for signs seen on slit lamp and white light

By doing a slit lamp examination on every patient in the sample group, was it worthwhile to do the slit lamp examination, that is, were a significant number of OSD signs discovered overall with white light?

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Were OSD signs seen on Slit Lamp and white light?		Yes	83	.86	.50	.000
		No	13	.05		
	Total		96	1.00		

Table A8.9 Binomial Test for OSD signs seen on slit lamp and white light

Is there a link between OSD signs seen on the slit lamp and patients who scored Normal severity group in the OSDI?

		Were OSD signs seen on Slit Lamp?		Total
		Yes	No	
OSDI Severity Group	Normal	26(81.3%)	6(18.8%)	32(100%)
	Mild	16(84.2%)	3(15.8%)	19(100%)
	Moderate	15(88.2%)	2(11.8%)	17(100%)
	Severe	26(92.9%)	2(7.1%)	28(100%)
Total		83	13	96

Table A8.10 Contingency Table for OSDI Severity Group and OSD signs seen on slit lamp

Binomial Test

	Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Comparison of Normal OSDI with OSD signs seen in slit lamp	Yes	26	.81	.50	.001
	No	6	.19		
Total		32	1.00		

Table A8.11 Binomial Test for Normal OSDI score with OSD signs seen on slit lamp

Was there a significant number of patients who were symptomatic using the OSDI yet had no signs using Slit Lamp?

Binomial Test

	Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
OSDI Symptomatic and OSD signs	No	7	.11	.50	.000
	Yes	57	.89		
Total		64	1.00		

Table A8.12 Binomial Test for symptomatic on OSDI with OSD signs seen on slit lamp

Was there a significant number of patients who were asymptomatic using the six symptom list yet had OSD signs using Slit Lamp?

		Were OSD signs seen on Slit Lamp?		Total
		Yes	No	
Six Symptom List answered Yes	No to all	43(86.0%)	7(14.0%)	50(100%)
	1 - 2 yes	38(86.4%)	6(13.6%)	44(100%)
	3 - 4 yes	2(100.0%)	0	2(100%)
Total		83	13	96

Table A8.13 Contingency Table for Six symptom list and OSD signs seen on slit lamp

Binomial Test

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Comparison of asymptomatic on six symptom list with OSD signs seen in slit lamp		Yes	43	.86	.50	.000
		No	7	.14		
	Total		50	1.00		

Table A8.14 Binomial Test for asymptomatic on OSDI with OSD signs seen on slit lamp

Was there a significant number of patients who were symptomatic using the history questions yet had no signs using Slit Lamp?

Binomial Test

	Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Comparison of Symptomatic with the six symptom list with OSD signs seen in slit lamp	No	6	.13	.50	.000
	Yes	40	.87		
Total		46	1.00		

Table A8.15 Binomial Test for symptomatic on six symptom list and OSD signs seen on slit lamp

Signs with NaFl

By using NaFl on every patient in the research group, was it worthwhile using NaFl, that is, were a significant number of signs discovered overall using NaFl?

Binomial Test

	Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Were signs seen with NaFl?	Yes	52	.54	.50	.475
	No	44	.46		
Total		96	1.00		

Table A8.16 Binomial Test for signs seen with NaFl

Is there a link between signs seen with NaFI and patients who scored normal in the OSDI questionnaire?

		Were signs seen with NaFI? Yes	No	Total
OSDI Severity Group	Normal	20(62.5%)	12(37.5%)	32(100%)
	Mild	10(52.6%)	9(47.4%)	19(100%)
	Moderate	8(47.1%)	9(52.9%)	17(100%)
	Severe	14(50.0%)	14(50.0%)	28(100%)
Total		52	44	96

Table A8.17 Contingency Table for OSDI severity group and signs seen with NaFI

Binomial Test

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Comparison of Normal OSDI with NaFI signs		Yes	20	.63	.50	.215
		No	12	.37		
	Total		32	1.00		

Table A8.18 Binomial Test for normal on OSDI with signs seen with NaFI

Was there a significant number of patients who were symptomatic using the OSDI questionnaire yet had <u>no</u> signs using NaFI?

Binomial Test

	Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
OSDI Symptomatic and NaFI signs	No	32	.50	.50	1.000
	Yes	32	.50		
Total		64	1.00		

Table A8.19 Binomial Test for symptomatic on OSDI with signs seen with NaFI

Was there a significant number of patients who were asymptomatic using the six symptom list yet had signs using NaFI?

		Were signs seen with NaFI?		Total
		Yes	No	
Symptomatic Scale Using Six Symptom List	No to all	29(58.0%)	21(42.0%)	50(100%)
	1 - 2 yes	23(52.3%)	21(47.7%)	44(100%)
	3 - 4 yes	0	2(100.0%)	2(100%)
Total		52	44	96

Table A8.20 Contingency Table for Asymptomatic on the six symptom list and Signs seen with NaFI

Binomial Test

	Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Comparison of asymptomatic patients on six symptom list with signs seen in NaFI	Yes	29	.58	.50	.322
	No	21	.42		
Total		50	1.00		

Table A8.21 Binomial Test for asymptomatic patients on six symptom list with signs seen with NaFI

Was there a significant number of patients who were symptomatic using the six symptom list yet had NO signs using NaFI?

Binomial Test

	Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Comparison of Symptomatic with signs seen in NaFI	No	23	.50	.50	1.000
	Yes	23	.50		
Total		46	1.00		

Table A8.22 Binomial Test for symptomatic patients on six symptom list with signs seen with NaFI

Signs with Wratten Filter

		Were signs seen using Wratten?		Total
		Yes	No	
Were signs seen with NaFl?	Yes	52(100%)	0	52(100%)
	No	0	44(100.0%)	44(100%)
Total		52	44	96

Table A8.23 Contingency Table for Signs seen with NaFl and Signs seen with Wratten