CITY UNIVERSITY LONDON

Optometry and Visual Science

A Study of Case Finding for Chronic Open Angle Glaucoma by UK Community Optometrists

Joy Myint

Submitted for the degree of

Doctor of Philosophy

City University

Division of Optometry and Visual Science

July 2013

Contents

List of Tables

List of Figures

Acknowledgments

I will be forever indebted to my supervisors Professor John Lawrenson and Professor David Edgar without whom this project, and this thesis, would not have been possible. They believed in me enough to give me this opportunity and have shown me unfaltering patience, encouragement, guidance, reassurance and kindness. Their support and endless efforts through related and unrelated difficulties as well as their vast academic knowledge and expertise, have been invaluable to me. I am extremely proud to call them supervisors, mentors and friends and owe them my deepest gratitude. An enormous credit for this thesis must be afforded to them both.

Thanks also to my advisors Mr. Ian Murdoch and Dr. Aachal Kotecha, for generously and selflessly giving encouragement, inspiration, advice and time. To my examiners Professor Andrew McNaught and Dr Paul Spry, I am grateful for a very pleasant experience, and for allowing me the opportunity to learn from their wisdom.

It has been an honour to have once again studied and worked in the Division of Optometry and Visual Science, City University, London, and to collaborate with esteemed colleagues at Moorfields Eye Hospital.

Heartfelt thanks also should go to Pfizer Ophthalmology, Ms. Anita Lightstone, the Association of Optometrists, Professor David Henson, Dr. Helen Baker, Professor David Crabb, Mr Henri Obstfeld, Professor Chris Hull ("The Chair"), to Dutch colleagues and of course to the Delphi panel and my many "respondents".

To my friends and colleagues who were there when I needed enthusiasm, wisdom and moral support. There are too many to thank but I will mention (in alphabetical order) Andrew, Caroline, Colin, D and D, David, Duncan, Jane M, Jane P, Janet (is it Friday yet?), Kez, Liam, Matilda, Miriam, Paul, Peter and B & C and T & T. To Bill, Clare, Kalpana, Karen and especially Lynne to whom I will always be eternally grateful, you deserve a special mention, your patience, thoughtfulness and care has been seemingly untiring and limitless. Thank you also to the various medical and surgical experts I have visited in recent times.

To my family for their endless faith and belief in me and for their love, nurture, care and understanding which has aided me immensely. Even in my darkest hours, they were there for me. For my late (much missed) father, my mother, Steven, Fiona, Tim, Nick, Lucy and Poppy; it is to you that this is dedicated. 无难事只怕有心人 有志者事竟成

Declaration

I grant powers of discretion to the Division of Optometry and Visual Science, City University London to allow this project to be copied in whole or in part without further reference to me. This permission covers only single copies made for study purposes, subject to the normal consideration of acknowledgement.

Abstract

A Study of Case Finding for Chronic Open Angle Glaucoma (COAG) by UK Community Optometrists

In 2009 approximately 480,000 people were affected by COAG in England. Furthermore, glaucoma sufferers and suspects are responsible for over one million glaucoma-related outpatient visits annually. Community optometrists make over 95% of suspect COAG referrals, identifying suspects through opportunistic case-finding. Optometrists' case-finding is largely based on a triad of tests: optic nerve head assessment, tonometry, and visual fields. There has been little research into optometrists' COAG case-finding strategies.

Chapter 2 reports on a national survey regarding COAG case-finding methodologies and referral criteria. Survey response validity was confirmed by comparing these with a national sample of referral letters. UK optometrists are well-equipped to detect COAG. Optometrist's skills and scope of practice in the detection of glaucoma have evolved since the last national survey in the late 1980's. The level of funding and nature of the GOS contract in England limits development of effective services for glaucoma detection. For comparison, the survey was also performed in the Netherlands. Dutch optometrists own fewer automated field screeners but more goniolenses and pachymeters, and are more likely to use binocular indirect ophthalmoscopy than UK optometrists.

Chapter 3 describes the development of a competency framework for optometrists with a specialist interest in glaucoma utilising Delphi methodology. The Delphi technique is a robust method for gaining autonomous expert opinion. This approach has led to the development of an accepted national competency framework for optometrists with a special interest in glaucoma.

Chapter 4 evaluated the impact of a postgraduate educational intervention on aspects of glaucoma detection. The intervention increased awareness of disc changes in glaucoma, but was less effective for clinical decision-making and for improving performance in the Discus program for disc assessment. The traditional didactic teaching style is unsuited for training optometrists in the clinical competencies required for glaucoma detection and management.

Chapter 5 is a unifying summary of preceding chapters and contains recommendations for future research.

Abbreviations

ABDO	Association of British Dispensing Opticians
A/C	Anterior Chamber
ACG	Angle Closure Glaucoma
AOP	Association of Optometrists
AUROC	Area under the receiver operating characteristic curve
BSc	Bachelor of Science
BEH	Bristol Eye Hospital
CCT	Central corneal thickness
CDM	Clinical Decision Making
CDR	Cup-disc ratio
CET	Continuing Education and Training
CHANGES	Community and Hospital Allied Network Glaucoma Evaluation Scheme
CIGTS	Collaborative Initial Glaucoma Treatment Study
CNTGS	Collaborative Normal-Tension Glaucoma Study
COAG	Chronic open angle glaucoma
CoO	College of Optometrists
CPD	Continuing Professional Development
DH	David Henson
EMGT	Early Manifest Glaucoma Treatment
F+	False Positive
F-	False Negative
FDT	Frequency Doubling Technology
FH	Family History
FODO	Federation of Ophthalmic and Dispensing Opticians
GAT	Goldman applanation tonometry
GIST	Glaucoma Inheritance Study in Tasmania
GOC	General Optical Council
GON	Glaucomatous Optic Neuropathy
GONE	Glaucomatous Optic Neuropathy Evaluation
Gonio	Goniolens
GOS	General Ophthalmic Services
GMP	General Medical Practitioner
GPS	Glaucoma Probability Score
GRR	Glaucoma referral refinement

HES	Hospital Eye Service
HFA	Humphrey Field Analyser
HRT	Heidelberg Retina Tomograph
HTA	Health Technology Assessment
IGA	International Glaucoma Association
IOP	Intraocular pressure
ISNT	Inferior, Superior, Nasal, Temporal (Jonas' Rule)
LOCSU	Local Optical Committee Support Unit
MD	Mean Deviation
MRA	Moorfields Regression Analysis
MREH	Manchester Royal Eye Hospital
MYOC	Myocilin
NCT	Non-contact tonometry
NHS	National Health Service
NICE	National Institute of Health and Clinical Excellence
NIHR	National Institute of Health Research
N. Ireland	Northern Ireland
NPC	National Prescribing Centre
NRR	Neural Retinal Rim
NTG	Normal tension glaucoma
NTGS	Normal Tension Glaucoma Study
OAG	Open-angle glaucoma
OCT	Optical Coherence Tomography
OHT	Ocular hypertension
OHTS	Ocular Hypertension Treatment Study
OLGA	Optometric Led Glaucoma Assessment
OMP	Ophthalmic Medical Practitioner
ONH	Optic Nerve Head
OVN	Optometristen Vereniging Nederland
PCT	Primary Care Trust
POAG	Primary open-angle glaucoma
PPA	Peripapillary Atrophy
PPV	Positive Predictive Value
PQE	Professional Qualifying Examination
PSD	Pattern Standard Deviation
RCOphth	Royal College of Ophthalmologists

RNFL	Retinal Nerve Fibre Layer
ROC	Receiver Operating Characteristic
SAP	Standardised automated perimetry
SD	Standard Deviation
SfR	Scheme for Registration
SP	Standardised patient
SWAP	Short wavelength automated perimetry
T+	True Positive
T-	True Negative
UK	United Kingdom
VF	Visual Fields
VFA	Visual Field Analyser (Friedmann)
WCO	World Council of Optometry
WECI	Welsh Eyecare Initiative
WEHE	Welsh Eye Health Examination
WHO	World Health Organisation

Chapter 1: Introduction

1.1 Definition of glaucoma

The word “glaucoma” is derived from the Greek word “glaukos” which means blue-green glow (Tsatos & Broadway, 2007). Glaucoma is actually not a single disease entity but a group of diseases. There are many definitions of glaucoma, but one frequently used is that published by the European Glaucoma Society: “Glaucoma is a group of diseases that result in a progressive optic neuropathy that causes characteristic changes in the optic nerve head and retinal nerve fibre layer” (European Glaucoma Society, 2003). The biological basis or pathogenesis of the disease is not fully understood (Weinreb and Khaw, 2004), though it is undoubtedly multifactorial in nature (Anderson, 1989; Drance, 1997; Bonomi et al, 2001; Foster et al, 2002).

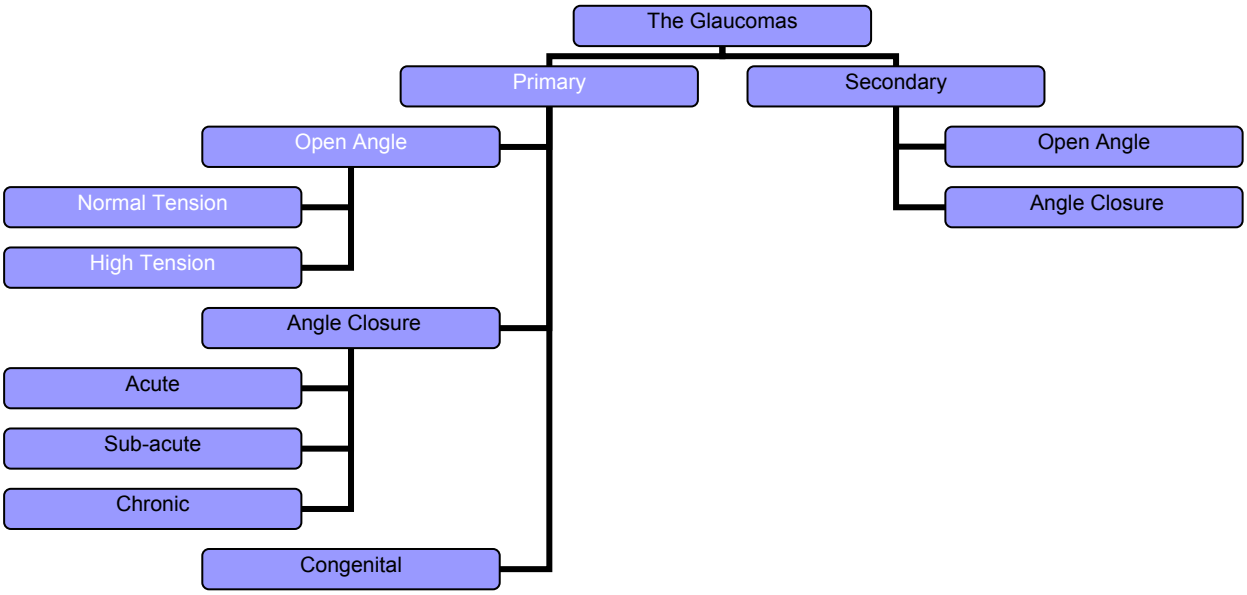
The association between raised intraocular pressure (IOP) and glaucoma has been known since the 19th century, but since the late 1980s and early 1990s (Sponsel, 1989; Quigley, 1993) IOP has been omitted from the definitions of open angle glaucoma, instead being regarded as an important risk factor for the condition.

1.2 Classification of the glaucomas

The glaucomas can be classified in several ways, for example according to the mechanism of damage, or by the aetiology of IOP elevation (Allingham et al., 2005). The classification chosen for this thesis is based on the cause of IOP elevation (Spry & Harper, 2010), and a simplified version of this classification is shown in Figure 1.1.

The first subdivision indicates whether the disease is primary or secondary in origin, and then each of these is further subdivided into open-angle or angle-closure. Open-angle glaucoma also includes congenital glaucoma. As approximately 95% of all glaucomas are primary, and glaucoma detection by community optometrists focuses on primary glaucoma, there will be no further consideration of secondary glaucoma in this thesis.

Figure 1.1: Simplified Classification of the Glaucomas.



1.2.1 Terminology

An ongoing issue in glaucoma is accommodating the different terms that can be used to describe the same condition. During the course of the research studies which are reported in this PhD thesis, the National Institute for Health and Clinical Excellence (NICE) Clinical Guideline 85 was published (NICE, 2009) and this has led to the increased use of the term Chronic Open Angle Glaucoma (COAG). NICE defined COAG as: *Glaucoma without evident secondary cause, which follows a chronic time course and occurs in the presence of an open anterior chamber angle*

The author adopted the term COAG following the publication of the Guideline, and this term has been used in three publications to emerge from this thesis. Two earlier publications based on the research presented in the thesis use the term Primary open angle glaucoma (POAG) to refer to what is now called COAG. Furthermore, the term POAG was used in many of the publications referenced in this thesis and is still used in many current publications. There is clearly potential for confusion in the use of terminology here and, in an effort to address this issue, the author has adopted the following strategy in the thesis:

- Where there is no scope for confusion (i.e. where either the author or the publications referred to in the text have used the term COAG) the term COAG is used.
- Where the possibility for confusion exists (i.e. where either the author or the publications referred to in the text have used the term POAG in place of COAG) the term OAG has been used.

1.2.2 Angle closure glaucoma (ACG)

A common feature of the group of conditions that comprise ACG is closure of the angle of the anterior chamber, a closure which can result from a number of possible causes. Angle closure leads to elevated IOP which causes glaucomatous optic neuropathy. There are a number of risk factors for ACG, including increasing age, hypermetropia, ethnicity and female gender (Spry & Harper, 2010). Unlike COAG, ACG is sometimes accompanied by symptoms. The prevalence of ACG in European populations was estimated to be 0.25% in 2010 (Quigley & Broman, 2006). The focus of the current thesis is on case-finding for COAG, but community optometrists have an important role to play in the detection and appropriate management of acute, chronic and intermittent ACG (College of Optometrists Clinical Management Guidelines, 2009a).

1.2.3 Normal Tension Glaucoma

Normal Tension Glaucoma (NTG) is defined by NICE (2009) as: “A type of chronic open-angle glaucoma where intraocular pressure has rarely been recorded above 21 mm of Hg (a figure frequently taken as the ‘statistical’ upper limit of the normal range)”.

1.3 Ocular Hypertension

Ocular hypertension (OHT) is usually defined as an intra-ocular pressure that is consistently or recurrently greater than 21mmHg, in the absence of any optic nerve head damage and/or visual field defect (NICE, 2009). The prevalence of OHT is greater than that of OAG and in Caucasian populations has been estimated to lie in the range from 4.5% to 9.4% for those older than 40 years of age (Burr et al., 2012). Based on a prevalence of 5%, Burr et al calculate that around 1 million adults over the age of 40 in the UK have OHT. Since the publication of the NICE guideline (2009)

optometrists have had a key role to play in the detection and appropriate referral of OHT.

1.4 Epidemiology of glaucoma

There have been many major population-based studies related to glaucoma (Friedmann et al., 2004a). Among the most notable of these are the Baltimore Eye Survey (US), the Beaver Dam Eye Study (US), the Blue Mountains Eye Study (Australia), the Roscommon study (Irish Republic), the Melbourne project (Australia) and the Rotterdam Eye Study (The Netherlands). They have identified the prevalence of OAG in adults, with some studies including those aged over 40 years of age (e.g. Baltimore and Melbourne) up to one study including patients over 55 years of age (Rotterdam). The prevalence figures vary, reflecting different inclusion criteria in terms of age and different definitions of glaucoma, but a broad consensus emerges from these well-designed and well-executed studies: the prevalence of OAG varies from around 1.1% to 2.4% in adult White populations (Table 1.1) (Coffey et al., 1993; Dielemans et al., 1994; Mitchell et al., 1996; Sack et al., 1996; Kroese et al., 2002; Owen et al., 2006).

Table 1.1: Estimates of the prevalence of Open Angle Glaucoma in White adult populations from well-designed population-based studies.

Study	Prevalence
Baltimore (1990)	1.1% (40 years of age and over)
Beaver Dam (1992)	2.1% (43 years of age and over)
Blue Mountains (1996)	2.4% (49 years of age and over)
Roscommon (Ireland) (1992)	1.9% (50 years of age and over)
Melbourne (1997)	1.7% (40 years of age and over)
Rotterdam (1996)	1.1% (55 years of age and over)

1.4.1 Ethnic variations in OAG prevalence

Using data from population-based studies, Quigley and Broman (2006) generated prevalence models that allowed them to estimate the numbers of people in different regions of the world predicted to be suffering from glaucoma in 2010 and 2020. These

estimates for 2010 are presented in Table 1.2 as percentages of the population over 40 years of age in each region predicted to have OAG. Africans are most likely to develop OAG (prevalence 4.16%) compared to all other ethnicities and compared to the world prevalence of 1.96%, which is virtually identical to the prevalence in Europe.

Table 1.2: Estimated prevalence of open angle glaucoma (OAG) in the over-40s in different regions as reported by Quigley and Broman (Quigley & Broman, 2006).

World Region	% with OAG
Africa	4.16%
Japan	3.31%
Latin America	3.16%
Europe	1.97%
India	1.75%
China	1.40%
Middle East	1.31%
South East Asia	1.18%
World	1.96%

In world terms glaucoma is a major health problem and Quigley and Broman's modelling predicted that in 2010 there would be 60.5 million people with glaucoma, comprising 44.7 million with OAG and 15.7 million with Angle Closure Glaucoma (ACG). The total for all glaucomas is set to increase to 79.6 million by 2020, of which 74% will have OAG. If not treated, all glaucomas could result in permanent impairment of vision, and glaucoma is one of the world's leading causes of irreversible low vision (Thylefors et al., 1995; Congdon et al., 2003). There are several definitions of low vision that are in use internationally. The World Health Organisation (WHO) uses two definitions of low vision, the first as included in ICD-10 (a subsection of the International standard diagnostic classification) is "a visual acuity less than 6/18 and equal to or better than 3/60 in the better eye with best correction". The alternative definition is a person who has an "impairment of visual functioning even after treatment

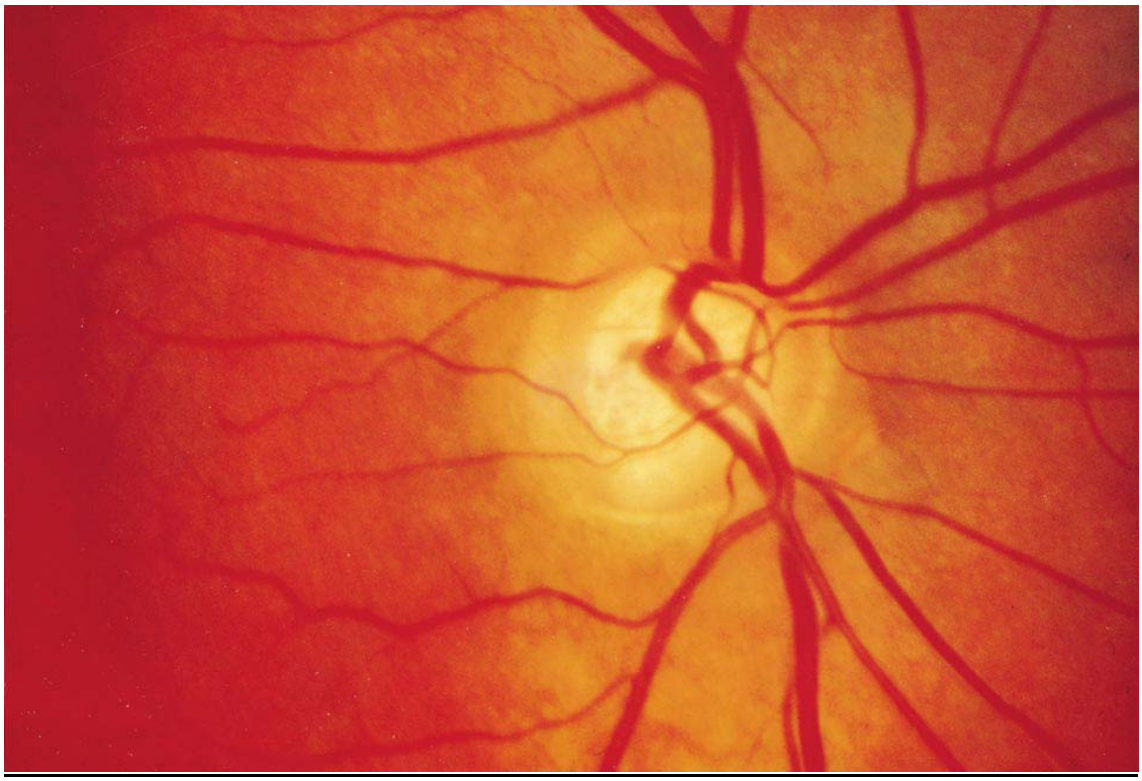
and/or standard refractive correction, and has a visual acuity of less than 6/18 to light perception, or a visual field less than 10 degrees from the point of fixation, but who uses, or is potentially able to use, vision for the planning and/or execution of a task for which vision is essential." Blindness is defined by the WHO, as included in ICD-10, as a visual acuity <3/60 in the better eye or visual field constricted to <=10 degrees in the better eye.

The World Health Organisation (Thylelfors et al., 1995) indicated from blindness survey data that glaucoma accounted for blindness in 5.2 million people, or 15% of total global blindness (Thylefors et al., 1994). Three million of these blind people were blind as a result of OAG. The numbers of those classified as blind as a result of glaucoma has increased dramatically since then, with a prediction from Quigley and Broman (2006) that bilateral blindness would be present in 4.5 million people suffering from OAG in 2010, rising to 5.9 million people by 2020.

1.5 Chronic open angle glaucoma

Chronic open angle glaucoma is a bilateral condition, though usually asymmetric in the nature of its progression, with one eye having more advanced disease than the other when the disease is detected (Hatt et al., 2009). It is characterised by an excavated optic nerve head appearance (see Figure 1.2), often referred to as Glaucomatous Optic Neuropathy (GON), resulting from atrophy with loss of ganglion cell axons. The anterior chamber drainage angle is open and will have a normal appearance. In the early stages of the condition there may not be any detectable visual field defect, and any defect that is present may go un-noticed by the patient, in part due to the naturally overlapping binocular components of the right and left visual fields. Hence OAG is largely asymptomatic in the early stages of the condition, though may become symptomatic in more advanced disease when severe visual field loss may have occurred and/or visual acuity is reduced. As the optic nerve head progresses to further excavation the field damage will worsen. A review of the literature shows considerable variability in how OAG is defined in studies (Bathija et al., 1998; Wolfs et al., 2000; Foster et al., 2002; European Glaucoma Society, 2003).

Figure 1.2: A glaucomatous optic disc showing focal loss of inferior neuro-retinal rim tissue (image credit: Broadway et al., Surv Ophthalmol 43 [Suppl 1] :S223–S243, 1999).

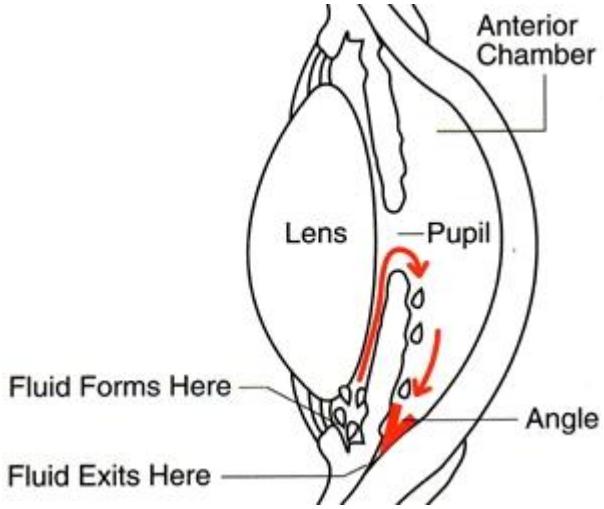


1.5.1 Aqueous production and drainage

Glaucomatous damage is often related to changes in the dynamics of aqueous humour, the transparent colourless fluid circulating in the anterior chamber of the eye. The primary actions of aqueous humour are to provide nutrients to the avascular components of the anterior eye (cornea and lens); and also to maintain the eye's intra-ocular pressure (Lawrenson, 2007). This is achieved via a balance between the rate of aqueous production in the ciliary body, and the rate of aqueous outflow. The majority of the outflow is through the conventional outflow pathway, via the trabecular meshwork, the canal of Schlemm and then into the venous system on the surface of the eye through aqueous veins or collector channels (Tripathi & Tripathi, 1982). The remainder drains via the alternative outflow route along the uveoscleral pathway (Hitchings, 2000). The percentage draining through the alternative route has been estimated to be approximately 15% based on measurements on cadaver eyes but indirect evidence from younger individuals gives a higher estimate (Alm, 2000). Intraocular pressure is therefore determined by the rate of aqueous production, the rate of outflow by both

routes and the episcleral venous pressure. It should be noted that outflow resistance increases with advancing age in a normal eye in the absence of glaucoma (Tamm, 2009). Figure 1.3 illustrates the dynamics of aqueous production and drainage.

Figure 1.3: The flow of Aqueous Humour (Image Credit: National Eye Institute, National Institutes of Health).



1.6 Mechanism of damage in OAG

The mechanism of axonal damage in the optic nerve head is a controversial topic with two main theories being proposed. These are that the damage is either mechanical or vascular in origin (He et al., 2011; Yanagi et al., 2011). The controversy regarding pathogenesis is further exacerbated when considering the appearance of glaucomatous optic neuropathy in individuals with intraocular pressure that could be considered to be within the 'normal' range and, conversely, people who present with no damage to nerve fibres despite having 'high' IOPs.

1.7 Structural changes in glaucoma and their assessment

OAG is typified by damage to retinal ganglion cells and their axons which lead to characteristic visual field loss. It is the characteristic pattern of damage to the optic nerve head, related to the distribution and arrangement of the retinal nerve fibres, "that differentiates glaucoma from other causes of visual morbidity" (Foster et al., 2002). The retinal nerve fibres that originate from the retina temporal to the fovea do not cross the fovea as they approach the optic nerve head because to do so would impair sharp image formation at the fovea. Instead these nerve fibres arch above and below the fovea, entering the optic disc at its upper and lower poles. Nor do these nerve fibres cross the midline (Horizontal Raphé), and these anatomical configurations give rise to the characteristic arcuate shape of the nerve fibre bundles on the retina. The initial damage to ganglion cells and their axons in glaucoma is primarily noted at the inferior and superior poles of the disc, where these arcuate fibres from the temporal retina enter the optic nerve head, and many practitioners will routinely record vertical cup/disc ratio and comment on the neuro-retinal rim in order to detect any glaucomatous changes (Kotecha, 2009).

It is clearly essential that the optic disc be carefully assessed to detect and monitor progression of glaucoma. For a clinician to conduct a comprehensive examination of the optic nerve head (ONH) it is necessary to dilate the pupil and use binocular indirect ophthalmoscopy to provide a stereoscopic view (Kotecha, 2009). However, this remains a subjective approach and more objective techniques for examining the optic disc in glaucoma and suspect glaucoma have emerged (Sharma et al*.,* 2008). For example, fundus cameras provide a relatively cheap way to document permanently the appearance of the optic nerve head, with stereoscopic images often used in the hospital setting. In recent years optical coherence tomography (OCT) has become increasingly popular. OCT makes use of low coherence interferometry to generate high-resolution cross-sectional images of the optic disc and the surrounding nerve fibre layer (Chang & Budenz, 2008). However the quality of the OCT scan can be affected by a number of factors including media opacities, movement and the severity of the underlying disease. The confocal scanning laser ophthalmoscope (SLO) takes multiple two-dimensional scans of the optic nerve head and surrounding retina. Combining data from these two-dimensional scans generates a three-dimensional image of the ONH (Spry & Harper, 2010). This method has been utilised in the Heidelberg Retinal Tomograph (HRT) and the latest version (HRT3) also incorporates the Moorfields

Regression Analysis (MRA) database and the Glaucoma Probability Score (GPS) as aids for detection of glaucomatous ONH change (Andersson et al., 2011). Scanning laser polarimetry (SLP) can objectively measure the retinal nerve fibre layer (RNFL) thickness surrounding the optic disc by taking advantage of the fact that the RNFL is a bi-refringent tissue. The SLP technique uses low intensity polarised laser light to measure the retardation or change in polarisation when light illuminates the bi-refringent RNFL. A challenge in this technique is to separate retardation resulting from the nerve fibre layer from retardation caused by the cornea and lens, with algorithms being employed to compensate for the retardation introduced by the cornea in particular (Lemij & Reus, 2008).

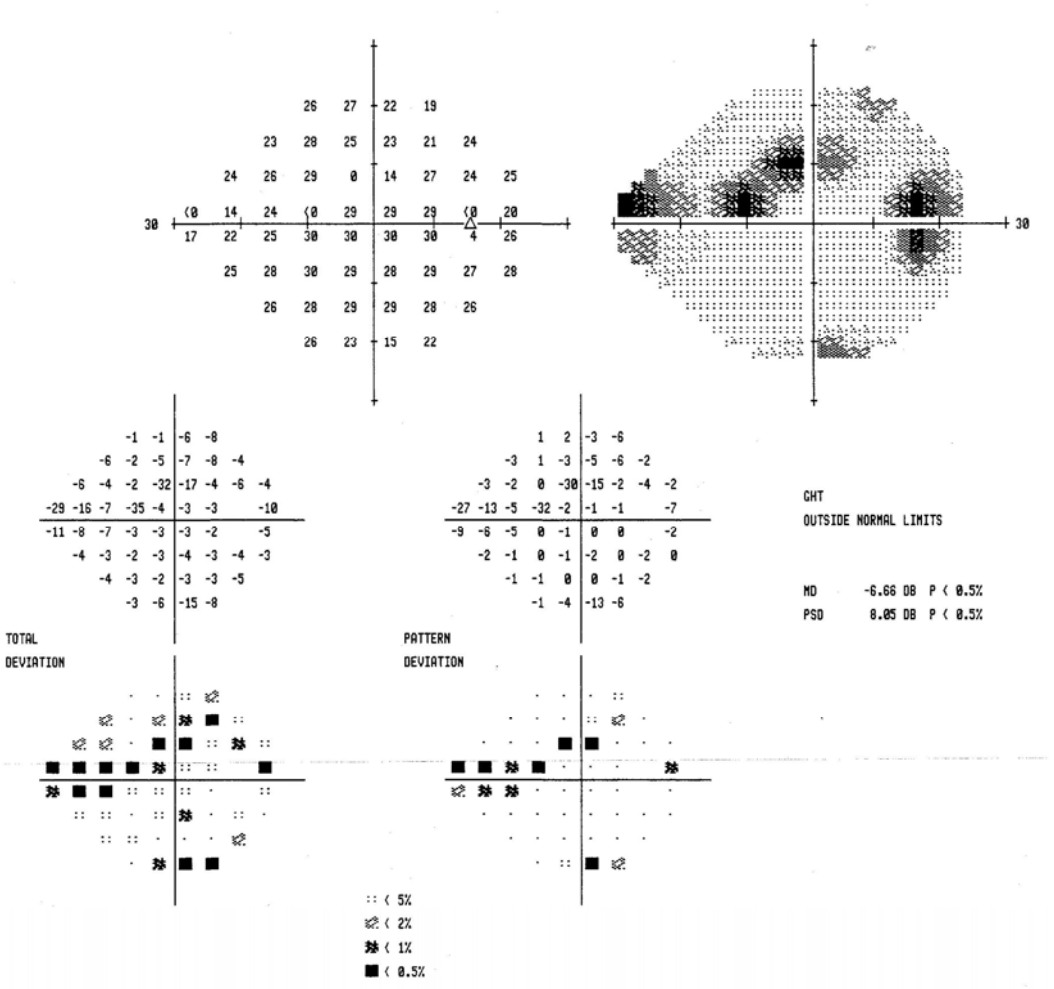
1.8 Changes in visual function in glaucoma and their detection

Although glaucoma can affect many aspects of visual function, including contrast sensitivity, colour vision, motion sensitivity, and eventually visual acuity (Sinclair, 2012), it is the effects of the disease on the visual field that is the aspect of visual function most frequently tested in both primary care optometry and secondary care. Over the years many tests have been developed for the assessment of the visual field but static automated perimetry (using both supra-threshold and threshold techniques) is now the established method. The field testing equipment routinely used by community optometrists in glaucoma case-finding has been investigated in the current research and the results are presented in Chapter 2 of this thesis. In hospital outpatient departments in the UK it is Standard Automated Perimetry (SAP) using the Humphrey Field Analyser (HFA) which predominates. Figure 1.4 shows an example of typical arcuate pattern of field loss in OAG as plotted on the HFA, with the shape of the visual field defects reflecting the damage to the arcuate nerve fibre bundles.

Reports in the 1980s, such as that by Quigley et al., 1988, suggest that as many as 30% of nerve fibre axons could have atrophied before a definite visual field defect could be detected, and these findings have led to the development of alternative tests for the detection of early glaucoma. More recent research, based on both psychophysics and histological research (e.g. Yucel et al*.,* 2000; McKendrick et al*.,* 2004) has challenged findings such as those by Quigley et al. However, in efforts to find improved tests for the early detection of OAG, several novel tests of visual function have been developed as alternatives to standard white-on-white perimetry. One of these, Frequency-Doubling Technology Perimetry (FDT), has been adopted in UK

community optometric practice as an alternative to conventional methods of perimetry. Automated perimetry is a non-selective test, in the sense that it tests all three subtypes of retinal ganglion cell (magnocellular, koniocellular and parvocellular). FDT makes use of the frequency doubling illusion, first described by Kelly (1981), in which a low spatial frequency grating is counter-phase modulated at a high temporal frequency. The illusion is said to be mediated principally by the magnocellular pathway. The gratings are presented at 16 locations in the visual field and the patient indicates if they can detect the grating against the uniform grey background. The test is fast, but recent research (Jampel et al., 2011) suggests that it there is no clear advantage to be obtained by using FDT compared with standard automated perimetry.

Figure 1.4: Typical Field Loss associated with Open Angle Glaucoma (Image Credit: Mr. Ian Murdoch).



1.9 Burden of glaucoma in the UK

1.9.1 Visual impairment and registration as a result of glaucoma

Analysis of blind (severely sight impaired) and partial sight (sight impaired) registrations in England and Wales between April 1990 and March 1991 revealed that 11.7% of blindness was caused by glaucoma in all age groups (Evans, 1995). A similar analysis covering the period between April 1999 and March 2000 found that glaucoma accounted for 10.9% of all blindness certifications and 10.2% of all partial sight registrations (Bunce & Wormald, 2006). In a more recent study, glaucoma accounted for 8.4% of all blindness certification and 7.4 % of all partial sight registration for the period April 2007-8 (Bunce et al., 2010). These studies indicate that, despite improvements in treatment modalities, glaucoma is a disease which continues to account for a significant proportion of those registered as sight impaired and severely sight impaired in the UK. There is evidence that these registration data may be an underestimate of the extent of the problem, as some of those eligible for registration may not wish to be registered. Also the criteria applied for registration have an element of subjectivity in their interpretation (Burr et al., 2007).

A study investigating visual impairment in a small sample of the North London elderly population established that 3% had open angle glaucoma while 7% had suspect glaucoma (Reidy et al., 1998). A study which quantified visual impairment in a sample of 75 year olds identified that 7.9% were visually impaired as a result of glaucoma (Evans et al., 2004).

1.9.2 Burden of glaucoma in secondary care

NICE (2009) estimated that 172,000 referrals of patients with suspected glaucoma are made to the HES each year, and that about one third of these patients will need long-term follow-up. With predicted changes in UK population demographics, the number of people with glaucoma can be expected to rise. One estimate was that there will be an increase of approximately one third in the total number of people with glaucoma (both detected and undetected) between 2001 and 2021, with a comparable further increase by 2031 (Tuck & Crick, 2003). This equates to an estimate of 400,000 people with OAG in England Wales in 2021, rising to 530,000 by 2031. However, these estimates have since been revised upwards with NICE estimating that in 2009 there were

approximately 480,000 people affected by OAG in England. Furthermore, glaucoma sufferers and suspects are responsible for over one million glaucoma-related outpatient visits to the Hospital Eye Service (HES) each year (NICE, 2009).

It is noteworthy that several population studies in the UK and Australia have indicated that only 50% approximately of cases of OAG are diagnosed (Crick, 1994; Mitchell et al., 1996; Wensor et al., 1998). This would equate to approximately 250,000 people in the UK with undetected glaucoma.

1.10 Risk Factors for OAG

During the past decade there has been a notable increase in our understanding of risk factors for OAG. A summary of aspects of this research that are particularly relevant to community optometrists is presented in this section.

1.10.1 Intraocular Pressure

Elevated intraocular pressure (IOP) is an extremely important risk factor for OAG (Bengtsson, 1980; Sommer et al., 1991; Leske et al., 1995), and the only proven treatable risk factor (Pohjanpelto & Plava, 1974; Anderson 1989; Vogel, 1990; Sommer et al., 1991; Quigley, 1993; Kass & Gordon, 2000; Kroese & Burton, 2003; Weinreb & Khaw, 2004). There is considerable evidence to demonstrate the importance of IOP in the development and progression of glaucoma. For example, as IOP increases so the risk of developing OAG also increases, and as IOP increases in those with OAG there is a greater risk of progression of visual field defects (Leske et al., 1999; Kass & Gordon, 2000; Heijl et al., 2002). Also, patients who are diagnosed with advanced glaucoma are found to have higher IOPs at the time of diagnosis than those with less advanced glaucoma (Sommer et al., 1991; Grødum et al., 2002)

However, although elevated IOP is a major risk factor, several population studies have demonstrated that up to 50% of newly diagnosed glaucoma sufferers have a ’normal’ IOP (i.e. IOP less than or equal to 21mmHg) at the time of diagnosis (Tielsch et al., 1991a; Klein et al., 1992; Coffey et al., 1993). It should be borne in mind that this ’upper limit of normal IOP’, which is quoted as 21mmHg, is a statistical construct based on a mean IOP plus two standard deviations. As such, it is of limited clinical value. OAG that occurs with IOPs below 22mmHg is often classified as normal tension

glaucoma (NTG) although Spry and Harper (2010) point out that this distinction between 'high' pressure and 'normal' pressure types of COAG is arbitrary, with both types belonging to the spectrum of disease that is COAG.

IOP is the only modifiable risk factor for OAG, and for many years lowering IOP by surgery or medication has been the method for managing OAG. Evidence for the benefits of IOP-lowering treatment in NTG has emerged from the Collaborative Normal-Tension Glaucoma Study Group (NTGS). They reported that lowering IOP by 30% from its baseline level can be effective in reducing the rate at which patients lose their visual field (or have progression of disc changes) in normal tension glaucoma (CNTGS 1998a; CNTGS 1998b; Anderson, 2003). The Early Manifest Glaucoma Treatment Study (EMGTS) also reported significantly lowered IOP from baseline (by an average of 25%) but used a patient sample which included patients with baseline pressures of up to 29mmHg. Results from this study demonstrated that lowering IOP significantly succeeded in delaying progression of OAG in patients with NTG and in those with higher pressures (Heijl et al., 2002).

1.10.2 Age

There have been a number of studies that have clearly demonstrated a strong association between age and OAG, with evidence showing that both incidence and prevalence of the disease increase with age (Tielsch et al., 1991b, Klein et al., 1992; Klein et al., 1993; Dielemans et al., 1994; Leske et al., 1994; Friedman et al., 2004a; Coleman & Miglior, 2008). The strength of this association varies considerably across populations, however Rudnicka and Owen (2007) note that on average the risk of OAG in those people over 70 years of age is 3 to 4 times greater than those in their 40s.

1.10.3 Myopia

Research, including the Blue Mountains Eye Study and the Barbados Eye Study, has found evidence that there is a relationship between myopia and glaucoma; with myopes of up to three dioptres demonstrating a twofold increased risk of glaucoma compared with that of emmetropes and hypermetropes, independent of other risk factors (Mitchell et al., 1999; Quigley 1999; Wu et al., 1999; Grødum et al., 2001; Rivera et al., 2008). This risk increased to three times if the magnitude of myopia was greater than three dioptres, with slightly higher IOPs also being found in myopic eyes.

A more recent meta-analysis confirmed that myopes had twice the risk of developing OAG (Marcus et al., 2011).

Myopic eyes tend to be large eyes and tend to have large optic discs. A number of studies have identified optic disc diameter as a risk factor for glaucoma (Healey et al., 1997; Quigley et al., 1999; Healey & Mitchell, 2000). Myopia is often associated with an elongation of the eye, and it is possible that this may lead to changes in the lamina cribrosa. It has been noted that the changes in the lamina cribrosa observed in eyes with myopia are similar to the changes seen in glaucoma (Quigley et al., 1983).

1.10.4 Ethnicity

There are striking ethnic variations in the prevalence of OAG (See also Section 1.4 Epidemiology of glaucoma). These were highlighted in the Baltimore Eye Survey, conducted in an inner city mixed Black and White population (Tielsch et al., 1991b). The glaucoma prevalence in the Black population aged 40 years and above was 4.2% compared with 1.1% in the equivalent White population. A Bayesian meta-analysis, which examined 46 published studies that investigated age, gender and race in relation to OAG, demonstrated that the prevalence of OAG in different racial groups varied with age (Rudnicka et al., 2006). In 40 to 49 year olds, the prevalence of OAG in Black populations was approximately 7 times higher than that in White populations, whereas by age 80 to 89 years the prevalence was only approximately 2.5 times higher in Black populations. In the 40 to 69 age group, the prevalence in Asian populations was similar to the prevalence in White populations but in the older age groups it was higher in White populations.

1.10.5 Systemic Disease

The epidemiological evidence supporting a relationship between diabetes and glaucoma is contradictory and inconclusive (Wong et al., 2011). Several studies including the Baltimore Eye Survey, Blue Mountains Eye Study, the Beaver Dam Eye Study, the Early Manifest Glaucoma Trial Group and the Rotterdam study concluded that those with diabetes are up to three times more likely to develop OAG (Klein et al., 1994; Dielemans et al., 1996; Mitchell et al., 1997; Leske et al., 2003; Pasquale et al., 2006). However other studies have suggested there is no association between the diseases. (Leske et al., 1995; Tielsch et al., 1995a; de Voogd et al., 2006). Wong et al

(2011) reviewed 18 epidemiological trials looking for any association between glaucoma and diabetes. Of these, 7 found an association and 11 failed to find an association. They explained these discrepancies by the use in these studies of different definitions of glaucoma, different ways of classifying diabetes, sample sizes that in some studies were too small, and variations in the statistical methods used. However, they concluded from laboratory-based research that there was good evidence for an association between the two diseases.

Associations between systemic hypertension and vascular regulatory disorders (e.g. cold extremities, migraine and Raynaud's phenomenon) have been found in some studies, although the research evidence is often contradictory (Pache & Flammer, 2006). If these conditions are associated with OAG then the link is likely to be through the vascular mechanism for development of the disease (Section 1.6). According to the vascular theory, a combination of low blood pressure and elevated IOP can lead to a reduction of perfusion pressure at the optic nerve head, leading to damage to the retinal ganglion cells. Paradoxically, elevated blood pressure has also been associated with increased risk of developing OAG because it too can reduce the perfusion pressure at the optic nerve head (Memarzadeh et al., 2010). The interaction between blood pressure and IOP is clearly complex. Nicolela (2008) reviewed the evidence that could link vasospasm (or vascular regulatory disorders), which manifests as migraine and Raynaud's phenomenon etc., and glaucoma. He concluded that there was increasing evidence, both clinical and epidemiological, of an association between vascular regulatory disorders and glaucoma, at least in certain subgroups of the population.

1.10.6 Family History

Family history is a well recognised risk factor for OAG. People who are siblings or offspring of glaucoma sufferers are likely to have a higher IOP and a larger CD ratio than matched controls (Wolfs et al., 1989). This study additionally established that siblings or offspring of the glaucoma group had a lifetime risk of glaucoma that was approximately 10 times greater than in siblings or offspring of controls (i.e. people who did not have glaucoma). McNaught et al., (2000) point out that these figures may be underestimates, as children examined may not yet have developed glaucoma. They also noted that a further investigation that went beyond first degree relatives to include aunts, uncles, cousins etc may have revealed even greater family aggregation of

glaucoma. Further evidence was provided by The Barbados Family Study which found that 10% of living relatives of those diagnosed with OAG also had the disease. They estimated that a further 13% probably had OAG (Nemesure et al., 2001).

McNaught et al (2000) investigated 5 long-established pedigrees comprising over 400 glaucoma sufferers in Tasmania, Australia (GIST study). 13% of this sample had already been diagnosed as having OAG or as being OAG suspects, and a further 16% were identified during the GIST study. This was the first study to examine such a large sample belonging to glaucoma families in such detail and it was striking that so many new, admittedly mostly suspect, OAGs were detected. Interestingly, 27% of those with a family history of glaucoma were unaware of it.

Optineurin (OPTN) and myocilin (MYOC) are among the genes that can independently cause glaucoma, (Boland & Quigley 2007; Weinreb & Khaw 2004). However, glaucoma is a most complex disease and in many cases it is likely that multiple genes are acting to cause the condition and that interaction between these genes may account for the inter-individual variations that occur in glaucoma (Carbonaro & Hammond, 2007).

1.10.7 Other factors

The relationship between OAG and corneal thickness is particularly important when investigating intraocular pressure, as a thinner than average cornea will lead to underestimation of the IOP as measured with an applanation tonometry, while a thicker than average cornea will lead to an overestimation of IOP (Ehlers et al., 1975). Recent studies have shown no association between glaucoma and central corneal thickness (CCT) (Terai et al., 2011; Wanga et al., 2011; Brandt et al., 2012). However, the European Glaucoma Society reports that the measurement of CCT is a requirement when managing ocular hypertension (OHT) (European Glaucoma Society, 2003). The importance of CCT measurement in the diagnosis and monitoring of OHT is highlighted in the NICE Clinical Guideline (NICE, 2009). Furthermore, the Ocular Hypertension Treatment Study (OHTS) (Gordon et al., 2002) identified CCT as being the best predictor for conversion of their OHT subjects to open angle glaucoma.

Many studies have investigated a possible link between gender and glaucoma but there was insufficient evidence to come to a definite conclusion. However, the meta-analysis by Rudnicka et al., (2006) overcame the disadvantage of inadequate sample

size that thwarted many earlier studies. They identified a 1.23 times greater risk for OAG in males than in females in Whites, with similar increased risks in Black and Asian populations. Czudowska et al, (2010) subsequently also found increased risk for OAG in males. Other suggested risk factors include socio-economic status (Leske & Rosenthal, 1979; Fraser et al., 2001; Ng et al., 2010), and alcohol abuse (Katz & Sommer, 1988). A UK-based study found that approximately two-thirds of glaucoma patients (66.6%) had no academic qualification, which is higher than national statistics figures would predict (Sharma et al., 2010). Smoking has been suggested as a risk factor for glaucoma but studies have yet to find a definite association (Katz and Sommer, 1988; Rudnicka et al, 2006).

1.11 Disease Progression

If left untreated all glaucomas can lead to permanent visual impairment, which in some cases will be severe. OAG is usually slowly progressing as aforementioned, with initially characteristic arcuate paracentral scotomata, and is usually asymptomatic due to overlapping central fields of the right and left eye, but the advanced stages of the disease are more likely to be symptomatic, especially when the field loss approaches or involves fixation, when it will be coupled with an associated loss in acuity. A study examining the rate of OAG progression from cross-sectional, population-based data found that progression rates are not affected by age; and rates were not different between different ethnic groups (Broman et al., 2008).

The Health Technology Assessment (HTA) review (Burr et al., HTA 2007) examined the rates of progression from randomly controlled trials and used a classification of glaucoma into mild, moderate, severe and sight impaired/severely sight impaired according to the degree of field loss defined using the global index Mean Deviation (MD). The review found the average treated patient would spend 5 years in the mild stage of glaucoma before progressing to the moderate stage; they would on average spend 14 years progressing from moderate to severe glaucoma, and a further 16 years progressing from severe to visually impaired. This gives a total cumulative period during which the average treated patient would progress from mild glaucoma to becoming visually impaired of 35 years. The equivalent average period to visual impairment for untreated glaucoma is 23 years.

1.12 Case-finding Strategies for OAG

In the UK, the current practice of chronic open angle glaucoma (OAG) detection depends largely on community optometrists, who are responsible for over 95% of suspect OAG referrals to secondary care (Bowling et al., 2005). Although 5.3 million NHS sight tests were conducted on patients over 60 in England and Wales in the year ending March 2011, significant numbers of the population in this age group who are 'at risk' of OAG do not consult optometrists or do not consult them on a sufficiently regular basis. Moreover, higher rates of late presentation are associated with living in areas of high social deprivation where optometrists' premises are poorly represented (Day et al., 2010).

Given this background, it could be argued that there is a case for initiating a national screening programme for the detection of OAG. This question was addressed by the Health Technology Assessment (HTA) programme, which is part of the National Institute for Health Research (NIHR). Its primary remit is to research the effectiveness of healthcare within the NHS.

The HTA completed a review titled "*The clinical effectiveness and cost-effectiveness of screening for open angle glaucoma: a systematic review and economic evaluation*" which concluded that population screening would not be cost-effective, although they suggested that targeted screening directed towards groups at high-risk of developing OAG could be cost-effective (Burr et al., 2007). The HTA review also concluded that in order to improve the effectiveness of OAG detection, strategies would be needed to identify those belonging to at-risk groups and there would need to be adequate service provision to cope with the demand on resources. Furthermore, the review also acknowledged that community-based primary eye care and the efficiency of glaucoma case-finding should be improved both by the possible introduction of additional technology to improve the standard of the optometrist's investigation for the possibility of glaucoma, and by the route of trying to increase the uptake of eye examinations. Lawrenson (2013) noted that there are significant challenges associated with striving to increase the uptake of eye examinations. This was previously demonstrated by Baker and Murdoch (2008) who instigated a public health campaign for glaucoma in an Indian population in London using a variety of media approaches. They concluded that although the campaign was successful in increasing awareness of the condition (with radio being the most effective medium to use) there was no change in "health-seeking behaviour".

In the absence of a formal screening programme, optometrists identify glaucoma suspects through opportunistic case-finding. Optometrists' case-finding approach to OAG is largely based on the results of three diagnostic tests: assessment of the optic nerve head, tonometry, and assessment of the central visual field. The College of Optometrists (CoO) has developed guidelines for *Examining the Patient at Risk from Primary Open Angle Glaucoma* (College of Optometrists, 2009b) and these, together with a more detailed discussion of the triad of tests commonly used in community practice are included in Chapter 2 of this thesis.

1.13 The profession of optometry in the UK

Compared to medicine, optometry is a relatively new profession. With the creation of the NHS in 1948, the anticipation was that eyecare would be provided in a hospital setting. However, this proved unrealistic because of the huge numbers involved - over 80% of eye examinations in the UK were provided by community-based ophthalmic opticians (http://www.optical.org/goc/filemanager/root/site_assets/publications/celebrating_ 50_years.pdf). There was a need to provide regulation of eyecare services but it was not until 1958 that this came about with the passing of The Opticians Act and the formation of the General Optical Council (GOC) (Taylor, 1986). The GOC is the statutory regulatory body for optometrists and dispensing opticians, one of several health and social care regulatory bodies which also includes the General Medical Council (GMC). The GOC has, as its primary purpose, the protection of the public but it also maintains the registers of all optometrists and dispensing opticians, oversees all training and provides disciplinary powers, not just regarding clinical practice but professional behaviour.

The original legislation was subsequently consolidated and amended to the current 1989 act (Taylor, 1991) (http://www.legislation.gov.uk/ukpga/1989/44/pdfs/ukpga_19890044_en.pdf). Further minor amendments have been included since then, most notably in 2005 when mandatory Continuing Education and Training (CET) was introduced for all optometrists. This initiative is partly funded by the NHS, with individual grants for registrants.

The Opticians Act states that an optometrist (or Ophthalmic Medical Practitioner (OMP)) is "to perform such examinations of the eye for the purpose of detecting injury,

disease or abnormality in the eye or elsewhere as the regulations require", which would include detection of glaucoma.

The GOC annual report for the period 2007/8 states that there were 11,094 optometrists on the register for the UK (GOC, 2008a). Subsequent annual reports showed that this figure increased by 3.7% to 11,559 for the period 2008/9 and again to 12,414 for the period 2009/10 (GOC, 2009; GOC, 2010). Though there are opportunities for optometrists to work in secondary care, the majority of optometrists work in community-based primary care settings (Burr et al., 2007). Although patients may often consult their general medical practitioners (GMP) regarding eye problems, GMPs are rarely able to access the necessary specialist equipment, or do not usually have the essential training and skills to adequately detect certain eye diseases, notably glaucoma (Smeeth, 1998)

1.14 Optometry Education and Training

UK optometrists have to obtain a Bachelor's degree qualification at one of the 9 universities (six in England, one in Wales, one in Scotland and one in Northern Ireland) which offer BSc (or equivalent) degrees in Optometry. Students follow syllabi to ultimately satisfy the core competencies set out by the General Optical Council (GOC Optometry Core Curriculum, Core Competencies and Learning Outcomes).

Before they are able to practice, students must first obtain at least a second division second class (2:2) degree in Optometry and then can commence their pre-registration period where they work under supervision, and also participate in the College of Optometrists Scheme for Registration (SfR) where they need to complete a number of worked-based assessments and a final OSCE examination to satisfy competencies set out by the GOC (General Optical Council Stage 2 Core Competencies for Optometry, 2005). Post-registration, optometrists can elect to work in High Street practice, either for an independent or multiple; the hospital eye service; laser eye clinics, academia or a combination. Optometrists can often elect to be employed, self-employed, a locum or again a combination.

Continuing education and training post-registration is compulsory but there was, until 2013 when new CET regulations were introduced, considerable freedom as to which topics could be studied and which learning methodology adopted. Further

qualifications, accreditation or higher degrees are taken through an individual's personal choice. In terms of glaucoma there may be local accreditation processes for enhanced schemes, or a more formal certificate or diploma. As part of their modular MSc in Clinical Optometry, City University London has a glaucoma-specific module, aspects of which are evaluated as part of this research (see Chapter 4 of the thesis). The College of Optometrists has a number of specialist higher qualifications which during the course of this PhD research comprised two separate glaucoma certificates which jointly led to a diploma. The current higher qualifications are being phased out from 2012 and the CoO has introduced a new pathway to gain higher qualifications. The new higher qualifications framework has a modular approach to achieving a new set of professional higher qualifications (http://www.college-optometrists.org/en/professionaldevelopment/hq/new-college-accredited-courses/index.cfm).

1.15 Aims of this thesis

This research has four primary aims which are discussed in detail in the next four chapters.

1. To carry out a national survey of optometrists' self-reported practice for glaucoma case-finding.
2. To evaluate strategies used by optometrists for the detection of glaucoma.
3. To identify the training needs of optometrists involved in the detection and management of glaucoma.
4. To study the impact of an educational intervention on clinical decision making in glaucoma.

Chapter 2 addresses the first and second primary aims. It reports on a national survey conducted regarding OAG case-finding methodologies and referral criteria used by UK community optometrists. Questionnaires are a proxy measure for actual clinical practice so the validity of optometrists self-reporting of their clinical practice in the survey was tested by comparing their responses with the content of a national sample of referral letters collected from consultant ophthalmologists across the UK. The UK survey was translated into Dutch and this allowed a comparison between optometric practice in the UK and the Netherlands.

Chapter 3 focuses on the third primary aim and describes the development of a competency framework for optometrists with a specialist interest in glaucoma utilising Delphi methodology.

Chapter 4 addresses the final primary aim and evaluates the impact on clinical decision making of a current, established postgraduate educational course in glaucoma.

Chapter 5 is the concluding chapter. It gives a summary of the preceding chapters and contains recommendations for future research in this area.

Chapter 2: A Survey of Glaucoma Detection and Referral in Community Practice

2.1 Introduction

This chapter describes the results of a national survey regarding COAG case-finding methodologies/referral criteria used by community optometrists in the UK. The survey was delivered entirely online and was conducted in mid-2008, prior to the introduction of the National Institute for Health and Clinical Excellence (NICE) Glaucoma Clinical Guideline CG85 (NICE, 2009). The survey included sections on strategies for glaucoma detection, screening equipment used, barriers to case-finding and processes for referral, including the content of referral letters to an ophthalmologist.

Because questionnaires can only act as a proxy measure for actual clinical practice (Theodossiades et al., 2012), the validity of self-reporting by optometrists was assessed by comparing the survey responses in relation to referral with a national sample of referral letters obtained from consultant ophthalmologists across the UK. The chapter also reports on the findings of a version of the glaucoma survey translated into Dutch carried out in the Netherlands in early 2009.

2.2 Case-Finding Strategies for COAG

COAG is an insidious blinding disease that leads to a slowly progressive loss of visual field. Sufferers are often unaware of their field defect until it encroaches into their central vision. Since glaucomatous optic nerve damage is irreversible, early detection would provide access to effective pressure-lowering therapeutic interventions. However, population screening for glaucoma presents a considerable challenge; COAG is asymptomatic, has a low prevalence and there is no consensus definition for diagnosis. Consequently, there insufficient evidence for the effectiveness of a COAG screening programme that targets the general population (Hatt et al., 2006). In all parts of the developed world, the detection of COAG continues to rely heavily on opportunistic case-finding (Lawrenson, 2013).

In the UK, 96% of referrals for suspected COAG are generated by community optometrists (Bell & O'Brien, 1997; Bowling et al., 2005) following a routine eye examination. In England, Wales and Northern Ireland, NHS-funded 'Sight Tests' are

available to everyone over 60 years and those over 40 with a family history of glaucoma through the General Ophthalmic Services (GOS). In Scotland, NHS-funded Sight Tests are available to all. The choice of equipment and the actual glaucoma case-finding protocol used is at the discretion of the individual optometrist, which can lead to significant variation in practice (Ang et al., 2009; Shah et al., 2009a).

Guidance for all UK optometrists has been published by their professional body (College of Optometrists, 2005), regarding the 'examination of patients at risk from glaucoma' (College of Optometrists, Code of Ethics and Guidelines for Professional Conduct, Section D3 Examining patients at risk from glaucoma). This guidance states that: "It is for the practitioner to satisfy him/herself that procedures are included or excluded according to the patient's clinical need but in addition to the guideline on the eye examination, good practice for these patients should normally include:

- Assessment of the optic nerve head;
- Tonometry. Where pressures are high or borderline, arrangements should be made for the test to be repeated, noting the time of day of each test; the examination may also include:
- Central visual field assessment using perimetry with threshold control. Where necessary, practitioners should consider repeating visual fields assessment to obtain a meaningful result."

The College of Optometrists guidelines also state that *"Non-contact applanation tonometry is acceptable for screening but good practice would suggest that equivocal results be followed up with contact applanation tonometry."* And additionally that both for tonometry and perimetry, these tests should be repeated to obtain a significant result.

2.2.1. Tests used by optometrists for the diagnosis of COAG

Glaucoma detection in community optometric practice has traditionally relied on a triad of tests (examination of the optic nerve head, measurement of intra-ocular pressures and central visual field testing). Although several previous surveys have reported on the methods used by optometrists for glaucoma detection (Vernon & Henry, 1989; Strong, 1992; Tuck & Crick, 1994a; Tuck & Crick, 1994b), there have not been any recent in-depth national surveys of glaucoma case-finding. This is significant, as the

last 10 years has seen considerable changes within the optical sector, including: the scope of optometric practice, developments in the training and accreditation of optometrists and the adoption of new technology.

There is a strong body of opinion that combining structural and functional tests improves the ability to diagnose glaucoma (Malik et al., 2012). The presence of structural damage is conventionally assessed by a subjective assessment of the optic nerve head. Although direct ophthalmoscopy provides a magnified view of the optic disc, monocular viewing does not allow an appreciation of the three-dimensional morphology of the optic nerve head. Indirect slit-lamp ophthalmoscopy overcomes this problem, although usually requires pupil dilation to ensure a consistent stereoscopic view.

Conventional standardised automated perimetry (SAP) is the most widely used test of visual function for glaucoma diagnosis and monitoring. For screening, suprathreshold testing is typically employed, using stimuli of greater intensity than the estimated threshold at each test location. Although this test strategy does not always quantify the depth of any visual field defect, its principal advantage for routine case-finding is that the test duration is considerably shorter than full threshold testing.

The measurement of IOP is an integral part of glaucoma diagnosis and there is good-quality evidence to support ocular hypertension being a significant risk factor for the development of glaucoma (Kass et al., 2002). IOP can be determined by both contact and non-contact methods. The slit-lamp mounted Goldmann applanation tonometer is considered to be the reference standard for the determination of IOP (Burr et al., 2007). A hand-held version (Perkins applanation tonometer) is also widely used. Non-contact tonometers (NCT) have been available since the 1970's (Grolman, 1972). These devices use a jet of air to applanate the cornea. Topical anaesthesia is not required and the technique is simple to use allowing the measurement of IOP in community optometric practice to be delegated to optical assistants.

Newer structural and functional techniques for glaucoma detection and monitoring have been developed over the last decade. Ophthalmoscopic assessment of the optic nerve head can be augmented by digital imaging devices such as scanning laser polarimetry, scanning laser tomography or ocular coherence tomography. Methods for determining functional status have also been introduced e.g. Short wavelength automated perimetry (SWAP) and frequency doubling perimetry (FDT).

2.3 Referral for COAG

If, when examining a patient, an optometrist suspects that glaucoma may be present, the optometrist has a duty of care to refer the patient to the appropriate practitioner for diagnosis and/or treatment.

The College of Optometrists Code of Ethics and Guidelines for Professional Conduct (2005) state that:

> *"During the course of professional practice, the optometrist has a duty to refer the patient for appropriate ongoing clinical care and/or management whenever s/he observes a sign or symptom of a condition that cannot be managed within his/her competence and scope of practice, whether the observation is made during the eye examination or at any other time in the course of practice."*

Optometrists conventionally would refer patients they suspect of having COAG to the hospital eye service (HES) via their General Practitioner (GP). The responsibility then essentially lies with the GP to decide if onward referral is necessary. GPs can choose to forward on the referral by the optometrist, or may alternatively choose to write their own referral including the information supplied by the optometrist (Scully et al., 2009).

The challenge for case detection in a primary care setting is that COAG has a low prevalence. Consequently, even when a combination of screening tests is used to maximise sensitivity and specificity the positive predictive value (PPV) of referrals is likely to be low. Reported PPVs are generally in the region of 30-40% (Harrison et al., 1988; Bell & O'Brien, 1997; Theodossiades & Murdoch 1999; Bowling et al., 2005). Since inappropriate referrals place high demands on the HES and may also result in longer waiting times and considerable financial costs (Vernon, 1998; Henson et al., 2003), there have been several attempts to reduce the number of false positive referrals through a process of community refinement of glaucoma referrals using accredited community optometrists (Henson et al., 2003; Parkins & Edgar, 2011).

2.4. Impact of the NICE glaucoma guideline on glaucoma case-finding

The survey was carried out prior to the publication of the NICE guideline on the diagnosis and management of COAG and ocular hypertension. Although the scope of

the guideline did not encompass case-finding and screening (Sparrow, 2012), the publication of the guideline had an immediate and unintentional impact on case-finding practice and patterns of referral. Immediately following publication in April 2009, the Association of Optometrists (AOP), Association of British Dispensing Opticians (ABDO) and the Federation of Dispensing Opticians and Optometrists (FODO) issued advice to its members to refer all patients with an IOP >21mmHg irrespective of the tonometer used and even if the discs and fields were normal (AOP: April 2009 and reiterated in June and October 2009).

When the NICE guidance was issued, colleagues at City University were in the final stages of developing a web-based questionnaire to collect data on the patterns of referrals made by optometrists to medical practitioners. The timing of this survey provided an opportunity to assess the effects of the NICE guidance on referral numbers. An additional question was included at the start of the questionnaire which asked each optometrist for the number of extra referrals, based on the NICE glaucoma guidelines only, made in the previous working month. These data provided the first national and profession-wide snapshot of the immediate impact of the NICE guidance on the number of glaucoma referrals.

2.5 Optometry in the Netherlands

Optometry is a well established profession in the UK, with perhaps the most significant milestone being statutory regulation with the creation of the Opticians Act and the General Optical Council in 1958, though opticians had been practicing unregulated prior to this point.

However in the Netherlands, optometry is a relatively new profession with regulation and legislation only being introduced in 2000 (Stevens et al., 2007). Prior to 2000 the optometric profession in the Netherlands were akin to the dispensing opticians in the UK, and dealt mainly with the fitting and supply of optical appliances. The use of diagnostic instruments such as the retinoscope and ophthalmoscope was technically illegal. However, the profession developed rapidly and the current scope of practice in the Netherlands is similar to the UK, with some restrictions on therapeutic practice and the management of binocular vision problems (orthoptics). There is currently only one optometry course available in the Netherlands, with a one year foundation course and

a three year advanced course. There is no equivalent of the pre-registration year and no compulsory requirement for continuing education and training (CET).

There are only about 700 registered optometrists in the Netherlands (Stevens et al,. 2002) as opposed to the 11,000+ in the UK. The profession is regulated by the Ministerie Van Volksgezondheid, which monitors entry into the profession, registration, use of titles and scope of practice. Sale of optical appliances is not regulated.

2.6. Aims of Chapter 2

1. To conduct a national web-based survey to determine:
    - diagnostic tests used by optometrists for glaucoma case-finding
    - referral behaviour in relation to the detection of glaucoma
    - perceived barriers to case-finding

2. To determine the impact of the publication of the NICE glaucoma guideline on referral behaviour

3. To estimate the validity of self-reporting as a measure of optometrist case-finding practice for glaucoma and the appropriate referral of suspects

4. To report on the findings of a version of the glaucoma survey translated into Dutch and carried out in the Netherlands.

2.7 Methods

2.7.1 Survey of Case-finding Practice Reported by UK Optometrists

A survey to investigate UK community optometrists' current practice in the detection of COAG was developed. The survey was entirely web-based and hosted by a US provider of online surveys (Survey Monkey; http://www.surveymonkey.com; Oregon, USA).

The survey was piloted on 100 optometrists selected using a convenience sampling technique. Based on their feedback, minor amendments were made and the final

survey was open for 16 weeks between April and July 2008. See Appendix 1 for a copy of the final questionnaire.

All optometrists on the Association of Optometrists (AOP) electronic database were invited to participate. The AOP represents the professional interests of UK optometrists. Seven thousand four hundred and thirty emails were sent to AOP members, but this total included non-practicing and retired optometrists, and non-community practitioners (e.g. hospital-based optometrists). The GOC annual report for 2007/8 stated that there were 11094 optometrists on the register for the UK, considerably greater than the AOP membership. There were also some duplicate email addresses. The email invited members to participate in the survey online via a hyperlink to the website. Two reminders were sent and news features promoting the survey were included in AOP membership publications.

The survey was anonymous and no incentives to participate or feedback were offered. It consisted of 27 forced choice or free-text questions covering different aspects of glaucoma case-finding practice. All questions required an answer, and once a section was completed respondents could not return to alter an answer.

The final survey consisted of five sections totalling 27 questions.

The first question asked respondents “Are you currently practising as a community optometrist?” This question was designed to screen out non-practising optometrists and those not working in community practice. Respondents providing a negative response to this question did not enter the survey and were presented with an acknowledgement page.

The first section consisted of 8 questions relating to mode of practice. The initial questions asked the principal mode of practice (question 2) and the proportion (%) of working time spent working in the principal practice (question 3). Subsequent questions asked for information regarding how many days a week they spent in their principal practice (question 4), and the location of the practice (questions 5-7).

The final questions in this section asked for information regarding the number of eye examinations performed each week (question 8) and the demographic of the patient database (question 9).

The second section consisted of two free-text boxes to investigate strategies for glaucoma detection. The first asked for details regarding how the optometrist would investigate for suspect OAG, including the elements of the eye examination they regarded as most important. The second asked the optometrist to comment on any potential barriers that they felt would compromise effective detection of primary open angle glaucoma in community optometric practice and how they felt these barriers constrained implementation of practice.

The third section had nine questions relating to equipment used for glaucoma detection, and additionally practice organisation. This consisted of questions regarding pre-screening, screening equipment available in practice, any involvement in local glaucoma schemes and whether the individual had completed any further postgraduate training specifically related to glaucoma.

The fourth section asked how many referrals the optometrist made and how many specifically were related to glaucoma. It also enquired to whom referrals were made and what information was included in the referral.

The final section collected personal demographic information relating to gender and year of registration on the GOC register. A message thanking the optometrist for their participation was then displayed.

The questionnaire was designed such that once a page of questions had been completed and the respondent had advanced to the next page they were unable to return to the previous page to amend the answers. All questions were mandatory.

2.7.2 Survey Validation (UK)

Three methods were used to validate the survey responses:

1. Internal validation: the use of forced choice questions following a free-text question regarding referral information (Questions 24 and 25). Respondents could not return to the free-text question once they had advanced to the next (validation) question.

2. External validation: for the validation of the free-text question regarding the information included in optometrists' referral letters for suspect glaucoma (Q25), a

national sample of referral letters was obtained. In February 2009, we wrote to 941 members of the Royal College of Ophthalmologists (RCOphth) who were working as consultant ophthalmologists across a range of ophthalmology sub-specialties, to request that they provide photocopies of the next ten referrals for suspected primary open angle glaucoma that arrived in their clinics. An instruction was given to remove patient details and the identity of the referring optometrist, and a stamped addressed envelope was provided for convenience. After four weeks a second letter was sent as a reminder of the original request.

3. The geographical location of survey respondents in terms of distribution across England, Scotland, Wales and Northern Ireland was validated by cross-checking a sample of 100 of the supplied postcodes.

2.7.3 Impact of NICE Guidance on referral practice

Following the introduction of the NICE guidance on glaucoma in April 2009, the Association of Optometrists (AOP), Association of British Dispensing Opticians (ABDO) and Federation of Ophthalmic and Dispensing Opticians (FODO) subsequently issued guidance (AOP: April 2009 and reiterated in June and October 2009) advising optometrists to refer intraocular pressures (IOPs) exceeding 21mmHg to an ophthalmologist, even if optic nerve heads and visual fields appeared normal.

At the time the guidelines were released a separate survey was being trialled regarding patterns of referrals made by optometrists. The timing of this second survey provided an opportunity to assess the effects of the guidance on referral numbers and hence the survey was modified to include an extra question which asked each optometrist for the number of additional referrals, based on the NICE glaucoma guidelines only, made in the previous working month. The survey was run between June and July 2009 using the College of Optometrists membership database.

2.7.4 Survey of glaucoma case-finding in the Netherlands

In order to compare glaucoma case-finding practice in the Netherlands to the UK, with the collaboration of colleagues from the University of Utrecht and Optometristen Vereniging Nederland (OVN), the survey was translated into Dutch, with minor country-specific modifications, and initially piloted via a convenience sampling technique with

Dutch Optometrists. The OVN is the Dutch equivalent of the UK Association of Optometrists (AOP).

After inclusion of minor modifications optometrists were recruited via the OVN and the survey was run in Holland for 21 weeks between December 2008 and May 2009. As with the UK survey the invitation was via email to 676 optometrists on the OVN database, which had similar flaws to the AOP database in the UK. The management of the Dutch survey was administrated by Dr Ineke Krijger and Dr Marten Fortuin and colleagues at the University of Utrecht. Two email reminders and an invitation to participate during a conference helped to increase the response rate.

The final Dutch survey is available in Appendix 2.

Ethical approval for all parts of the study was granted by the City University School of Health Sciences Research and Ethics Committee and the research was carried out in compliance with the Declaration of Helsinki http://www.wma.net/en/30publications/10policies/b3/index.html

2.8. Results of the UK Survey of Optometrists Case-finding Practice

For the UK survey, a total of 2044 (full or partial) responses were received, which equates to a response rate of 27.5% of AOP members receiving the invitation email. One thousand eight hundred and seventy five (91.7%) of respondents were eligible to complete the survey. This represented approximately 17% of the total number of optometrists on the GOC register at the time of the survey.

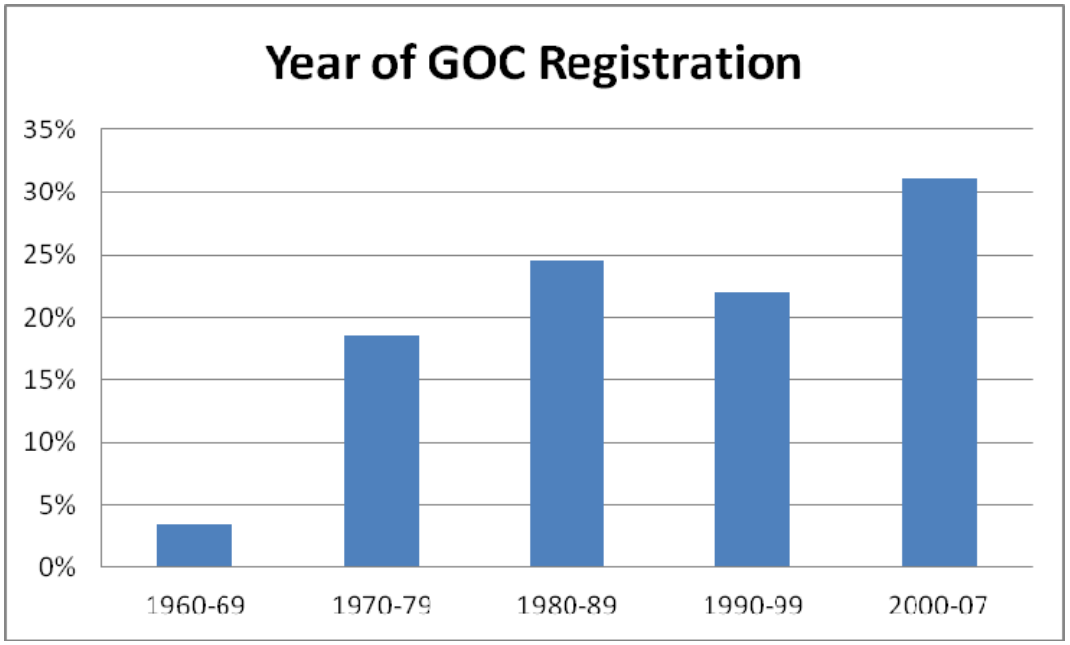
Although each question in the survey was compulsory, the online format allowed respondents to exit the survey at any time, although answers to previous questions were automatically saved.

2.8.1. Respondent Demographics

Demographic information was available on 1243 respondents. Forty seven percent were male and 53% were female (similar to the 48.2% male and 51.8% female distribution of GOC registrants for the year 2007-2008 (GOC Annual Report 2007-8)). Rather than ask for the respondents' age, the survey asked for year of GOC

registration. This ranged from 1960 (representing the year the first GOC Opticians Register was produced in the UK) to 2007, the year before the survey was conducted. The distribution of respondents based on year of registration is shown in Figure 2.1.

Figure 2.1: Distribution of respondents based on year of GOC registration (N=1243).



The percentage of respondents practising in England (83.3%), Scotland (8.2%), Wales (5.9%) and Northern Ireland (2.6%) was similar to the distribution of GOC registrants (82%, 9.5%, 4.8% and 4.1% respectively) in those countries (Table 2.1).

Table 2.1: Distribution of optometrists by country according to the 2007/8 Annual Report, AOP membership database and among survey respondents.

	GOC N (%)	AOP n (%)	Survey Respondents n (%)
England	9052 (81.6)	8973 (82.5)	1053 (83.3)
Scotland	1053 (9.5)	920 (8.5)	104 (8.2)
Wales	534 (4.8)	567 (5.2)	74 (5.9)
Northern Ireland	455 (4.1)	415 (3.8)	33 (2.6)
TOTAL	11094	10875	1264

One of the survey questions asked for the first part of the postcode of the principal practice. This was used to check the validity of the specified country location of the practice. Two hundred and fifty of the responses were selected at random and cross-referenced against the country specified. There was 100% agreement between the supplied postcode and the specified practice location.

Twenty two per cent of those completing the survey reported that they had received postgraduate training specific to glaucoma.

2.8.2. Mode of practice and practice organisation

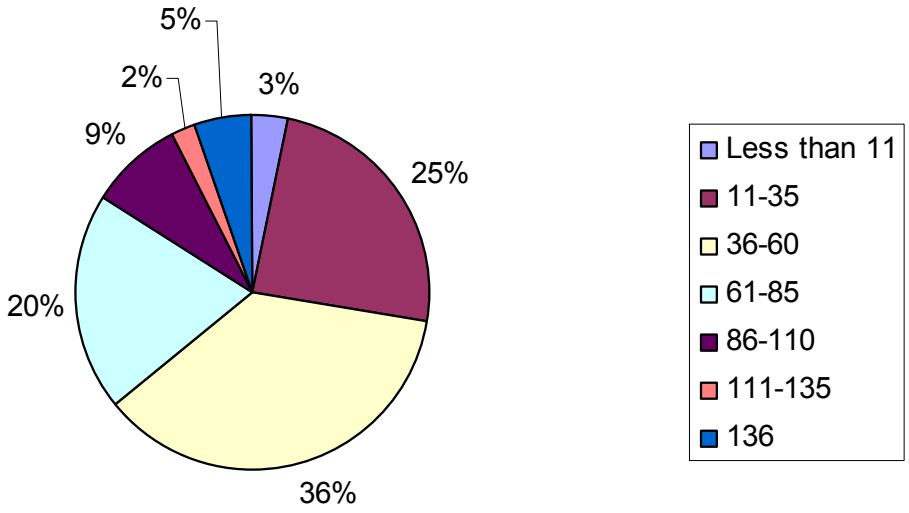
In terms of mode of practice, 56.1% of survey responses were received from independent practitioners, 23.9% were from those working in multiples (familiar High Street optometrists) or group practices, and 18% were from locums. Eighty three per cent of respondents were working more than 70% of their working week in the practice they regarded as their 'principal practice' for which they provided information about the practice organisation, equipment and patient numbers. Twenty three per cent of practices were located in the inner city, 59% urban but not inner city and 18% rural. Optometrists working in rural practices were more common in Scotland and Northern Ireland (Table 2.2).

Table 2.2: Distribution of practices by the nature of their location across the four countries of the UK (N=1680).

	England	Scotland	Wales	N. Ireland
Inner City	22.8%	31.1%	9.2%	19.1%
Urban	60.0%	43.7%	70.4%	51.1%
Rural	17.2%	25.2%	20.4%	29.8%

Respondents were asked to estimate the number of eye examinations performed per week in the previous working month. Over 60% opted for either 11-35 or 36-60 examinations (Figure 2.2), although the sample showed a large variation. Approximately 96% of patients seen were aged 40 or over with 45% aged over 60.

Figure 2.2: Number of eye examinations performed by respondents in a typical week (N=1680).



Only 14% of optometrists reported that their principal practice participated in glaucoma shared care/direct referral/co-management schemes. A similar percentage had completed postgraduate training specific to glaucoma.

2.8.3 Case finding strategies and screening equipment used

Respondents were initially asked in a free-text question to list the optometric tests they felt were appropriate for the investigation of COAG. It should be noted that as this was a free-text option participants were at liberty to describe tests using their personal choice of words. Equivalent tests were grouped together (Table 2.3). For example under the category “tonometry” – this could have been described as ‘intra-ocular pressures’ or ‘applanation’.

Table 2.3: Reported screening tests for the investigation of COAG (free-text question).
Key: Disc= Examination of the optic nerve head, Gonio= Gonioscopy, HRT= Heidelberg Retinal Tomograph, Angle: estimation of the anterior chamber angle. (N=1293).

Test	Tonometry	Disc	Fields	HRT	Angle	Gonio	Pachymetry
Percentage respondents	99.1	99.2	99.1	1.4	15.4	2.7	3.5

2.8.3.1 Sub Analysis

The College of Optometrists guidance for the assessment of patients at risk of glaucoma states that the eye examination for these patients should normally include: assessment of the optic nerve head and tonometry and may also include central visual field assessment using perimetry with threshold control. The percentages of optometrists who reported particular combinations of tests are shown in Table 2.4.

Table 2.4: Reported combinations of screening tests for the investigation of COAG (N=1293).

Percentage who reported all three tests	97.5
Percentage who reported Disc and IOP (No Fields)	0.7
Percentage who reported IOP and Fields (No Disc)	0.9
Percentage who reported Disc and Fields (No IOP)	0.9

Subsequent questions asked respondents to indicate via forced-choice options which specific equipment they used for glaucoma detection i.e. field testing, disc examination and for the measurement of intra-ocular pressures. An additional question asked whether participants possessed any more “specialist” equipment from a pre-determined list.

The first question asked “which field testing equipment is normally used routinely for primary open angle glaucoma detection in the principal practice?” The choices were “Humphrey, Henson, Dicon, FDT, VFA, Oculus Easyfield and Other”, the final option

incorporating a free-text box in which the respondent could indicate the instrument used. The survey revealed that a wide range of perimeters were used, however the instruments most frequently used were either one of the Henson range of instruments (39%) or the Humphrey Field Analyser (HFA) (approx. 22%) (Table 2.5).

Table 2.5: Relative frequency of field screener use by community optometrists
Key: FDT= Frequency Doubling Technology Perimeter, VFA = Friedman Visual Field Analyzer (N=1264).

Field screener	Frequency (%)
Henson	39.0
Humphrey	22.2
Dicon	14.7
FDT	11.9
Oculus Easyfield	6.0
Medmont	2.8
VFA	1.8
Other	1.6

Respondents were then asked to indicate their usual method of examining the disc. Options were, “Direct”, “Indirect”, “Direct and Indirect” or “Other please specify” (Table 2.6). The majority (62%) used a combination of direct and indirect. 43% of respondents stated that they additionally used a fundus photographic imaging system.

Table 2.6: Relative frequency of the different methods of disc examination (N=1264).

Method for examining the fundus	Frequency (%)
Direct and Indirect	62.3
Direct Only	25.0
Indirect Only	11.4
Other (please specify)	1.3

Respondents were asked to indicate which method they used routinely to measure intra-ocular pressures. The choices were "NCT, Pulsair, Perkins, Goldmann, Tonopen, Schiotz, I-Care and Other (please specify)". Non-contact methods were most popular (78%), with respondents mainly using a hand-held Pulsair (36%) (Keeler) or one of the table-mounted non-contact tonometers (43%) (NCT). Of those 16% using contact tonometry, 11% used a Perkins and 5% a Goldmann Applanation tonometer (GAT) (Table 2.7).

Table 2.7: Relative frequency of the different types of tonometer used for the measurement of IOP (N=1264).

Type of tonometer	Frequency (%*)
NCT	42.6
Pulsair	35.6
Perkins	10.7
Goldmann	5.4
i-Care	4.4
Tonopen	1.2
Pascal	0.1
Schiotz	0.1

*Percentages have been rounded to the nearest decimal place resulting in percentage totals differing from 100.

The final question asked "Does your principal practice possess any of the following specialist equipment?" and respondents were asked to indicate the availability of equipment from the following list "OCT, GDx, Pachymetry, HRT, Gonioscopy, Other Scanning Laser, Indirect Binocular Headset and Other (please specify)". A breakdown of responses is given in Table 2.8.

Table 2.8: Relative frequency of the availability of specialist equipment in community optometric practice.

Instrument	Frequency (%)
Goniolens	11.9
Pachymeter	7.4
GDx	2.8
Other Scanning Laser	2.8
HRT	2.3
OCT	2
Other (please specify)	0

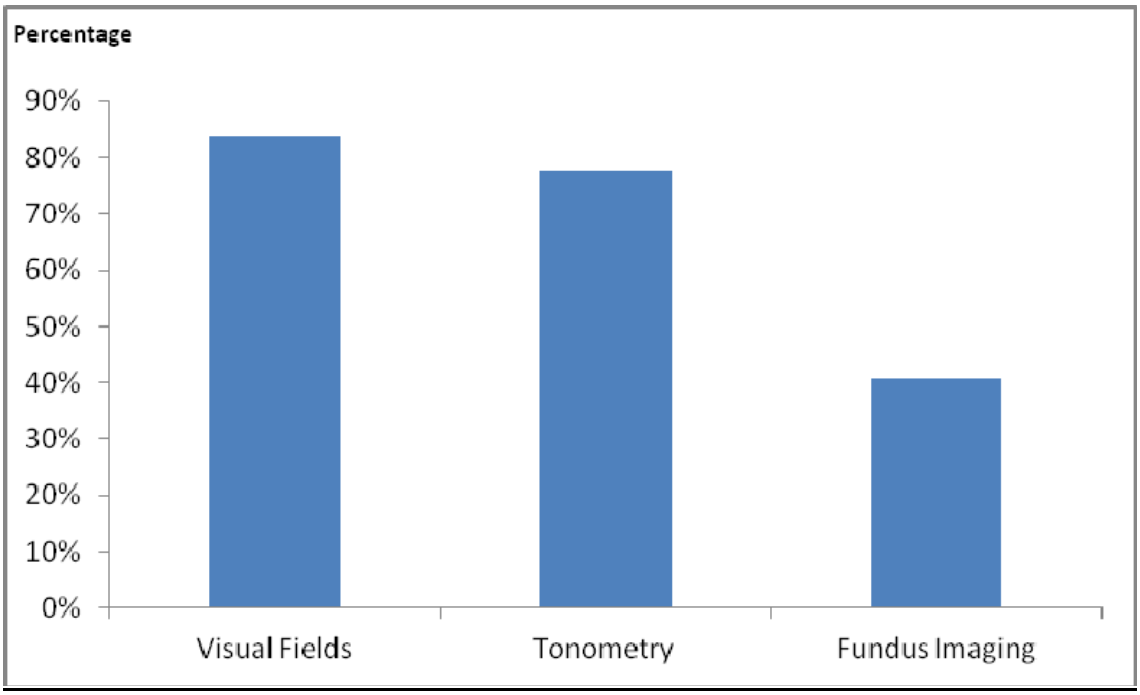
In a related series of questions the survey asked whether pre-screening was performed in the practice and if so which tests were delegated to a pre-screener or optical assistant. Approximately 36% of respondents (N=1293) utilized pre-screening. A sub-analysis indicated that pre-screening was most common in multiple or group practices (Table 2.9), with visual fields, non-contact tonometry, and fundus imaging the most commonly delegated tests (Figure 2.3).

Table 2.9: Relative frequency of pre-screening by mode of practice.

Mode of Practice	Frequency (%*)
Independent	26.1
Multiple/Group	48.1
Locum	23.3
Other	2.4

*Percentages have been rounded to the nearest decimal place resulting in percentage totals differing from 100.

Figure 2.3: Delegated screening tests in practices using pre-screening (N=459).



2.8.4. Referral practice

This section of the survey asked for information on numbers of glaucoma referrals, referral pathways and information included in the referral letter. The majority of optometrists (65.8%) were making an average of 1–3 glaucoma referrals per month. Sixty nine per cent of suspect glaucoma referrals were sent to the ophthalmologist via the patient's general practitioner, 28% were directly referred to an ophthalmologist and 2% to a glaucoma specialist optometrist. The survey was conducted prior to the publication of the NICE glaucoma guidelines. In response to these guidelines, the optometry professional representative bodies AOP and FODO advised their members to refer all patients with IOPs exceeding 21mmHg to an ophthalmologist, even in the presence of normal fields and discs. This led to an unprecedented change in optometrists' referral behaviour for suspect glaucoma. It was possible to quantify this behaviour change since an opportunity arose to collect data in a separate survey of members of the College of Optometrists on the general pattern of referrals made by optometrists to medical practitioners by adding a question that asked for the additional number of referrals for suspected glaucoma/OHT that were made per month following the introduction of the NICE guidelines. Since the survey went 'live' soon after the publication of the NICE guidance, it provided the first nationwide and profession-wide

snapshot of the immediate effect of the guidance on the number of glaucoma referrals. There were 1124 responses to this question and these are summarised in Table 2.10.

Table 2.10: Estimate of the number of additional glaucoma referrals made in a month following publication of the NICE guidelines (N=1124).

Number of additional glaucoma referrals in the previous month (post NICE)	Response %*
0	17.4
1-4	51.0
5-9	21.6
10-14	7.1
15-19	2.1
20-25	0.5
25+	0.2

*Percentages have been rounded to the nearest decimal place resulting in percentage totals differing from 100.

Based on the data in Table 2.10 it is possible to calculate an approximate 'average number of additional referrals per optometrist per month'. To arrive at this average figure it is necessary to assume an 'average' number of referrals from each of the specified ranges. This was taken as the midpoint of each range and a value of 25 for the 25+ category. Multiplying the average number of referrals in each category by the number of respondents who selected that category and adding these together gives an approximate total number of referrals. This gives an average of 3.9 additional referrals per optometrist per month. This was equivalent to approximately 540,000 additional referrals per year as a result of the NICE guidelines when extrapolated to reflect the 11,500 optometrists on the General Optical Council (GOC) register at the time of the survey.

A free-text question in the glaucoma case-finding survey sought to determine the clinical information that was included in the referral letter when referring a patient for further investigation for suspect COAG. The results are presented in Table 2.11.

Table 2.11: Information included in a referral letter for suspect glaucoma (N=1245).

Key: IOP: Intra-Ocular pressure, Disc: Optic Nerve Head, FH: Family History, A/C: Anterior Chamber Angle, VA: Visual Acuity, Rx: Refraction/Spectacle Prescription.

	IOP	Disc	Fields	FH	A/C	VA	Rx
Respondents %	96.1	95.7	95.8	52.9	7.2	35.7	32.3

Although the percentage of respondents reporting each of the standard triad of tests (IOP, discs and fields) was above 95%, this did not mean that all three screening tests were reported by each respondent. These data are provided in Table 2.12.

Table 2.12: Self-reported test combinations for the 'standard' screening triad included in a referral letter for suspect glaucoma (N=1245).

Percentage who reported all three tests	87.4
Percentage who reported IOP and Fields (No Disc)	4.4
Percentage who reported Disc and IOP (No Fields)	4.2
Percentage who reported Disc and Fields (No IOP)	3.9
Percentage who reported "none"	0.1

As a small number of referrals (n=42) were included from various glaucoma referral refinement (GRR) schemes, this subgroup was analysed separately. Removing the GRR referrals from the entire group did not significantly affect the overall results.

2.8.5 Validation of self-reporting on referral practice

To validate the self-reported data on clinical information included in a glaucoma referral letter, a national sample of referral letters for suspect glaucoma was obtained. All consultant ophthalmologists on the Royal College of Ophthalmologists membership database were contacted by post and asked to supply copies of the 10 most recent optometrist referral letters for suspect COAG. The validation was carried out prior to the publication of the NICE guidance on glaucoma. A total of 571 referral letters were

received from 59 consultant ophthalmologists. 60% of these were written on a standard General Ophthalmic Services (GOS18) referral form, 16% used a local proforma and the remainder were handwritten (14%) or used a bespoke template specific to the practice (6%). A small proportion of referral letters were received from GP's (4%) who included information on the optometrist's findings.

Analysis of information extracted from the referral letters allowed for correspondence between survey responses and referral letters to be assessed (Table 2.14).

62% of letters made reference to all three pieces of clinical information (IOP, discs and fields) with the remainder referring to combinations of two out of three of these (Table 2.13).

Table 2.13: Test combinations for the 'standard' screening triad included in actual referral letters for suspect glaucoma (N=1245).*

Percentage who reported Disc, IOP and Fields	62.4
Percentage who reported Disc and IOP (No Fields)	24.8
Percentage who reported IOP and Fields (No Disc)	3.1
Percentage who reported Disc and Fields (No IOP)	1.5
Percentage who reported IOP only	3.9
Percentage who reported Disc only	2.2
Percentage who reported Fields only	0.3
Percentage who reported "none"	1.7

*Percentages have been rounded to the nearest decimal place resulting in percentage totals differing from 100.

The degree of correspondence between the questionnaires and the information contained in the referral letters was assessed by chi-square analysis (Table 2.14)

Table 2.14: Criterion validity: Correspondence between the survey responses (self-reports) and actual referral letters obtained from consultant ophthalmologists.

	Survey response N (%) (Total=1245)	Included in Referral Letters N (%) (Total=571)	Chi^2	Correspondence
IOP	1196 (96)	549 (96)	P = 0.93	yes
Disc	1190 (96)	527 (92)	P = 0.004	no
Fields	1192 (96)	406 (71)	P<0.0001	no
All three tests	1088(87)	356(62)	P<0.0001	no
Family history	658 (53)	165 (29)	P<0.0001	no
Visual acuity	444 (36)	545 (94)	P<0.0001	no
Refraction	402 (32)	536 (94)	P<0.0001	no
Anterior chamber depth	89 (7)	1 (0.2)	P<0.0001	no

There was correspondence between the survey responses and referral letters for IOP only.

2.8.6. Perceived barriers to case-finding

To identify potential barriers to case-finding, a free-text question was used which stated:

> *In the box below (free-text entry) comment on any potential barriers that compromise effective detection for primary open angle glaucoma in community optometric practice. How do these barriers constrain implementation of practice and are there are any routine tests that sometimes have to be carried out selectively because of these barriers/constraints?*

One thousand two hundred and ninety three optometrists responded to this question and the analysis revealed eight main perceived barriers to COAG detection: time constraints, financial issues, equipment availability, optometry practice management, patient loyalty, patient information, training issues, and inter-disciplinary communication (Table 2.15).

Table 2.15: Main barriers reported by survey respondents.

Barrier	Explanation
Time	Related mostly to the extra time required to either complete relevant tests or to repeat tests.
Financial issues	Issues with loss of income and in turn the lack of finance to pay for equipment or staff.
Patient Information	Two main issues; record keeping and the ability to detect change over time, closely linked with patient loyalty to the practice. Patients 'shopping around' leads to problems with access to previous records, and consequently with detection of change in patient status.
Equipment	Inadequate practice equipment to detect COAG.
Practice	Barriers relating to staffing or management issues.
Patient issues	Many of the barriers grouped together in this section related to public perception of the value of an eye test. These included: Glaucoma cases cannot be detected if the patients do not present. Lack of public awareness/patient education regarding the serious nature of COAG. Failure to attend for follow-up. Other barriers in this section included communication problems and physical constraints affecting patients' abilities to access equipment.
Training issues	Optometrists need for training to use newer technologies for glaucoma diagnosis e.g. HRT, OCT.
Inter-disciplinary communication	If optometrists received feedback on referrals, this would have a training effect which could improve referral accuracy.

Most respondents reported more than one barrier. The most commonly cited barrier was time constraints, closely followed by financial issues. A sub-analysis by area revealed that these two issues remained major barriers across the UK (Table 2.16). Of respondents in England who stated that financial issues were a barrier, 73% (n = 350) specifically referred to the General Ophthalmic Services (GOS) system.

Table 2.16: Barriers by region.

Barrier	England %	Scotland %	Wales %	Northern Ireland %
No Barriers	12	23	4	6
Time	57	48	58	50
Financial	50	34	53	41
Equipment	23	27	21	13
Patient education	24	20	14	22
Practice management	7	7	7	9
Clinical information	4	9	7	3
Training issues	3	9	3	0
Interdisciplinary communication	3	2	1	0

Considering the results from the 948 respondents who reported at least one barrier, there was a statistically significant difference between the proportion of respondents in England (50%) and Scotland (34%) who reported financial issues as a barrier (chi squared test with Bonferroni correction for multiple comparisons, $p = 0.03$). The proportion of respondents from Scotland (23.4%) who reported no barriers was also statistically significantly different from those from England (12%) and Wales (4%) who reported no barriers (chi squared test with Bonferroni correction, $p < 0.001$). Other

regional differences between those reporting barriers were not statistically significant, although it should be noted that only a small number of respondents from Northern Ireland reported barriers. The data were not collected in a way which allowed analysis of responses from different regions in England.

2.9 Results of the Survey of Case-finding Practice Reported by Optometrists in the Netherlands

2.9.1 Respondent demographics, mode of practice and practice organization

Three hundred and twenty four respondents started the survey which equates to a response rate of 47.9%. Seventy seven percent (N=184) were working in community practice and were therefore eligible to complete the survey. Seventy three percent of these were male and 26% female; 36.2% qualified as an optometrist between 1990 and 1999 and 63.8% between 2000 and 2010. Significantly, 39% had completed postgraduate training specific to glaucoma, compared to 22% in the UK.

In terms of mode of practice, 82.1% were working in independent practice and 9.2% in multiple or group practices (the remainder were working in unspecified alternatives). Thirty eight percent were working in the inner city, 27.2% practiced in urban but not inner city environments, and 34.8% in rural practice. Seventy eight percent were working 4 or more days per week in their principal practice. Eighteen percent of practitioners participated in shared care/direct referral/co-management schemes etc for COAG.

Respondents were asked to indicate approximately how many eye examinations they performed per week, in their principal practice. The results are shown in Table 2.17 and compared with respondents to the UK survey.

Table 2.17: Number of eye examinations performed by respondents from the Netherlands and the UK in a typical week.

No. of Eye Examinations	Response Percent (Holland)	Response Percent* (UK)
Less than 11	16.3	3.3
11-35	26.6	24.6
36-60	20.7	36.0
61-85	13.0	20.1
86-110	7.6	8.5
111-135	6.0	2.3
136 or more	9.8	5.3

*Percentages have been rounded to the nearest decimal place resulting in percentage totals differing from 100.

2.9.2. Screening for COAG

A section was included in the survey asking about specific items of screening equipment used for glaucoma detection using a series of forced-choice questions.

The first question referred to equipment used for visual field screening. Thirty one percent of respondents did not routinely screen fields and hence did not possess a field screener. The Humphrey VFA (20.9%), the FDT (22.7%) and the Oculus Easyfield (6.4%) were the most commonly used perimeters in the Netherlands.

Respondents were then asked to indicate their usual method of examining the disc. Options were, “Direct”, “Indirect”, “Direct and Indirect” or “Other please specify”. The majority (40%) used indirect only, 35.5% direct only and 10.9% used a combination of direct and indirect. Forty nine percent of respondents stated that they additionally used a fundus photographic imaging system.

In terms of tonometers, all respondents had access to a method of measuring IOP. The majority (78.2%) used non-contact tonometry (Goldmann or Perkins) (Table 2.18), although greater numbers performed applanation tonometry (28.1%) than their UK colleagues (16.1%).

Table 2.18: Relative frequency of the different types of tonometer by optometrists in the Netherlands compared to the UK.

Instrument	Response Percent (Holland)	Response Percent* (UK)
NCT	58.2	42.6
Pulsair	6.4	35.6
Perkins	4.5	10.7
Goldmann	23.6	5.4
i-Care	6.4	4.4
Tonopen	0.0	1.2
Pascal	0.9	0.1
Schiotz	0.0	0.1

*Percentages have been rounded to the nearest decimal place resulting in percentage totals differing from 100.

Optometrists in the Netherlands were more likely to have access to specialist screening equipment than optometrists in the UK (Table 2.19).

Table 2.19: Relative frequency of the availability of specialist equipment in community optometric practice in the Netherlands and UK.

Instrument	Response Percent (Holland)	Response Percent (UK)
Goniolens	52.7	11.9
Pachymeter	53.6	7.4
GDX	7.3	2.8
Other Scanning Laser	7.3	2.8
HRT	4.5	2.3
OCT	9.1	2
Other (please specify)	0	0

2.10. Discussion

Twenty years ago a large survey was conducted on behalf of the International Glaucoma Association (IGA) to examine aspects of screening and referral for glaucoma by optometrists in England and Wales ((Tuck & Crick, 1992; Tuck & Crick, 1993; Tuck & Crick, 1994a; Tuck & Crick, 1994b). Since that time, there has not been an equivalent in-depth national survey of glaucoma case-finding practices within the UK, although to some extent the College of Optometrists Clinical Practice Surveys (conducted in 2001 and 2007) have captured longitudinal changes in the scope of optometric practice (College of Optometrists, 2001; College of Optometrists, 2007). This chapter reports the results of a large online survey of members of the AOP that was conducted in 2008. Significant developments in clinical practice and training of optometrists have occurred in the years since the IGA survey and the significant role played by UK optometrists in glaucoma case-finding has been re-emphasised in a NIHR (National Institute of Health Research) Health Technology Assessment (HTA) review considering the clinical and cost effectiveness of population-based screening for COAG (Burr et al., 2007). The conclusion of the review was that population screening was not cost-effective and, by implication, that detection of the disease would continue to depend on opportunistic case-finding by optometrists. However there was an acknowledgement that glaucoma detection could be enhanced by increasing the uptake of sight tests and improving the standard of optometric assessment. Although guidance is available from the College of Optometrists on the management of a patient at risk of glaucoma, the choice of equipment and the actual tests performed is at the discretion of the individual optometrist, which could potentially lead to significant variability in the quality of screening. The current survey therefore provides valuable data on current practice and has identified perceived barriers to case finding for COAG. The survey also provided information on referral practice. The survey was conducted prior to the publication of the NICE guidelines on the diagnosis and management of COAG and OHT which had an unprecedented impact on the number of referrals for suspect glaucoma from optometrists. In a further survey we were able to quantify the increased number of referrals for suspect glaucoma that occurred post-NICE and recognise that referral patterns and case-finding practice may have changed subsequent to the publication of the guidance.

2.10.1 How representative is the survey sample?

It is important when considering the results of a survey of this type to address the question of sample bias. The AOP provides professional indemnity insurance for approximately 90% of UK optometrists (David Craig 2008, personal communication, 5th November) and therefore its membership database should reflect the demographics of the GOC register. Since optometrists were invited to participate in the survey via email, only those AOP members who had provided a current email address were contacted, which may also have biased the sample. However the demographics of those responding to the survey were consistent with membership of the GOC register at the time of the survey in terms of age and gender, with a similar stratification by geographic location. Approximately 56% of survey respondents were independent practitioners with only 24% from larger "High Street" chains, the majority of the remainder (18%) classifying themselves as locums. The AOP (David Craig 2008, personal communication, 5th November) state that approximately 50% of their members who practice as community optometrists are independents. The rapid expansion of the corporate optical sector in recent years would suggest that an increasing proportion of practitioners are employed by the multiples and this group may be underrepresented in those completing the survey.

2.10.2 Equipment and Case-Finding Strategies

The results of the survey suggests that optometrists are well-equipped to perform the usual triad of tests (IOP, optic nerve head assessment and visual fields) necessary to detect glaucoma, and significant developments in clinical practice have occurred in the years since the last large-scale national survey of optometrists (the IGA survey) conducted 20 years ago. These comparisons with the IGA study cannot take into account the different modes of delivery of the two surveys (paper-based in the IGA survey vs. computer-based) nor the geographical variations in the scope of the surveys (targeting specific areas in the IGA survey vs. national) which may lead to a different demographic distribution among respondents.

2.10.2.1 Visual field testing

At the time of the IGA survey only half of optometrists had access to an automated perimeter (Tuck et al., 1994). The routine use of visual field testing equipment in

optometric practice increased throughout the 1990s and by 1998 it was reported that one-third of practitioners were performing routine visual fields in patients over 40 years of age (Tuck & Crick 1999). Virtually all optometrists (>95%) in the present survey reported that they had access to an appropriate automated perimeter that was used for the detection of glaucoma. Although respondents had access to a range of instruments, the majority used either one of the Henson range of instruments (39%) or the Humphrey Field Analyser (22%). In routine practice, visual field testing is only performed if deemed clinically necessary. This reflects the College of Optometrists guidance on examining patients at risk from glaucoma (College of Optometrists, 2012) which states that although tonometry and disc examination 'should' be performed, an assessment of the visual field 'may' be performed on all patients at risk of COAG. Although published audits of referrals for COAG have shown that information on visual fields is provided in 67–82% of referrals (Lash, 2003, Lockwood et al., 2010) a recent study, using a standardised patient methodology, found that visual fields were assessed by only 36% of optometrists in a patient at risk of developing COAG (Shah et al., 2009) Counter intuitively, it has been shown that the increased adoption of perimetry by optometrists has not necessarily led to an improvement in diagnostic accuracy (Vernon 1998; Lockwood et al., 2010). A possible explanation is that the GOS contract in England and Wales does not currently remunerate optometrists for repeat testing and so optometrists may not ascertain that a defect is reproducible before referral. Furthermore the increased use of visual field screening may identify non-glaucomatous field defects.

Another question in the survey asked respondents to give details in free-text form of their case-finding strategies for patients with suspect glaucoma. However, of relevance is whether optometrists surveyed used suprathreshold or threshold (full threshold or SITA) paradigms when assessing visual fields. Sixteen percent of our respondents referred to a specific testing strategy. Of these, 6.3% referred specifically to suprathreshold field testing strategies and 9.7% referred to threshold or full threshold strategies. This preference for threshold strategies over suprathreshold is encouraging as it indicates that optometrists recognise the value of a more in-depth field investigation in patients with suspect glaucoma.

2.10.2.2 IOP measurement

The current survey revealed that 79% of optometrists used a NCT for IOP measurement, specifically a table-mounted NCT (43%) or a hand-held Keeler Pulsair (36%). NCT gained popularity in optometric practice during the 1980s. It had obvious advantages as a screening test for glaucoma: the test was quick and easy to perform, did not require anaesthetic eyedrops, was acceptable to patients and could be delegated to optical assistants. NCT is associated with high levels of sensitivity and specificity for detecting IOPs > 21 mmHg. However, instruments require regular maintenance and accuracy is compromised when fewer than the recommended number of readings are performed (Vernon et al., 1991). Recently, the Colleges of Optometrists and Ophthalmologists have jointly produced guidance on referral for glaucoma which provides advice on maximising the accuracy of NCT (College of Optometrists, 2010).

Surprisingly few optometrists (16%) reported using applanation tonometry, the accepted reference standard for routine glaucoma detection, despite the findings of a recent College of Optometrists Clinical Practice Survey showing that approximately 53% of optometrists possessed an applanation tonometer within their practice (College of Optometrists, 2007). The preference for the NCT as the tonometer of choice for most optometrists was confirmed in a standardised patient study conducted, just prior the current survey, in the South-East of England (Shah et al., 2009b). In this study 84% of optometrists performed NCT on a patient at risk of glaucoma by virtue of Afro-Caribbean ancestry.

Potential barriers to the widespread adoption of applanation tonometry may include; training issues, recurring costs of the procedure and patient acceptance. Evidence from Scotland suggests that these barriers can be overcome. In 2006, a new General Ophthalmic Services (GOS) contract for Scotland required that optometrists demonstrate competence in Goldmann applanation tonometry (GAT) before they could be accredited. As part of the contract a supplementary fee was negotiated to perform the test. These measures led to an increase in the number of glaucoma referrals which included information on applanation tonometry from 11.8% prior to the new contract to 50% following its introduction (Ang et al., 2009).

The increased number of referrals that occurred following the publication of the NICE guidance and the optical representative bodies' standpoint that optometrists should refer based on intra-ocular pressures above 21 mmHg resulted in an overburdening of eye departments. For example, we found that in the first few months following guidance publication, optometrists were typically referring 3 additional patients per month based on the 'NICE criteria'. This has led to a widespread adoption of 'glaucoma repeat measures schemes' where optometrists are remunerated to perform applanation tonometry immediately after a sight test if IOPs are found to be raised by NCT and again on another occasion if necessary (Parkins & Edgar, 2011). It is therefore likely that the usage of applanation tonometry would have increased in the time since the survey was performed.

2.10.2.3 Optic nerve head assessment

Ophthalmoscopic examination of the fundus, including the optic nerve head, is mandatory in all optometric eye examinations performed by community optometrists. However, the choice of technique is at the discretion of the optometrist. Traditionally, optometrists have used direct ophthalmoscopy through undilated pupils to examine the fundus as part of a general evaluation of the posterior pole. However, the reference standard for the assessment of the optic nerve head in glaucoma is slit lamp binocular indirect ophthalmoscopy, which provides a stereoscopic view of the optic nerve head. The majority of respondents in the survey (62%) reported used a combination of direct and indirect, with 25% using direct only. This figure is higher than that found by Shah and colleagues using a standardised patient considered to be at risk of glaucoma. This study found that 86% of optometrists performed direct ophthalmoscopy and only 22% used binocular indirect methods (including 8% who performed both tests).

Although increasingly optometric practices are incorporating fundus imaging into a general eye examination (43% in our sample), fewer than 2% were specifically using fundus imaging as their only method of assessing the optic nerve head for the purposes of glaucoma detection. This finding is consistent with the findings of Shah and colleagues (Shah et al., 2009c).

The use of slit-lamp binocular indirect ophthalmoscopy has increased amongst optometrists in recent years. It is now a core competency for GOC registration and is

formally assessed by the College of Optometrists in the current professional qualifying examinations (see Chapter 3).

2.10.2.4 Specialised equipment for the detection of COAG

The survey also obtained data on more specialist equipment used by optometrists for glaucoma detection. In this question respondents were invited to select as many or as few instruments as applied, with the result that some will have selected two or more items of equipment from the list supplied. Fewer than 7% of respondents possessed specialist imaging devices (e.g. GDx, or OCT) that quantify nerve fibre loss in glaucoma. Significantly, only 7% of optometrists had access to a pachymeter and 12% had access to a goniolens. The recently published NICE guideline (NICE, 2009), on the diagnosis and management of glaucoma, states that all patients with suspect COAG or ocular hypertension should have pachymetry and gonioscopy at diagnosis. Pachymetry and gonioscopy are not core competencies for optometrists although since publication of the guideline both techniques have been given prominence at optometry continuing professional development events. It is likely, given the rapid development of new screening technologies, that there will be an increased adoption of modern imaging technology in community optometric practice in the future.

2.10.2.5 Referral practice for glaucoma suspects

Most respondents (66%) reported that they were referring 1–3 glaucoma suspects per month for an ophthalmology opinion. In the current survey 97.5% of respondents reported that they would include all three screening tests when case-finding for COAG. However, a sample of referral letters for suspect glaucoma obtained from consultant ophthalmologists throughout the UK revealed that only 62% of letters made reference to all three pieces of information (IOP, discs and fields) with the remainder referring to combinations of two out of three of these. Whilst a large percentage of letters contained information on discs (92%), there was correspondence between the survey findings and referral letters for IOP only. Although 96% of survey respondents reported that they would include visual field results, these were reported in 71% of referral letters. Similarly, 53% completing the survey stated that they would include information on family history of glaucoma, but this was only included in 29% of referral letters. However, it is possible that optometrists may be choosing not to include information in referral letters on negative findings.

Notably, only a small proportion (7%) of survey respondents stated that they would include information on anterior chamber depth and <0.5% of referral letters included this information.

The information content of this national sample of referral letters agreed closely with that reported in local audits; for example, 62% of the current sample of referrals included information on the triad of discs, fields and IOP, which is similar to the 66% found in a recent audit of optometrists' referrals for suspect glaucoma in the Portsmouth area (Lockwood et al., 2010).

The lack of correspondence relating to visual acuity (VA) and refraction may be a function of the design of the generic GOS18 referral form and related templates. These standard referral proformas include sections that require input of VA and refraction. Although this information is potentially useful to an ophthalmologist in the context of a referral for suspect glaucoma, the lack of correspondence may have arisen since the free-text question in the survey asked for information specific to a glaucoma referral.

The study of referral practice was conducted immediately prior to the introduction of the NICE guideline on the diagnosis and management of COAG and ocular hypertension. Although the guideline did not specifically address case-finding, it significantly impacted on referral practice due to the recommendation that all patients with repeatable IOPs over 21 mmHg should be assessed by 'a suitably trained healthcare professional with a specialist qualification and relevant experience' in glaucoma. This led to a substantial increase in referral volume together with a reduction in diagnostic accuracy (Shah & Murdoch, 2011). Consequently it is likely that current referral practice may differ from that reported here.

2.10.2.6 Barriers to case-finding for COAG

Seventy seven percent of respondents (N=1293) answered the free-text question relating to perceived barriers to COAG case-finding. Eighty-eight per cent of these reported one or more barriers to the detection of glaucoma in the community,

2.10.2.6.1 Time and financial barriers

The most commonly stated barriers were financial issues and time constraints, which for many respondents were inextricably linked.

It should be noted that there are differences in the arrangement of ophthalmic services across the UK. The NHS provides some primary eye care, namely 'sight tests', to the general public via the GOS (Association of Optometrists Sight Test Resource Pack, 2003). The GOS system includes 'free' NHS sight tests to eligible groups only (apart from Scotland, where GOS sight tests are free for everyone); the remainder pay a private eye examination fee, usually set by the practice owner. Patients eligible for 'free' examinations include those over 40 years of age with an immediate family history of glaucoma, and those over the age of 60. The GOS system differs across the UK. In England, the fee paid to optometrists for completing a GOS NHS sight test at the time of the survey was £19.80 (Federation of Dispensing Opticians, 2008). According to the Federation of Ophthalmic and Dispensing Opticians the average private examination fee in 2008 was £22.90 (Federation of Dispensing Opticians, 2008). It has been estimated that the actual cost is approximately £37, with NHS sight tests being heavily subsidised through spectacle sales (Bosanquet, 2006).

Of respondents in England who stated that financial issues were a barrier (50%), the majority specifically referred to the GOS system. Unlike Scotland, the GOS in England does not include any additional incentives to support optometrists in case-finding for COAG. A patient recalled for repeat testing occupies an appointment slot and in some cases this could lead to an increase in the loss in revenue if an additional fee is not charged, which may lead to tensions between the clinical and retail sides of the optometric practice. Additionally, it is in the practice's business interests for practitioners to complete tests as quickly as possible, as the testing element generates little income per hour. The average optometrist has only 20–30 min to complete all the tests required to comply with their terms of service. As a result, optometrists may feel pressurised to refer patients for suspect glaucoma on the basis of a single test result (Stevenson, 1999; Salmon et al., 2007). Some practices charge for supplementary procedures such as repeat fields, but it is the individual patient's decision whether they are willing to pay this additional fee.

On 1 April 2006, Scotland implemented a new GOS contract for community optometrists (Ang et al., 2009), which introduced 'free' eye examinations for all. Under the new contract optometrists must pass an accreditation process to ensure a basic level of clinical competence. The new contract aimed to reduce inappropriate (including glaucoma) referrals to the HES and introduced supplementary examinations, which allowed for repetition of some or all of the triad of tests for glaucoma case-finding. This change also included a new fee structure, where optometrists were paid a fee for the primary eye examination and a separate fee for any supplementary eye examination. The primary eye examination fee, when this survey was conducted, was £36 for those under 60, £40 for those over 60, and £21 for a supplementary examination. Ang et al. reported an improvement in the quality of glaucoma referrals from optometrists in Scotland, notably an increase in the percentage of true positive referrals from 18% to 31.7% and a reduction in false positives from 36.6% to 31.7%, since the introduction of the new contract (Ang et al., 2009). Optometry Scotland, which represents the optical professions in Scotland, has also negotiated equipment and training grants.

Every referral to the HES incurs costs to the NHS. Traverso et al. (2005) noted that each ophthalmology outpatient appointment costs £380, a heavy price for each false positive referral. Fewer respondents from Scotland (34%) cite financial implications as a barrier. In fact Scottish respondents were more likely to report 'no barriers' compared to their English counterparts, with this difference being statistically significant. The barriers most commonly reported by optometrists in England related to inadequate time available to perform tests, remuneration for NHS services, and adequacy of equipment for glaucoma screening. These were addressed by the GOS contract in Scotland, which, in addition to the introduction of the supplementary examination and the increases in the sight test fee, also provided equipment grants (Ang et al., 2009).

In Wales, under the Welsh Eye Care Initiative (WECI) (Association of Optometrists, 2004), the Welsh Eye Health Examination (WEHE) is a scheme which caters for those who may be 'at risk of eye disease' and entitles them to a free eye examination from a WECI accredited optometrist. It should be noted that the provision of WEHE is outside the GOS provided by the NHS. All WEHE accredited optometrists undergo further postgraduate training and regular re-accreditation (Sheen et al., 2008). They are also required to have a minimum standard of equipment, including an applanation tonometer. From a COAG perspective the criteria for eligibility for the WEHE include those 'at risk of eye disease by reason of race or family history', notably those of Black

African and Black Caribbean descent. When performing a WEHE, it is mandatory to carry out the triad of tests recommended for COAG case-finding, however optometrists receive a higher fee (currently £40 per patient, which is double that received in England). Despite the additional remuneration, the survey found that optometrists in Wales still perceived financial barriers similar to their English counterparts. One possible explanation is that the WEHE is only available to certain patient groups and there is no additional funding for repeat testing, unlike the situation in Scotland.

2.10.2.6.2 Equipment

Many UK optometrists do not own or share ownership of the practice in which they work. Practices may be owned or franchised by one of the well-known 'multiples'. Optometrists may be employed or self-employed (a locum) and may work in a number of practices. Hence the equipment available is not necessarily the choice of the optometrist. Furthermore, equipment issues are inextricably linked to financial issues. Some modern equipment for glaucoma case-finding is highly specialised and expensive. In some cases, specialised equipment does not generate further practice income and use of equipment may occupy valuable appointment slots at a cost to the practice.

The percentage of Scottish respondents (27%) who cited equipment as a barrier was higher than in England, Wales and Northern Ireland. This is perhaps a surprising finding since, at the time of the survey, each practice was eligible for an equipment grant of £10,000, a scheme unique to Scotland. However, it should be noted that Scottish optometrists cited barriers that related to more specialised items of equipment such as gonioscopes and pachymeters whereas in England the comments related more to equipment required for the more traditional 'triad' of tests.

2.10.2.6.3 Patient education

Many of the barriers grouped together in this section related to patient compliance and general public perception of the value of an eye test. Practitioners felt that there was lack of public awareness and poor patient education relating to COAG. This, in turn, could lead to patients either not presenting in the first instance for an eye examination or, if they do attend initially, subsequently failing to return for follow-up appointments.

Other perceived barriers cited included communication problems, such as language difficulties, and physical constraints affecting patients' abilities to access equipment.

2.10.2.6.4 Practice management

Practice related barriers were focused on staffing or management issues. Optometrists who reported barriers in this area felt that they were hindered by lack of support from either managers or ancillary staff. In some cases it was felt that support staff required more training to increase their knowledge and understanding of glaucoma.

2.10.2.6.5 Clinical information

Another commonly reported barrier was that patients no longer demonstrated loyalty to a practice. This highlights the commercial nature of the profession, with patients 'shopping around' for the best spectacle deal. Though freedom of choice should be encouraged, patients do not carry their clinical records and practices are not obliged to send them on to the next practice. As a fundamental factor in the accurate detection of glaucoma is to detect change in the patient's clinical status, difficulties accessing patient records can impair COAG case-finding.

2.10.2.6.6 Training

Optometrists' personal training was an infrequently cited barrier, suggesting that the majority of optometrists feel they are adequately trained to detect glaucoma. Significantly, only 22% of survey respondents had received specialist training in glaucoma.

2.10.2.6.7 Communication

Barriers less frequently mentioned included intra-optometrist, patient and inter-disciplinary communication issues.

The first raises the issue of record keeping. Whilst optometrists are legally required to keep adequate clinical records, the level and accuracy of information recorded differs greatly and poor record keeping hinders the detection of a change in the patient's clinical status. There is evidence that optometrists both under-record and to a lesser

extent over-record the findings of eye examinations, including eye examinations on a patient at risk of COAG (Shah et al., 2009a). Patient communication problems included poor compliance with follow-up visits, lack of patient understanding of the importance of family history, and language difficulties. When an optometrist suspects glaucoma, a referral to an ophthalmologist for investigation is initiated, normally via the patient's general practitioner. If the optometrist does not receive any correspondence following the referral, they will be unaware of the diagnosis. Some respondents felt that if optometrists received more feedback on referrals, this would have a training effect which could improve referral accuracy. However, among our respondents, this was not a major barrier to COAG detection.

2.10.3 COAG case-finding practice in the Netherlands

Optometry is a relative new profession in the Netherlands. Training in the form of an undergraduate bachelor's degree takes place in a single higher education training centre in Utrecht (Hogeschool, Utrecht). There were major demographic differences between the Dutch and UK survey respondents e.g. proportionally more males (75%) and over 80% were working in independent practice. Significantly more than 40% had received postgraduate training in glaucoma, compared to 22% in the UK.

Unexpectedly, 31% of optometrists in the Netherlands did not possess an automated field screener. By contrast, all UK optometrists reported access to this instrument. However, Dutch optometrists were more likely to possess more specialist items of diagnostic equipment e.g. 52.7% had access to a goniolens and 53.6% a pachymeter (the equivalent frequencies for UK optometrists were 11.9% and 7.4% respectively). One possible explanation for the difference is that as a new profession, optometrists in the Netherlands would most likely be exposed to these techniques at university or during postgraduate training. Similarly Dutch optometrists were most likely to use a binocular indirect ophthalmoscope as their primary method for evaluating the disc. Although this technique is becoming more widespread amongst optometrists in the UK and competence in indirect ophthalmoscopy is now a compulsory pre-requisite for GOC registration, there are large numbers of older optometrists who have not been trained in the technique.

2.11 Limitations of this study

A potential source of bias may be introduced by the self-selection inherent in surveys of this nature. Only 27.5% of the national sample of AOP optometrists responded to the online survey. It is probable that those who elected to participate, even though all input was anonymous, are likely to include a higher proportion of better motivated practitioners who feel most confident about glaucoma detection. It is possible that this self-selection will lead to some overestimation of the quality of equipment found in practices and the reported level of adherence to professional guidance. Furthermore, the use of the AOP membership database may have resulted in an over-representation of independent practitioners.

The other bias is that reported practice may not conform to actual practice. The validity of surveys as a proxy measurement of clinical practice in optometry has only recently been investigated (Theodossiades et al., 2012). This study found that self-reports overestimated routine tests undertaken in practice. This overestimation was in line with recommendations made in published guidelines and 'best practice'. Actual practice revealed correspondence in mandatory test performance and poor correspondence with discretionary tests. This is similar to the findings in studies of other health care professions, which show that clinicians' self-reports may overestimate performance of some clinical actions and underestimate others (Hrisos et al., 2009). Significantly, substantial overestimation has been observed when investigating adherence to best practice guidelines (Lomas et al., 1989, Adams et al., 1999).

2.12 Conclusions

The results of the present study demonstrate that UK optometrists are well equipped to screen for COAG and that they report using these tests in glaucoma case-finding. The study also provides evidence that optometrist's skills and scope of practice in the detection of glaucoma have evolved since the last national survey, which was commissioned by the IGA in the late 1980's. However, the level of funding and nature of the GOS contract for most UK optometrists continues to limit the development of an effective service for glaucoma detection, whether it is in primary care practice or as part of a co-management scheme. There is a lack of standardisation of the screening protocol and the tests performed are at the discretion of the optometrist, thereby compromising diagnostic accuracy. Attempts at standardisation using accredited

community optometrists in a variety of referral refinement/shared care models appear to be safe and clinically effective alternatives.

Chapter 3: Development of a competency framework for optometrists with a special interest in glaucoma.

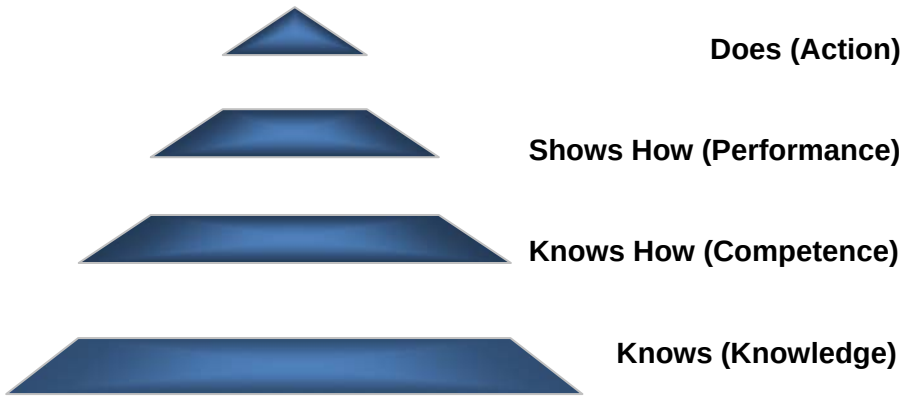
3.1 Introduction

This chapter describes the development of a competency framework for optometrists with a specialist interest in glaucoma, utilising the Delphi methodology.

3.1.1 Competence

Competence, when used in the context of clinical competence, can be defined in many ways but one definition often quoted is: “the degree to which a clinician can use their associated knowledge, aptitude, attitude and good judgement in the course of their professional practise and be able to work in an effective way in all situations that correspond to their field of practice” (Miller, 1990). Clinical competence includes different levels of both “knowing” and “doing”, and Miller’s pyramid (Figure 3.1) is a classic schematic representation of these levels of clinical competence.

Figure 3.1: Miller's pyramid of clinical competence.



The “knows” section makes up the base of the pyramid and consists of factual knowledge. Much of this factual information is acquired by optometrists during their undergraduate training, which still often follows the conventional approach to education, which in optometric training is heavily reliant on didactic learning. Following

registration, optometrists have tended to acquire their knowledge from CET material published in journals etc (Shah et al., 2007).

Ascending to the next level of the pyramid we reach the level which, according to Miller, is the "knows how" region, which describes the ability to use knowledge in a particular context. An optometrist operating at this level would be using clinical reasoning and problem solving. Assessment of these skills is increasingly carried out on undergraduate optometry courses and in post-registration training by presenting the student/practitioner with a clinical scenario (paper based or online). In the assessment the student/practitioner records those procedures they would select to perform on the patient described in the clinical scenario.

At the next level (Figure 3.1), the optometrist is in the "shows how" region of the pyramid, which allows an assessment of the student/practitioner's ability to perform appropriately in a practical situation. This involves hands-on behaviour using clinical equipment in a practice situation, which may be simulated or real. Students are assessed regularly for "shows how" competence during their BSc Optometry courses, notably to satisfy the Stage 1 GOC Core Competencies. For optometry graduates, who are undertaking their pre-registration period, "shows how" is tested in their own practices (in work-based assessments) and again during the "Final Assessment" using OSCE-based (Objective Structured Clinical Examination) station examinations at the end of the pre-registration period (College of Optometrists, 2010b). For many registered optometrists this is, at present, the last time in their professional careers that their "shows how" skills will be assessed. However, registered optometrists are becoming increasingly involved in hospital co-management schemes (Spry, 2008) or providing enhanced services in the community (Parkins & Edgar, 2011). Participation in schemes such as these will involve the optometrist in additional training which often culminates in a "shows how" element of assessment.

The top section of the pyramid refers to actual performance in habitual practice (the "does" level). At this level of the pyramid, the skills being tested are those directly related to the real-life practice environment. Therefore, the assessment at this "does" level needs to be as clinically authentic as possible. This "action" or "does" component of professional behaviour is the most difficult to measure reliably and accurately (Miller, 1990). Research into the performance of optometrists at this highest level of Miller's pyramid is scant (Shah et al., 2010).

3.1.2 Competency-based training

The competency-based approach to medical training has become increasingly popular worldwide over the past 25 years. However, there is nothing particularly new in the concept of competency-based education, there having been arguments made for its introduction into the training of professionals for more than 60 years (Frank et al., 2010). The move towards adoption of the competency approach to optometry has progressed in parallel in a number of countries, including Canada and the United States, but much of the trailblazing work in this area occurred in Australia and New Zealand (Leung, 2002). The catalyst for this development in Australia was a bi-product of a raft of economic policies introduced in the late 1980s, and which included the introduction in 1989 of competency frameworks for entry into and movement within professions and trades (Kiely, 2009). There were several aims that underpinned this initiative. Some were generic across professions, such as the desire to maximise existing skills among the workforce in Australia. One of the major drivers behind these moves was of particular relevance both to medicine in general and to optometry: the desire to facilitate and better regulate the entry into Australia of those whose qualifications had been obtained in other countries (Kiely, 2009). Over the years many UK trained optometrists, for example, have taken their skills to Australia and New Zealand, so there was an obvious need to ensure that optometrists trained outside Australia possessed the necessary skills to practise in their adopted country.

A notable feature of the competency model of training is that a qualification is awarded by virtue of demonstration of competencies achieved rather than by a “time served” approach in an educational setting. In medicine, the time-serving structure was exemplified by the “rotation” model used in the training of doctors. This model has increasingly been augmented with or superseded by a competency-based structure (Leung, 2002).

Within any competency-based approach the trainee makes progress by successfully demonstrating competence at a number of clearly defined outcomes. These discrete elements can be assessed in a much more objective way than the less defined components of traditional educational assessment processes, notably viva voce examinations and “one-off” assessments of practical skills on patients who may be of

varying degrees of difficulty. Benefits of the competency model include the scope for having more flexible training, which can be focused on the individual's needs, and greater transparency in the assessment process.

Leung (2009) also identified some of the disadvantages of the competency approach. For example, it can be difficult to identify all the competencies that encompass the entire scope of a worker's role. Furthermore, even the advantages inherent in a competency-based assessment do not make it entirely free from subjectivity on the part of an examiner. Perhaps the greatest weakness of the approach is that breaking down any profession's activities into a number of discrete elements can make it difficult to appreciate and make use of those connections between the separate tasks and their outcomes that can be crucial to the detection and management of disease. These disadvantages can be often be overcome by the introduction of "higher order competencies" and assessing performance (Diwarkar, 2002). Another possible disadvantage, for the professional in training, is that having to "tick off" competencies can be de-motivating and discourage critical thinking.

Nevertheless, the advantages of competency-based training have led to its widespread adoption in both medical and optometric training. In Australia, entry level competencies for optometry were first introduced in 1993 and these were revised in 1997 in the light of experience and to reflect the increasing scope of optometric practice (Kiely, 2009).

These developments influenced progress in other countries with long-established optometric professions. In Canada, for example, the Canadian Examiners in Optometry introduced competency-based performance standards in 2005, drawing heavily from the seminal work by their colleagues in Australia (Winslade, 2005). Optometry worldwide has embraced this trend, culminating in the publication in 2005 of a "*Global competency-based model of scope of practice in optometry*" (WCO, 2005).

It is interesting to track how the competency-based approach to training and assessment has been introduced to UK optometry. As recently as 10 years ago our optometric training post-university followed the traditional "time served" model. This was embodied in the "pre-registration year", which trainee optometrists undertook following graduation from university with a BSc in Optometry, and which ended with the "big bang" assessment known as the PQE ("Professional Qualifying Examination") at the end of that year. This examination consisted of a series of viva-voce oral

examinations conducted by a range of examiners, plus the assessment of practical skills on patients who could present with varying degrees of difficulty. All the individual elements of the examination had to be passed to achieve registration. This structure was inevitably prone to subjectivity on the part of examiners and inequality of the challenge posed to the candidates taking the examination. The PQE was modified in the middle of the last decade, notably with the introduction of an element of practice-based assessment, but the big bang nature of the final examination was partially retained, with four elements that had to be passed individually. All this has now been replaced by the more flexible "*Scheme for registration*" which was piloted in 2008 and introduced fully in its present form in 2009 (College of Optometrists, 2010b). The pre-registration year has been replaced by the less rigidly defined "pre-registration period". Stage 1 and Stage 2 work-based assessments have been introduced, in which trained assessors visit the trainees in their own practices and sign off competencies satisfactorily performed at each visit. The final examination adopts an OSCE model which tests a series of 14 competencies in 5-minute stations, which assess candidates' abilities across the competency framework. The competencies themselves are regularly reviewed for currency and appropriateness by the General Optical Council (GOC), working in collaboration with the College of Optometrists, and involving more wide-ranging consultation with stakeholders (GOC, 2008c).

So far, this section has focused on "entry level" competencies for professions such as optometry. But there has been recognition in optometry that the expanding scope of the profession into more specialised areas, notably therapeutics, would require competency-based training for registered optometrists who wished to participate in these new disciplines. This recognition led to the next major development in competency-based training and assessment, which again occurred in Australia with the development of specialist competencies in therapeutics in 2000 to coincide with the introduction of legislation to permit optometrists to become involved in therapeutics (Kiely, 2009). UK optometry embraced the competency-based model for specialist practise with the development of its training for optometrists wishing to become optometrist prescribers. An important early stage in the development process was the formulation of the "*Competency Framework for prescribing optometrists*" (National Prescribing Centre and General Optical Council, 2004, *Competency framework for prescribing optometrists*. General Optical Council *Stage 2 Core Competencies for Optometry*, 2005) which fulfilled a number of purposes, notably to:

- "Inform the development of an outline curriculum to prepare optometrists to prescribe.
- Help ensure that optometrist prescribers possess all the relevant expertise to initially undertake supplementary prescribing and, eventually, independent prescribing.
- Help optometrist prescribers and their employers/managers identify gaps in knowledge and skills and therefore identify ongoing training and development needs.
- Inform the commissioning, development and provision of appropriate continuing education and training programmes for optometrist prescribers".

There are obvious applications of the competency-based approach to the management by optometrists of patients with glaucoma and ocular hypertension. Indeed the bullet points above are directly applicable to glaucoma and OHT, with the substitution of "detection and management of glaucoma and OHT" where appropriate for "prescribing" etc. The first step in any competency-driven scheme is to develop the competency framework itself and this was the primary aim of this Chapter.

3.1.3 Competency Framework

A competency framework is a collection of competencies that are thought to be central to effective performance. Competency frameworks can be used to:

- Inform the development of curricula for specialist training.
- Allow educational providers to identify learning outcomes.
- Provide a framework for assessment of skills and knowledge.
- Support continuing professional development (CPD) and personal reflection on practice.

Competency frameworks have been used extensively in optometry for both pre-registration and specialist post-registration education and training (National Prescribing Centre and General Optical Council, 2004, *Competency framework for prescribing optometrists*. General Optical Council *Stage 2 Core Competencies for Optometry*, 2005).

3.1.4 Delphi Method

The name Delphi probably derives from the Oracle of Delphi, where Apollo is said to have received ambiguous messages from a priestess, so it is perhaps not the most apt name for the process that is about to be described! The Delphi method is based on the theory that a group judgement is more robust than the judgement of an individual.

The Delphi method has its origins in the 1950s, during the cold war, when the US Air Force funded the Rand Corporation to determine a method to establish a reliable consensus of opinion from a group of experts (Dalkey & Helmer, 1963; Linstone & Turrof, 1975). This consensus of opinion was obtained by a series of questionnaires which were interspersed by "controlled opinion feedback", which allowed a large number of experts to include their controlled opinions without the need for an actual meeting. The controlled feedback allowed some regulation of both the positive and negative qualities of the panel.

There are four key elements to the method; anonymity, iteration, controlled feedback and statistical aggregation. The use of questionnaires ensures anonymity and reduces or even eliminates any outside influences such as peer pressure. The initial questionnaire may be relatively unstructured allowing the most freedom of expression. After analysis a second round of questions is produced taking into account the first set of responses, with this second questionnaire being more structured. The process is repeated, with each subsequent questionnaire becoming more robust, and often simpler e.g. progressing from asking for an opinion to a forced-choice question. This iteration or repetition element allows individuals to change their opinion, once again anonymously, facilitated by the feedback, thus providing them with further information. The feedback can consist of simple statistical analyses of responses or more detailed opinion. The analysis of each "round" also allows the identification of any "outliers" which could then be further addressed. After the required number of iterations, usually when a fairly repeatable agreement has been achieved, the mean of the responses should provide a final "result".

As with any method there are always variations to the technique. Although variations exist they adhere to the basic principles of the method, and the Delphi technique is a well-established approach which has been previously applied to the development of competency frameworks and curricula for medical sub-specialities (Stewart et al, 1999;

Hay et al., 2007; Clancy et al., 2009).

3.1.5 Glaucoma training

Training schemes need to be established for optometrists for both the detection and management of chronic glaucoma (The National Eye Care Services Steering Group, 2004). Currently there is no formal screening programme for glaucoma in the UK (Mowatt et al., 2008) and case-finding is usually opportunistic with the public attending for eye examinations.

The National Institute for Health and Clinical Excellence (NICE) guideline (2009) on the diagnosis and management of chronic open angle glaucoma (COAG) and ocular hypertension (OHT) made recommendations regarding the involvement of non-medical healthcare professionals in the diagnosis of OHT and suspected COAG and the formulation of a management plan. Although NICE recommends that all patients with suspected glaucomatous damage should be referred to a consultant ophthalmologist for consideration of a definitive diagnosis and formulation of a management plan, there was recognition that appropriately trained non-medical healthcare professionals could diagnose OHT, suspect glaucoma and make a preliminary identification of cases of COAG (see Table 3.1).

Table 3.1: NICE recommendation for diagnosis of OHT and suspected COAG (from National Institute of Clinical Excellence (2009) Glaucoma: Diagnosis and management of chronic open angle glaucoma and ocular hypertension. National Collaborating Centre for Acute Care: London).

Recommendation	**Diagnosis of OHT and suspected COAG and formulation of a management plan should be made by a suitably trained healthcare professional with:** • **a specialist qualification (when not working under the supervision of a consultant ophthalmologist) and** • **relevant experience.**

Furthermore, persons with a diagnosis of OHT, suspect COAG or COAG could also be monitored and treated under shared-care arrangements by trained non-medical healthcare professionals (see Table 3.2).

Table 3.2: NICE recommendation for monitoring of OAG (from National Institute of Clinical Excellence (2009) Glaucoma: Diagnosis and management of chronic open angle glaucoma and ocular hypertension. National Collaborating Centre for Acute Care: London).

Recommendation	* **People with a diagnosis of OHT, suspected COAG or COAG should be monitored and treated by a trained healthcare professional who has all of the following:** • **a specialist qualification (when not working under the supervision of a consultant ophthalmologist)** • **relevant experience** • **ability to detect a change in clinical status.**

The NICE guideline stipulated that healthcare professionals involved in the diagnosis, monitoring and treatment of glaucoma should have relevant experience and a specialist qualification in glaucoma when not working under the direct supervision of a consultant ophthalmologist. An appropriate prescribing qualification would also be required for those involved in glaucoma treatment.

In order to develop curricula for specialist training and criteria for accreditation, the requisite diagnostic and management competencies need to be agreed. This chapter reports how the Delphi methodology was successfully used to develop these competencies.

3.1.6 Aim of Chapter 3

The aim of this chapter is to define a competency framework for optometrists with a specialist interest in glaucoma using a modified Delphi approach.

3.2 Methods

A panel of experts was selected and invited to participate using a convenience sampling technique. The panel was deliberately chosen to be multi-disciplinary and comprised 5 glaucoma sub-specialist ophthalmologists, 9 glaucoma specialist optometrists, and a researcher with extensive expertise in glaucoma. They were chosen to provide wide-ranging perspectives from ophthalmologists involved in glaucoma treatment, optometrists participating in hospital or community co-management of glaucoma and academics with extensive experience in the

postgraduate, post-registration education of optometrists. The process was facilitated by a smaller project steering group consisting of members of the Glaucoma Special Interest Group at City University London.

The first round of this Delphi process consisted of the panel members completing a questionnaire which was entirely web-based and hosted by a US provider of online surveys (Survey Monkey; http://www.surveymonkey.com; Oregon, USA). This online method ensured anonymity of the respondent and allowed respondents to express freely their opinions without being influenced by the views of others. To reduce the number of rounds in this modified process, the first survey consisted of draft competency statements generated by the project steering group. The group had taken existing competencies for the training of undergraduate and pre-registration optometrists as the baseline competency set, and then built upon these by adding additional statements relating to the diagnosis, monitoring and treatment of glaucoma.

The existing glaucoma-related competencies, obtained from the GOC (GOC, 2005), were:

- The ability to take an accurate history from patients with a range of optometric conditions.
- The ability to create and to keep clear, accurate and contemporaneous patient records.
- The ability to impart to patients an explanation of their physiological or pathological eye condition.
- An ability to understand the patient's expectations and aspirations and manage empathetically situations where these cannot be met.
- The ability to communicate bad news to patients in an empathetic and understandable way.
- The ability to assess the external eye and adnexa.
- The ability to use a slit lamp.
- The ability to examine fundi using direct and indirect techniques.
- The ability to investigate visual fields and to analyse and interpret the results.
- An understanding of the special examination needs of patients with severe visual field defects.
- The ability to use a contact tonometer to measure intraocular pressure and analyse and interpret the results.

- The ability to evaluate glaucoma risk factors, to detect glaucoma and refer accordingly.
- The ability to make a judgement regarding referral and an understanding of referral pathways.

It was assumed by virtue of achieving registration that all optometrists in practice have acquired the competencies included in the General Optical Council Stage 2 Core Competencies for Optometry. It should be noted that all glaucomas were considered in this Delphi process. Twenty draft competencies were initially agreed by the project steering group as follows, presented under three headings:

1. History Taking/Record keeping

    - The ability to take a comprehensive ophthalmic history in a patient with diagnosed or suspected glaucoma.

    - The ability to maintain clear, accurate and contemporaneous clinical records of ophthalmic history, examination and results of clinical investigations in patients at risk of or suffering from glaucoma.

2. Examination/ Data interpretation

    - The ability to carry out an appropriate examination of the anterior segment of the eye in a patient with diagnosed or suspected glaucoma and to interpret relevant clinical signs.

    - The ability to perform the van Herick technique for the assessment of peripheral anterior chamber depth and to interpret the significance of the results.

    - The ability to perform a gonioscopic examination of the anterior chamber angle and to identify anatomical structures, accurately grade the angle width and interpret the significance of clinical findings.

- The ability to perform an assessment of central corneal thickness using appropriate instrumentation and to interpret the significance of the results.

- The ability to recognise the signs and symptoms of a patient suffering from angle-closure glaucoma (or at risk of angle closure) and to refer the patient accordingly (including the instigation of emergency treatment if necessary).

- The ability to assess the optic nerve head by binocular indirect ophthalmoscopy and to detect the characteristic features of glaucomatous optic neuropathy.

- An understanding of supra-threshold perimetric techniques used in the assessment of a patient with suspected glaucoma including test strategies used, sources of error, interpretation of results and the recognition of glaucomatous field loss.

- An understanding of the use of threshold perimetric techniques used in the assessment of a patient with manifest glaucoma and the ability to detect the progression of disease.

- An understanding of the imaging techniques used to assess the optic nerve head and retinal nerve fibre layer and the ability to interpret the results of such investigations.

- The ability to differentially diagnose glaucoma through an interpretation and integration of the results of clinical examination and the results of any further investigative techniques.

- The ability to recognise the indications for treatment in glaucoma, the concept of target pressures and risk factors for disease progression.

- The ability to detect a change in clinical status (e.g. visual field status, intra-ocular pressure, assessment of anterior or posterior segments).

3. Management

- The ability to monitor the response to treatment and modify the management plan or consult a more experienced colleague or refer if necessary.

- An understanding of time frames for follow-up of patients with glaucoma taking into account target pressures and the risk of progression.

- Knowledge of the cautions, contraindications, interactions and side effects of anti-glaucoma medication.

- Knowledge of the surgical management of the glaucomas including indications for surgery, surgical techniques, complications and post-operative evaluation.

- An awareness of one's own limitations and the ability to make clinical decisions based on the needs of the patient.

- The ability to operate within local protocols for the detection and/or management of glaucoma.

The full survey is included in Appendix 3.

The panel members were invited to rate each competency on a 9-point Likert scale ranging from "0 = non essential" to "9 = essential", thus weighting the importance each member attaches to each enhanced skill or element of knowledge. Free-text boxes were provided to allow the panel members to add any comments, suggest modifications or re-wording and/or possible additional competencies. The survey was split into two distinct sections for two specialist optometric roles. The first related to those competencies that should be demonstrated by an optometrist involved in glaucoma diagnosis. NICE guidance describes this role as "diagnosis of OHT and suspect COAG status and preliminary identification of COAG". The second section related to those competencies that should be possessed by an optometrist additionally involved in glaucoma monitoring and treatment. NICE defined this role as "healthcare professionals involved in the monitoring and treatment of people with OHT, suspected

COAG and established COAG". The same draft competencies were included for each section, i.e. diagnosis and management.

The panel members were allowed 3 weeks to respond to the first questionnaire, after which the survey was closed and the results analysed. For each draft statement the mean rating was calculated, together with the mean percentage of respondents scoring the competency above 5 (the neutral point on the Likert scale). The project steering group reviewed the free-text comments and suggestions from panel members, which resulted in some modification of the competencies and the drafting and inclusion of some additional competencies. Following these changes, the panel members were again asked to rate, in the same way as in round 1, the now twenty-three competencies under the two sections of diagnosis and management. Prior to completing the round 2 questionnaire, they were provided with written feedback on the results of the first round. The full survey is included as Appendix 4.

The panel members were again allowed three weeks to respond, after which time the survey was closed and the results analysed as before. The Delphi process was followed by a face-to-face workshop to facilitate consensus on borderline competencies and to agree the final framework. Since the literature on the Delphi technique does not stipulate the level at which consensus is judged to have been reached, this was chosen arbitrarily by the steering group. Competencies with a mean score greater than 5 on the Likert scale and with more than a 2/3 majority (67%) scoring the statement ≥6 were included in the framework without further discussion at the workshop. Competencies were excluded from the framework if they had a mean score of <5 or if fewer than 67% of respondents scored the competency greater than 5. All borderline competencies were considered at the workshop discussion and a consensus was reached on the day (2/3 majority) regarding their inclusion in or exclusion from the framework.

The competency framework that was agreed at the workshop was circulated to relevant stakeholders (including national bodies representing optometrists, ophthalmologists, general practitioners, nurses and orthoptists) during a 4-month consultation period, after which a final framework was published. The full framework is included as Appendix 5.

Ethical approval for these studies was granted by the City University School of Health Sciences Research and Ethics Committee and the research was carried out in

compliance with the Declaration of Helsinki http://www.wma.net/en/30publications/10policies/b3/index.html

3.3 Results

3.3.1 Delphi: Round 1

There was a 100% (n = 15) completion and return rate for the round 1 questionnaires. Twenty competency statements were initially presented and following analysis of the round 1 responses, the wording of 8 statements was modified and 3 additional competencies were added. Twenty-three statements were presented for scoring and comment in round 2. These are listed in Table 3.3 and were distributed to the expert panel to initiate round 2.

3.3.2 Delphi: Round 2

There was a 93% (n = 14) completion and return rate for round 2. Tables 3.3 and 3.4 show the competency statements and corresponding scores at the end of round 2. The consensus view of the panel was that all 23 competencies were required for a role in glaucoma monitoring and treatment (Table 3.4).

For a role in diagnosis of glaucoma, 4 competencies (16, 17, 18 and 19 in Table 3.3) did not meet the criteria for consensus and were deemed not to be required for diagnosis. Four diagnostic competencies (10, 14, 15 and 22 in Table 3.3) were considered 'borderline' and were discussed at the subsequent workshop.

Table 3.3: Round 2 ratings for competencies required by optometrists involved in the diagnosis of glaucoma.

Competency	Mean Rating (9=essential)	% scoring >= 6
1.The ability to take a comprehensive ophthalmic history in a patient with diagnosed or suspected glaucoma, including the identification of ocular and systemic risk factors for glaucoma.	7.4	86.7
2.The ability to maintain clear, accurate and	7.9	86.7

contemporaneous clinical records of ophthalmic history, examination and results of clinical investigations in patients at risk of or with suspected glaucoma.		
3.The ability to carry out an appropriate examination of the anterior segment of the eye in a patient at risk of, or with suspected glaucoma and to interpret relevant clinical signs.	8.3	93.3
4.The ability to perform the van Herick technique for the assessment of peripheral anterior chamber depth and to interpret the significance of the results.	8.1	93.3
5.The ability to perform a gonioscopic examination of the anterior chamber angle and to identify anatomical structures, accurately grade the angle width and interpret the significance of clinical findings.	7.1	80.0
6.The ability to perform an assessment of central corneal thickness using appropriate instrumentation and to interpret the significance of the results.	7.6	86.6
7.The ability to recognise the signs and symptoms of a patient suffering from angle-closure glaucoma (or at risk of angle closure) and to refer the patient accordingly (including the instigation of emergency treatment if necessary).	8.5	93.3
8. The ability to assess the optic nerve head by binocular indirect ophthalmoscopy and to detect the characteristic features of glaucomatous optic neuropathy,	8.9	93.3
9. An understanding of supra-threshold perimetric techniques used in the assessment of a patient with suspected glaucoma including test strategies used, sources of error, interpretation of results and the recognition of glaucomatous field loss.	8.4	93.3
10. An understanding of the use of threshold perimetric techniques for the assessment of a patient with manifest glaucoma including test strategies used, sources of error and artefact, and the ability to detect progression of disease.	6.7	66.7
11. An understanding of the imaging techniques used to	6.5	73.3

assess the optic nerve head and retinal nerve fibre layer and the ability to interpret the results of such investigations.		
12. The ability to differentially diagnose glaucoma through an interpretation and integration of the results of clinical examination and the results of any further investigative techniques.	8.3	93.3
13. The ability to detect and appreciate the significance of concurrent pathology in the management of glaucoma.	7.5	93.7
14. The ability to recognise the indications for treatment in glaucoma, the concept of target pressures and risk factors for disease progression.	7.2	59.9
15. The ability to detect a change in clinical status (e.g. visual field status, intra-ocular pressure, assessment of anterior or posterior segments).	6.5	66.7
16. The ability to monitor the response to treatment and modify the management plan or consult a more experienced colleague if necessary.	4.1	33.3
17. An understanding of time-frames for follow-up of patients taking into account local preferences, risk of progression, and patient related factors (age, concurrent disease etc).	4.9	53.3
18. Knowledge of the pharmacology, cautions, contraindications, interactions and side effects of anti-glaucoma medication.	4.9	53.3
19. Knowledge of the surgical management of the glaucomas including indications for surgery, surgical techniques, complications and post-operative evaluation.	3.8	40.0
20. An awareness of one's own limitations and the ability to make clinical decisions based on the needs of the patient.	8.3	93.3
21. The ability to operate within local protocols for the detection and/or management of glaucoma.	8.1	93.3
22. The ability to help patients make informed choices about their management and to check their understanding of and commitment to their management and follow-up.	6.1	60.0

23. The ability to counsel patients regarding risks of blindness associated with glaucoma, risk to family members, potential impact of the disease on lifestyle (including driving) and provide information on available sources of help, counselling and support.	7.2	80.0

Table 3.4: Round 2 ratings for competencies required by optometrists involved in the monitoring and treatment of glaucoma

Competency	**Mean Rating (9=essential)**	**% scoring >= 6**
1. The ability to take a comprehensive ophthalmic history in a patient with diagnosed or suspected glaucoma, including the identification of ocular and systemic risk factors for glaucoma.	8.6	93
2.The ability to maintain clear, accurate and contemporaneous clinical records of ophthalmic history, examination and results of clinical investigations in patients at risk of or with suspected glaucoma.	8.6	93
3. The ability to carry out an appropriate examination of the anterior segment of the eye in a patient at risk of, or with suspected glaucoma and to interpret relevant clinical signs.	8.7	100
4. The ability to perform the van Herick technique for the assessment of peripheral anterior chamber depth and to interpret the significance of the results.	7.6	86
5. The ability to perform a gonioscopic examination of the anterior chamber angle and to identify anatomical structures, accurately grade the angle width and interpret the significance of clinical findings.	7.8	86
6. The ability to perform an assessment of central corneal thickness using appropriate instrumentation and to interpret the significance of the results.	8.1	86.6
7. The ability to recognise the signs and symptoms of a patient suffering from angle-closure glaucoma (or at risk of	7.9	100

angle closure) and to refer the patient accordingly (including the instigation of emergency treatment if necessary).		
8. The ability to assess the optic nerve head by binocular indirect ophthalmoscopy and to detect the characteristic features of glaucomatous optic neuropathy.	9.0	100
9. An understanding of supra-threshold perimetric techniques used in the assessment of a patient with suspected glaucoma including test strategies used, sources of error, interpretation of results and the recognition of glaucomatous field loss.	7.9	86
10. An understanding of the use of threshold perimetric techniques for the assessment of a patient with manifest glaucoma including test strategies used, sources of error and artefact, and the ability to detect progression of disease.	9.0	100
11. An understanding of the imaging techniques used to assess the optic nerve head and retinal nerve fibre layer and the ability to interpret the results of such investigations.	8.1	86
12. The ability to differentially diagnose glaucoma through an interpretation and integration of the results of clinical examination and the results of any further investigative techniques.	8.6	100
13. The ability to detect and appreciate the significance of concurrent pathology in the management of glaucoma.	8.0	100
14. The ability to recognise the indications for treatment in glaucoma, the concept of target pressures and risk factors for disease progression.	8.6	100
15. The ability to detect a change in clinical status (e.g. visual field status, intra-ocular pressure, assessment of anterior or posterior segments).	9.0	100
16. The ability to monitor the response to treatment and modify the management plan or consult a more experienced colleague if necessary.	9.0	100
17. An understanding of time-frames for follow-up of	8.9	100

patients taking into account local preferences, risk of progression, and patient related factors (age, concurrent disease etc).		
18. Knowledge of the pharmacology, cautions, contraindications, interactions and side effects of anti-glaucoma medication.	8.6	100
19. Knowledge of the surgical management of the glaucomas including indications for surgery, surgical techniques, complications and post-operative evaluation.	8.1	100
20. An awareness of one's own limitations and the ability to make clinical decisions based on the needs of the patient.	9.0	100
21. The ability to operate within local protocols for the detection and/or management of glaucoma.	8.9	100
22. The ability to help patients make informed choices about their management and to check their understanding of and commitment to their management and follow-up.	8.6	100
23. The ability to counsel patients regarding risks of blindness associated with glaucoma, risk to family members, potential impact of the disease on lifestyle (including driving) and provide information on available sources of help, counselling and support.	8.6	100

3.3.3 Workshop

All Delphi panel members attended the workshop, at which borderline competencies were discussed and consensus reached regarding their inclusion. Competencies 9 and 10 were condensed into a single statement. One focus of the workshop discussion was on applanation tonometry. Although applanation tonometry is a GOC entry level competency for registration as an optometrist, the panel felt that the specific competency statement relating to tonometry needed further precision and the revised statement *'The ability to accurately measure intraocular pressure using a slit-lamp mounted Goldmann applanation tonometer and the ability to analyse and interpret the results'* was added to the framework (new competency statement 8). The framework agreed following the workshop contained 19 competencies for glaucoma diagnosis and 7 further competencies for monitoring and treatment.

3.3.4 Stakeholder consultation

Following replies received during the consultation period, minor editorial changes were made to the wording of 3 competencies; however the final competency framework did not differ significantly in content from that agreed at the workshop. The final competency framework is included in Appendix 5.

3.4 Discussion

The Delphi approach has previously been successfully utilised in the development of other medical and allied health professions' curricula (Clancy et al., 2008). To the author's knowledge the Delphi approach has not been used previously in UK optometry, and its successful application to the development of the competency framework demonstrates the utility of the approach within the optometric sphere of activity. The scope of the new framework is broad, being applicable to all optometrists with a specialist interest in glaucoma, whether they are hospital-based or whether they provide primary care optometry in community practice.

In 2006, 58% of hospital ophthalmic departments were operating glaucoma schemes using a variety of non-medical healthcare professionals (Vernon & Adair, 2009). These were predominantly in-house (80%), although approximately 14% were operating community-based schemes using optometrists. Since 2006 there has been a rapid expansion of both hospital-based and community-based schemes involving optometrists (Parkins & Edgar, 2011). Many of these schemes, especially those in which optometrists work in the hospital environment, require participating optometrists to undertake additional training in glaucoma diagnosis and/or management (Spry, 2007; Bourne et al., 2010).

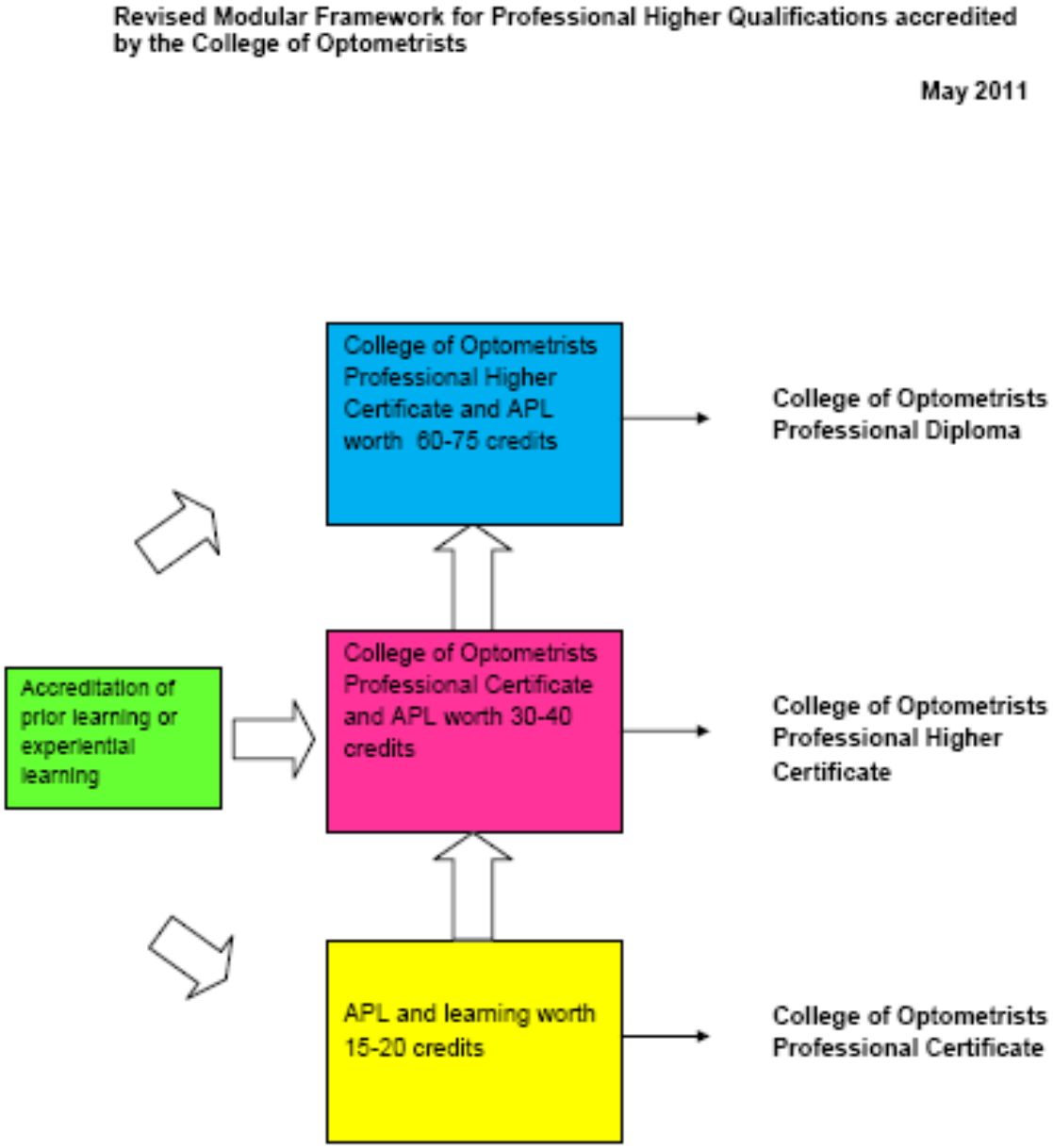
Studies suggest that optometrists with additional training in glaucoma are able to make reliable and accurate diagnostic and management decisions (Banes et al., 2006; Azuara-Blanco et al., 2007) However, training programmes differed widely across the UK. Whilst variations in training may reflect the experience and responsibilities of the optometrists involved, there was an urgent need for standardisation in training and accreditation.

The NICE guideline on the diagnosis and management of OHT and COAG (2009) made recommendations on the organisation of care and began to define the competencies required for healthcare professionals involved in glaucoma service delivery. Competency frameworks, which define the core skills and knowledge for effective performance, provide a sound underpinning of curricula for core and specialist training, provide criteria for accreditation and inform the commissioning of continual professional development (CPD). Such frameworks have been used extensively in the optometric profession at all levels both pre- and post-registration. The framework that emerged from the Delphi approach has already had impacts beyond this PhD thesis. Soon after its development, City University London was approached and subsequently commissioned by the College of Optometrists to develop specialist curricula and accreditation standards for optometrists involved in referral refinement diagnosis and management of glaucoma (College of Optometrists Higher Qualifications 2011: http://www.college-optometrists.org/en/utilities/document-summary.cfm/docid/B2C25602-1CF0-4616-BD8DA6A8B1039387).

Furthermore, the framework contributed to a revamped Glaucoma module delivered as part of City University's modular MSc in Clinical Optometry. This module is also accredited for the CoO's new Professional Certificate in Glaucoma (http://www.college-optometrists.org/en/professional-development/hq/new-college-accredited-courses/college-accredited-courses.cfm) (see Figure 3.2). This Certificate can be a stepping stone to the award of the Professional Higher Certificate or Diploma in Glaucoma.

Although the competency framework was developed specifically for optometrists, other non-medical healthcare professionals are also involved in glaucoma service delivery e.g. nurses and orthoptists (Vernon & Adair, 2010). It is to be anticipated and has been suggested that the framework could be adapted for these professions. A shared competency-based approach could enable a coordinated training and development model for all professionals involved in glaucoma detection and management. To facilitate the wider use of the framework this study has been published in *Eye* (Myint et al., 2010) and the published paper explains the modified Delphi approach adopted.

Figure 3.2 The new College of Optometrists' Higher Qualification structure, which illustrates how optometrists can progress from the entry level Professional Certificate in Glaucoma, through the Professional Higher Certificate to the Professional Diploma in Glaucoma (from Revised Modular Framework for Professional Higher Qualifications accredited by the College of Optometrists).



3.4.1 Possible limitations of this study

It is acknowledged that the use of a convenience sampling method for panel selection may have led to hidden bias. However, it is hoped that any potential bias was largely offset by the subsequent wide stakeholder consultation to validate the framework.

It could be argued that the initial selection of competencies by the project steering group may have made this selection prone to bias. However, this initial selection used established competencies for optometrists in training as a starting point. Furthermore, the Delphi panel had opportunities to refine and add further competencies during both survey rounds and again at the workshop, which all panel members attended. In further efforts to minimise bias, the expert panel was multidisciplinary in its composition and all members had extensive and broad experience in glaucoma detection and management.

The essence of the Delphi technique is to reach as close as possible to consensus by the end of the process (Hasson et al., 2000). This raises the issue of how consensus is to be defined. Here, in the absence of any direction on this topic from the literature, the definition of consensus was set by the steering group. This was of necessity a somewhat empirical and arbitrary definition and could therefore be regarded as a potential limitation. However, it is a limitation that must be common to other studies that have adopted the Delphi approach.

The online approach to the Delphi technique adopted in this study could perhaps be regarded as a potential limitation. However, Greenhalgh et al. (2011) have identified over 100 examples of successful online Delphi studies, and none of these reported the online mode of communication as being a significant barrier. Furthermore, we supplemented the online survey elements of this Delphi study with a face-to-face workshop, which ensured that the study did not rely entirely on online communication.

3.6 Conclusion

This study demonstrates that the Delphi technique is a robust method for gaining autonomous expert opinion. The approach has led to the development of an accepted competency framework for optometrists with a special interest in glaucoma.

Chapter 4: Education and Training

4.1 Introduction

This Chapter reports on findings relating to education and training of optometrists for the detection and management of glaucoma suspects and patients. It discusses the evaluation of the impact on disc assessment and clinical decision making of a current, well-established postgraduate educational course in glaucoma.

4.2 The need for glaucoma training and accreditation

There is currently no formal screening programme for glaucoma in the UK (Mowatt et al., 2008). In the absence of a screening test optometrists play a key role in glaucoma detection in the UK with over 95% of referrals to the HES for glaucoma originating from optometrists. Detection of glaucoma and suspect glaucoma by optometrists is achieved by case-finding and is of necessity limited to those members of the public who attend their optometrists for eye examinations. To reflect their key role in glaucoma case-finding, it has long been acknowledged that training schemes need to be established for optometrists for both the detection and management of chronic glaucoma (The Eye Care Services Steering Group, 2004).

The National Institute for Health and Clinical Excellence (NICE) guideline (2009) on the diagnosis and management of chronic open angle glaucoma (COAG) and ocular hypertension (OHT) made important recommendations regarding the involvement of non-medical healthcare professionals in the diagnosis of OHT and suspected COAG and the formulation of a management plan. These are described in detail in Section 3.1.4. The key messages for training are contained in the sections on service provision and are that:-

"Diagnosis of OHT and suspected COAG and formulation of a management plan should be made by a suitably trained healthcare professional with a specialist qualification (when not working under the supervision of a consultant ophthalmologist) and relevant experience."

"Healthcare professionals involved in the diagnosis of OHT and COAG suspect status and preliminary identification of COAG should be trained in case detection and referral

refinement and be able to identify abnormalities based on relevant clinical tests and assessments."

"People with a diagnosis of OHT, suspected COAG or COAG should be monitored and treated by a trained healthcare professional who has … a specialist qualification (when not working under the supervision of a consultant ophthalmologist), relevant experience and ability to detect a change in clinical status."

"Healthcare professionals involved in the monitoring and treatment of people with OHT, suspected COAG and established COAG should be trained to make management decisions …"

"People with a confirmed diagnosis of OHT or suspected COAG and who have an established management plan may be monitored (but not treated) by a suitably trained healthcare professional with knowledge of OHT and COAG, relevant experience and ability to detect a change in clinical status."

There is a clear emphasis in all of the above on the necessity for optometrists to be appropriately trained for the various roles they can undertake in glaucoma detection and management. The College of Optometrists have developed higher qualifications in a number of clinical areas including Glaucoma, notably with their Diploma in Glaucoma which ran for a number of years and has now been replaced by their new Professional Higher Certificate in Glaucoma which can lead to the award of the Professional Higher Diploma in Glaucoma (Harper, 2011).

4.3 Post-registration glaucoma training in the UK

A variety of training mechanisms have been developed for optometrists involved in glaucoma detection and management in either primary or secondary care settings. Optometrists working in hospital-based co-management schemes participate in bespoke in-house training programmes; training that is often augmented by the requirement that optometrists achieve a higher qualification in glaucoma. Notable schemes in the UK include the Bristol Shared Care Glaucoma Service (Spry, 2008), the OLGA scheme in the Manchester Royal Eye Hospital (Marks, 2007; Marks et al., 2012) and the glaucoma service at Moorfields Eye Hospital (Banes et al., 2006; Mandalos et al., 2012).

All these schemes have evolved their own training programs for optometrists working in the hospital, but it is interesting to note the similar progression from the original informal “apprenticeship-type training experience” at both the Bristol Eye Hospital (BEH) and the Manchester Royal Eye Hospital (MREH) to the structured approach found in both institutions today (Spry & Harper, 2010). Optometrists training to join the schemes begin by familiarising themselves with the glaucoma clinics through observation. The next stage involves a period during which the optometrist, under supervision from fully-trained staff, will take measurements which will inform the assessment of the glaucoma patient. If successful, the optometrist will progress to the final stage of training which focuses on acquiring the clinical decision-making skills which are essential for glaucoma management. During this period all measurements obtained and clinical decisions taken are discussed with, and must be approved by, fully qualified members of the clinical team.

At both BEH and MREH, all optometrists who work in the Bristol Shared Care Glaucoma Service or the OLGA (Optometric Led Glaucoma Assessment) scheme respectively must already possess, or are working to achieve, the College of Optometrists Diploma in glaucoma. This qualification is not only a recognition of their knowledge and experience but also offers external, national validation that the optometrist has achieved the required competency level in glaucoma care (Spry & Harper 2010).

Training for optometrists in the community to help in the detection and management of those with suspect glaucoma and diagnosed COAG has been more locally based and in general less structured. It has ranged from the extensive knowledge and practical training in the Bristol Shared Care Glaucoma Study (Gray et al., 2000) to the often limited training offered in glaucoma referral refinement schemes (Parkins & Edgar, 2011). The Local Optical Committee Support Unit (LOCSU) has developed enhanced service pathways for a number of eye conditions including a “Glaucoma repeat readings and OHT monitoring” pathway (http://www.locsu.co.uk/enhanced-services-pathways/glaucoma-and-oht/). This has led to the establishment of a number of schemes across the UK. Training for optometrists on LOCSU-type schemes is often provided by the Wales Optometry Postgraduate Education Centre (WOPEC). Much of the training is by online distance learning but supported by practical workshop sessions (http://www.wopec.co.uk).

4.4 The role of optic disc analysis in glaucoma detection

The experimental study reported in this chapter is focussed on one aspect of glaucoma detection, optic disc assessment. The importance of optic disc assessment in glaucoma detection is highlighted in two classic research studies. In the Ocular Hypertensive Treatment study, changes in the optic disc were the first clinically detectable change in the conversion from OHT to OAG in 50% of the group receiving medication and 57% of those who were in the observation group (Gordon et al., 2002; Keltner et al., 2006). In the European Glaucoma Prevention Study changes in the optic disc were identified before changes in the visual field in approximately 40% of patients (Miglior et al., 2007). It has also been argued that as many as 30% of ganglion cell axons can atrophy before a visual field defect can be detected (Kerrigan-Baumrind et al., 2000; Wollstein et al., 2000). More recent research, based on both psychophysics and histological research has challenged these findings (Yucel et al., 2000; McKendrick et al., 2004). Nevertheless, disc assessment continues to play a major role in glaucoma detection and management, and it is therefore imperative that optometrists are skilled at detecting the often subtle glaucomatous changes at the optic nerve head as early as possible to facilitate early detection.

Optic disc size varies physiologically by up to seven times between individuals, though there is little variation in the number of retinal ganglion cell axons (Jonas et al., 1988). Asymmetry of neuro-retinal rim appearance between the two eyes can be indicative of glaucoma though it can be the result of asymmetry in optic disc size (Kotecha, 2009).

Though most optometrists will faithfully record the vertical cup-to-disc ratio (CDR), this measurement is affected by optic disc size, and Kotecha (2009) notes that recording CDR without measuring optic disc size does not provide information that is clinically meaningful. Furthermore, CDR is a subjective measurement with relatively poor repeatability and reproducibility and, especially when considered in isolation, it is not particularly useful in glaucoma diagnosis (Burr et al., 2007). .

It is important to evaluate the thickness of the neuro-retinal rim (NRR) in the four quadrants i.e. inferior, superior, nasal and temporal. Jonas' ISNT rule suggests that in a healthy disc, the NRR is thickest inferiorly, followed by superiorly, then nasally, and

then temporally (Jonas et al. 1988). In the glaucomatous disc the rule may no longer be obeyed, but in the early stages of the disease two thirds of eyes will still show the ISNT pattern (Sihota et al., 2008). It can be difficult to assess the NRR so other indications of glaucomatous change may be easier to detect. These include baring or bayoneting of blood vessels (Kotecha, 2009).

Optic disc haemorrhages can also be indicative of glaucoma and, due to the distribution of nerve fibres in the retinal nerve fibre layer, will usually appear flame shaped. These haemorrhages do occur in the normal population, with an estimated prevalence of 0.2%, but the prevalence is higher in the glaucomatous population 2–4% (Drance, 1989). Like most retinal haemorrhages, glaucomatous optic disc haemorrhages will resolve but they are often precursors to more serious RNFL defects (Uhler & Piltz-Seymour, 2008).

Peripapillary atrophy (PPA) is a common physiological finding and is classified into two distinct areas: α-zone and β-zone (Jonas et al., 1989). It is the β-zone, adjacent to the disc that is commonly associated with glaucomatous change (Budde & Jonas, 2004).

Optic disc examination is one of the primary skills required in the early detection of glaucoma (Heijl et al., 2002), but many observers may miss early signs of glaucoma-related damage, at a stage in the disease process when the outcome of treatment would be optimal (Wollstein et al., 2000; Leong et al., 2003; Susanna and Vessani, 2007). Despite advances in modern technology relating to disc analysis (see Chapter 1 Section 1.6), it has been argued that subjective assessment by experienced practitioners is at least as effective (O'Connor et al., 1993; Caprioli et al., 1996; Wollstein et al., 2000; Deleón-Ortega et al., 2006; Rao et al., 2011).

Inter-observer variability in the interpretation of optic discs exists, even with expert clinicians (Lichter, 1977; Harper et al., 2000a; Reus et al., 2010), but intra-observer differences are often less substantial (Zeyen et al, 2003). Inter-observer and intra-observer differences for disc analysis are affected by training, relevant experience and practice setting (Spalding et al., 2000; Sheen et al., 2004; Breusegem et al., 2010).

4.5 Online and computer-based training for, and assessment of, optic disc analysis

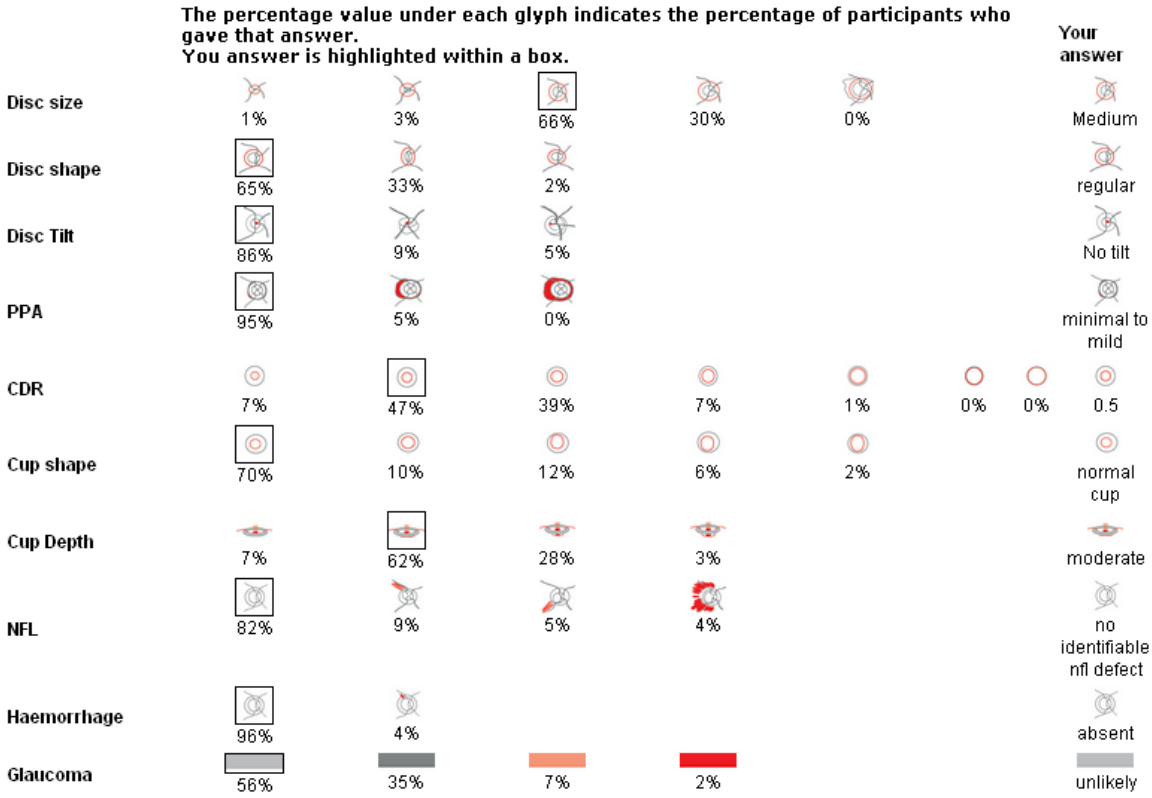
4.5.1 The GONE project

The Glaucomatous Optic Neuropathy Evaluation Project (GONE) is an internet-based system that allows participants to self assess their disc analysis skills (Kong et al., 2010) (see Figures 4.1 and 4.2). The project had an original cohort of 197 international glaucoma medical specialists who were asked to evaluate 42 disc images online and grade various glaucoma-related features; disc size, disc shape, disc tilt, PPA, vertical CDR, cup shape, cup depth, nerve fibre layer loss, haemorrhage and glaucoma likelihood. There was good agreement for overall probability of glaucoma across the group. For specific features, agreement was highest for haemorrhage, with good levels of agreement for disc size, disc shape, cup:disc ratio, peripapillary atrophy and cup shape. Interestingly, discs that had lower agreement for cup:disc ratio, cup shape, cup depth, retinal nerve fibre layer and moderate to deep CDR also had lower agreement for glaucoma probability.

Figure 4.1: Screenshot of the sample disc available on the GONE website http://www.gone-project.com.

The GONE project provides a non-judgemental learning environment where practitioners can assess their disc analysis skills against others. It represents a novel approach to this difficult aspect of clinical decision making.

Figure 4.2 Screenshot of the analysis of the results of the sample disc available on the GONE website (http:www.gone-project.com).



4.5.2 The Discus program

The Discus program was designed by Professor David Henson (DH) with his research team at the Research Group for Eye and Vision Sciences at the University of Manchester. Discus is a software package which allows clinicians to make a subjective judgement on the appearance of potentially glaucomatous optic discs. Evaluation of Discus by glaucoma specialists (Discus Expert Panel) has led to the development of a

reference standard against which other clinicians can judge their performance (Denniss et al., 2011).

The optic disc images used in the Discus program were collected from patients who attended the Optometrist-lead Glaucoma Assessment (OLGA) clinics at the Royal Eye Hospital (Manchester, UK) between June 2003 and May 2007, and who had undergone at least 4 visual field tests (using the Humphrey Visual Field Analyser) on each eye within a period of 2 to 5 years (Denniss et al., 2011). These patients were either glaucoma suspects or had been diagnosed with glaucoma which was considered at low risk of progression and was well controlled with medication. Two groups of patients were established; those classified as visual field positive ("damaged fields") (n=20) and a second group who were classified as visual field negative ("normal fields") (n=80). The decisions on visual field status were based on the Mean Deviation (MD) and Pattern Standard Deviation (PSD) global indices for each patient. The image quality of the disc images in each group was matched in an effort to eliminate any bias.

A Discus Expert Panel of 12 (10 were fellowship-trained glaucoma specialists and 2 were scientists with a glaucoma research background) agreed to take part in a study which involved them completing the Discus program. The task in Discus is to grade 126 disc images (20 visual field positive, 80 visual field negative, 2 repeats of visual field positive discs, and 24 repeats of visual field negative discs). The 26 images which are presented twice (2 in the "damaged" group and 24 in the "healthy" group) are included in order to check the consistency of the clinician's responses. The disc images are presented on a computer monitor and for each image the clinician has to base their response "on the basis of apparent disc damage". The grading of each disc is according to a five-point scale which has the options "Definitely healthy, probably healthy, not sure, probably damaged and definitely damaged". The Expert Panel could observe each disc for a maximum of 60 seconds after which it disappeared but had unlimited time after that to make a decision. No feedback was provided during the session (Denniss et al., 2011). Three screenshots of typical Discus images are shown in Figure 4.3 (a) – (c).

Figure 4.3 (a) – (c) Three screenshots of typical Discus images. Figure 4.3 (b) shows a close-up of the rating scale and of the "Next" button which the participant clicks to move on to the next image. These are the first three images of a typical Discus program in which the 126 disc images are presented in random order.

Figure 4.3 (a)

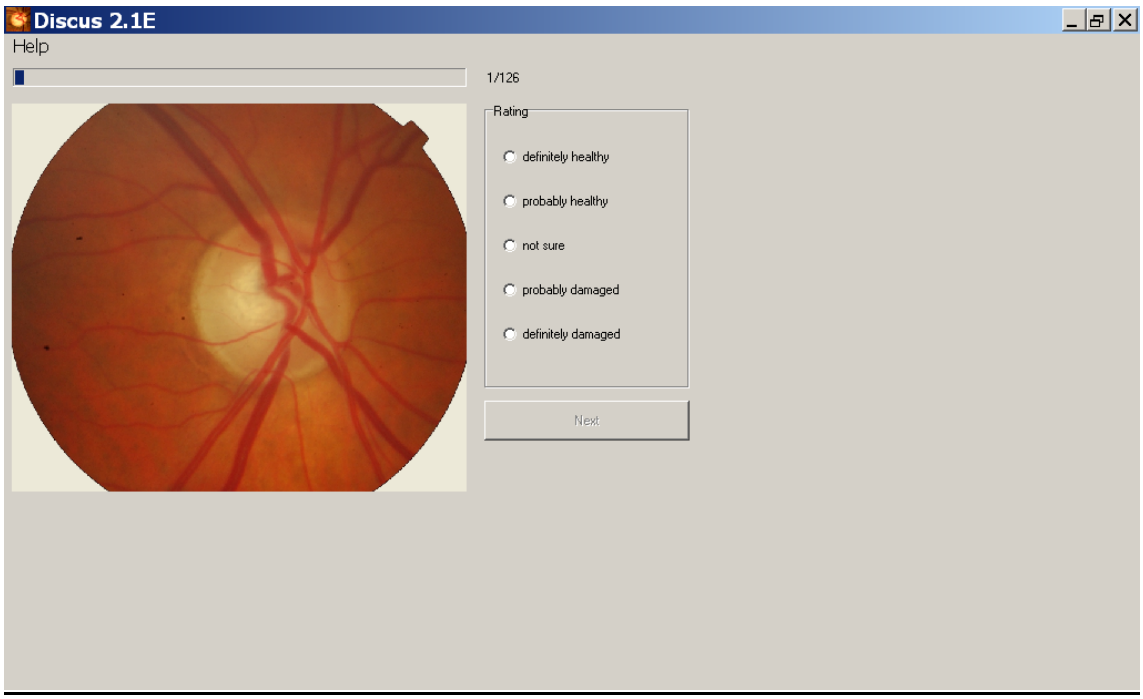


Figure 4.3 (b)

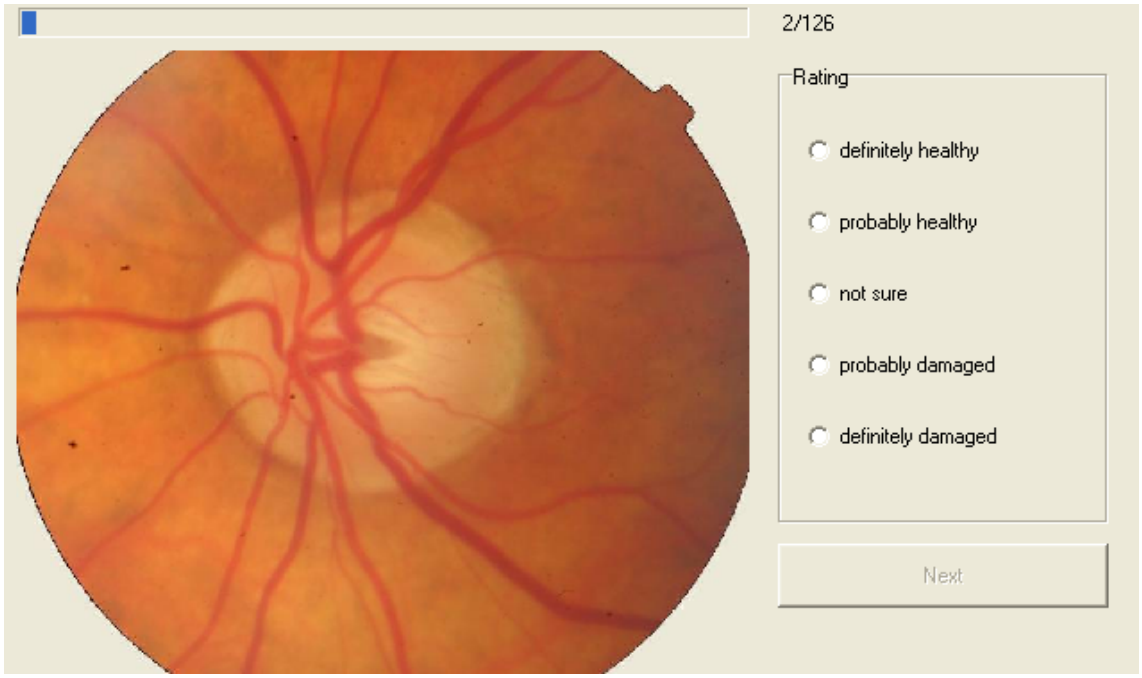
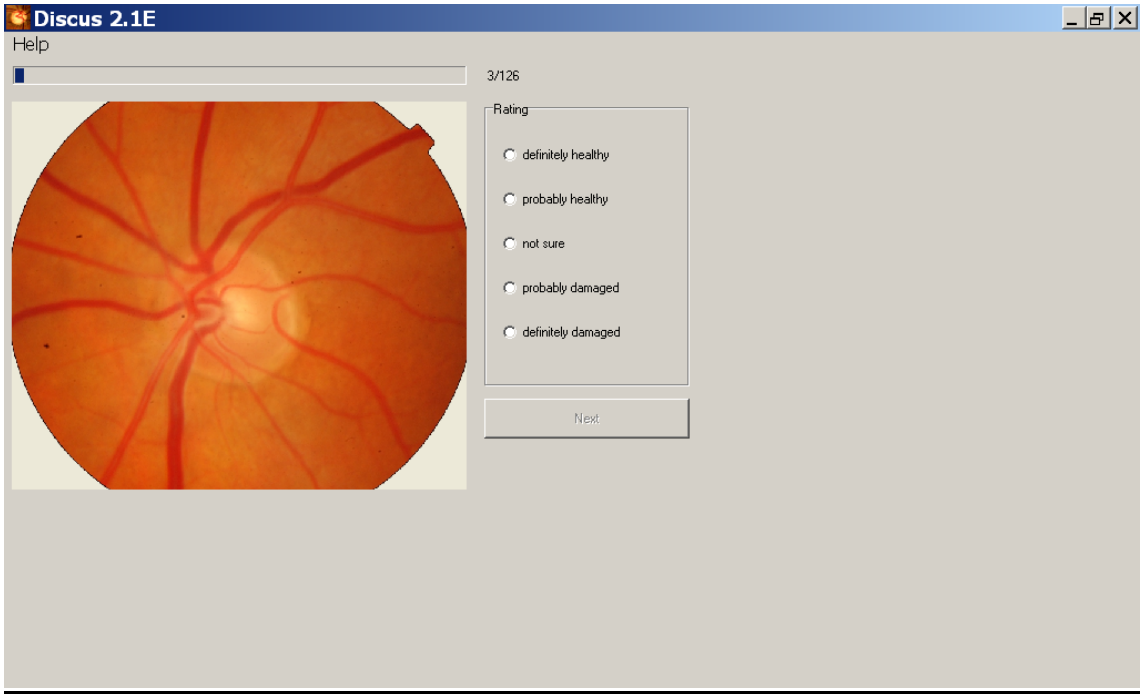
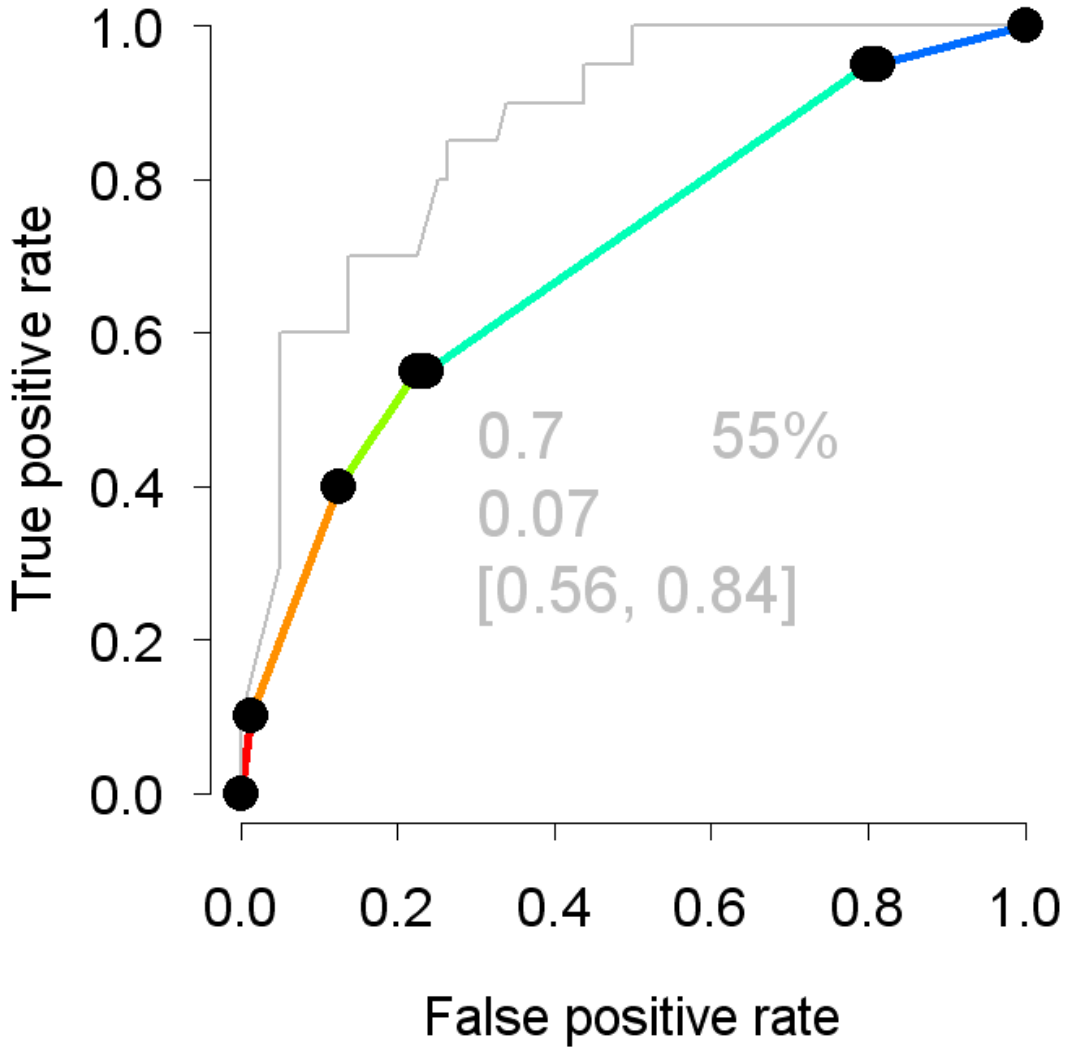


Figure 4.3 (c)



The total time taken by the experts for the experiment ranged from 13 to 46 minutes with an average time of 29 minutes. Discus records the “latency”, or the time taken to make the decision for each disc image, and the mean latency was 7s per image for the whole cohort. The data for the whole panel was pooled to create an overall response which could be used as a reference against which other clinicians could gauge their performance. The first step in this process involved calculating an average response (where ‘definitely healthy’ was scored as 1, ‘probably healthy’ as 2 etc) for the 12 experts for each of the 100 images. For the 26 repeated images the score obtained for the second presentation of the image was used in this calculation. These average scores were then used to generate a ranked order for the 100 images, from which a Receiver Operating Characteristic (ROC) curve was generated to represent the “best possible” performance. This ROC curve, and in particular the area under this curve (AUROC), can be regarded as the reference for comparison purposes for other users of the Discus program (Denniss et al., 2011). This procedure and its outcome are discussed in more detail in the Results (section 4.7) and Discussion (section 4.8) sections of this chapter. Figure 4.4 shows the reference ROC curve together with a ROC curve from an individual observer (Denniss et al, 2008). The reference AUROC obtained for the Discus Expert Panel is 0.87.

Figure 4.4: Reference ROC curve: The coloured curve is the ROC curve obtained by a clinician following analysis of their results on the Discus program. The numbers under the coloured curve are, from top to bottom left to right, the area under the curve for this clinician, the standard error, the 95% confidence interval and the percentage AUROC for observer compared with the group. The grey curve is the composite ROC curve for the Discus Expert Panel which serves as a reference. This composite curve has an area under the curve of 0.87 and is used in later sections of this chapter.



Professor Henson kindly allowed his program to be used as one of the evaluations reported in this chapter (see Section 4.7.2.3). Denniss et al. (2011) acknowledge a number of limitations of the software. These are considered in the Discussion (section

4.8). However, there are also many advantages of the program, notably the quality of images, ease of use, user-friendly data recording and analysis, and reference data from the Discus Expert Panel. These factors contributed to our choice of the Discus program as one of our approaches to investigating the effectiveness of our educational intervention.

4. 6 Aim of Chapter 4

The aim of this chapter is to evaluate the impact of an educational intervention on optometrists' ability to detect suspect OAG or OAG. Three methods of evaluation will be used:

- Knowledge of important features of the optic disc in glaucoma detection.
- Clinical decision making based on case scenarios related to glaucoma or suspect glaucoma.
- The Discus program for disc evaluation.

4.7 Methods

4.7.1 Subjects

The effectiveness of the intervention was assessed on two cohorts of postgraduate registered optometrists both before and after completing the 3-day didactic MSc module 'Optometric Management of Glaucoma' at City University London. The module is one of a series available on this flexible, modular MSc in Clinical Optometry course developed by City University to meet the needs of busy practicing clinicians. The emphasis in the range of modules available on the MSc is on co-management and therapeutics.

The glaucoma module was developed to deliver a number of objectives, which are listed below. If successful in this module the optometrist should be able to:

- Demonstrate specialised knowledge of the pathophysiology of the glaucomas in all segments of the eye.
- Provide a detailed explanation of, and differentiate between, the various techniques of ophthalmic investigation appropriate to the glaucomas, including binocular indirect ophthalmoscopy, and the use of new fundal imaging devices.

- Demonstrate a critical awareness of the various interdisciplinary patient management options.
- Demonstrate an awareness of management options available to manage patients suffering from glaucoma, synthesising research-based knowledge at the forefront of optometry and treatment methodologies.
- Exercise professional judgement with regards to referral of patients for glaucoma treatment or review of their current medical management.

The glaucoma module is held once or twice a year, and this evaluation of the educational benefits resulting from the module was completed on two successive groups of optometrists who took this module, resulting in a total of 53 eligible participants. Hospital optometrists were excluded from the evaluation as they may have acquired specialist knowledge of glaucoma in the HES. The first (pre-intervention) assessment took place on the morning of the first day of the module, before any relevant teaching or learning had taken place. The second (post-intervention) assessment took place during the usual module assessment period, which was held approximately 3 months after the completion of each module. Participants who failed to attend for the glaucoma modular assessment as a result of illness or for other reasons were removed from the study. This left a group of the aforementioned 53 subjects, referred to as the "MSc" cohort.

A smaller cohort (the "Control" cohort, n = 20) of community optometrists was recruited as a Control group. They comprised UK-registered optometrists who had not previously attended the City University glaucoma module (or had any other form of additional training in glaucoma). They completed the same assessment exercise as the MSc Cohort on two occasions, again separated by approximately 3 months, but without undergoing the educational intervention. Though there was no educational intervention with the Control cohort, for convenience the two assessments in this group will also be referred to as "Pre-intervention" and "Post-intervention" to facilitate comparison with the MSc cohort.

4.7.2 Evaluation of effectiveness of glaucoma training

There were three elements to this evaluation; knowledge of important features of the optic disc in glaucoma, clinical decision making and performance on the Discus program for disc evaluation.

4.7.2.1 Disc Analysis

Subjects were requested to list, in bullet-point form, the five most relevant features that should be observed and/or considered when assessing a patient's disc for possible OAG. This was a paper-based exercise and participants were supplied with a simple table to complete, as shown in Table 4.1:

Table 4.1: The format of the simple table used to record participants' choices of the five most relevant disc features to observe when assessing a patient's disc.

1.
2.
3.
4.
5.

A London-based expert panel (to distinguish them from the Discus Expert Panel described in Section 4.5.2), which included the lecturers involved in the glaucoma module, established the definitive list of features for the purpose of this study. In alphabetical order, these features are:-

- *Asymmetry of discs*
- *Disc haemorrhage*
- *Lamina cribrosa appearance*
- *Neuro-retinal rim appearance*
- *Retinal nerve fibre layer appearance*
- *Optic disc size*
- *Peri-papillary atrophy*

Some experts in the field may dispute the presence of some items on this list and/or prefer others, however the list reflects both the choices of the expert panel and the content of the material taught during the module.

A total score was awarded to each subject based on how many of the listed features they selected. One point was given for each feature listed by a subject that also appeared on the expert panel's selection

4.7.2.2 Clinical Decision Making

Subjects were given four clinical scenarios to view and asked a single clinical decision making question for each scenario, with their answers recorded on a 5-point Likert scale. Scenarios provided relevant clinical information, including patient history, field plots and photographs of optic discs. Again this was a desktop (paper-based) exercise and the four scenarios are given in Appendix 5.

An example of a typical question, to be answered after the subject had reviewed all the information provided in the scenario, is given below:

In your professional opinion, based on the information you have been given, is this person likely to have Open Angle Glaucoma?

1=Definitely Normal	2= Possibly Normal	3= Not sure Normal/Glaucoma	4=Possibly Glaucoma	5=Definitely Glaucoma
☐	☐	☐	☐	☐

The London-based expert panel of ophthalmologists and optometrists agreed on a reference answer for each scenario. If the respondent selected this reference answer they received two points. If the answer was regarded as acceptable practice, though not best practice as defined by the panel, they received one point. If the answer was regarded as incorrect they received no points. For example, if the expert panel answer for the question above was choice 4 = possibly glaucoma, a respondent would receive 2 points if they answered choice 4, would receive 1 point if they answered choices 3 or 5, and would receive zero points if they answered choices 1 or 2.

4.7.2.3 Discus Program

The software package Discus (see Section 4.5.2) was used to present the disc images to our MSc cohort under controlled conditions (see Figure 4.3). Using a randomised order of presentation, each of the 126 disc images was displayed on a computer screen for a maximum of thirty seconds. After the allocated time the image disappeared from view. Each participant was then required to select a single grade for the disc, based solely “on the basis of apparent disc damage” (Denniss et al., 2011), from a choice of five options (definitely healthy, probably healthy, not sure, probably

damaged, definitely damaged). Once the diagnosis had been made the next image could be selected. No feedback was given at any stage during the process.

Subjects in the MSc cohort viewed the program using computers at City University. All computers had flat screen monitors with the same specification in an effort to minimise bias. To anonymise the data, subjects were given a unique ID number by a third party, which was used in both the pre- and post-module assessments.

The Discus program collects responses into an Excel spreadsheet, recording the image shown, the response given and the time taken to make each decision.

The impossibility of bringing the Control group together to complete the Discus program necessitated a different approach for this group. Each Control subject was sent by post a memory stick containing the Discus program and standard instructions for its use. Subjects completed the Discus disc evaluation using their own computers and returned the stick to the researcher.

Ethical approval for the study was granted by the City University School of Health Sciences Research and Ethics Committee and the research was carried out in compliance with the Declaration of Helsinki http://www.wma.net/en/30publications/10policies/b3/index.html

4.8 Results

4.8.1 Knowledge of important features of the optic disc in glaucoma detection

The mean scores for the knowledge of important disc features for the MSc cohort increased from 2.3 (out of 5) to 4.4 post-intervention (Table 4.2). There was a statistically significant improvement in the median score post-intervention compared with pre-intervention ($P<0.001$; Wilcoxon Statistic = 1308.0) with an improvement in median score from 2 to 5. For the Control cohort the mean scores on this exercise also increased, from 2.9 to 3.1 after three months (Table 4.3) but there was no statistically significant difference between median scores (Median = 3 both pre- and post-intervention).

Comparing the MSc and Control cohorts there was no statistically significant difference between the median scores pre-intervention ($p = 0.10$, $U = 663.5$, Mann-Whitney test) although the difference in median scores (3 for Controls and 5 for MSc cohort) was

significant post-intervention ($p < 0.001$, $U = 869.5$).

Table 4.2: Number of optic disc features correctly identified by the MSc cohort (n = 53) pre- and post- the educational intervention. Scores given are out of a maximum of 5.

Subject ID	Pre	Post
1	2	5
2	1	5
3	3	4
4	4	5
5	1	4
6	3	2
7	2	5
8	2	3
9	2	4
10	4	5
11	3	5
12	2	4
13	2	5
14	2	5
15	4	5
16	2	5
17	2	3
18	4	5
19	3	5
20	3	5
21	4	5
22	3	5
23	4	5
24	3	5
25	2	5
26	2	5
27	2	5
28	2	5

29	4	5
30	1	5
31	3	5
32	4	5
33	4	4
34	1	5
35	3	2
36	2	3
37	1	3
38	0	5
39	2	5
40	2	2
41	0	2
42	1	4
43	1	5
44	2	5
45	2	3
46	2	5
47	2	4
48	3	4
49	2	4
50	3	4
51	2	5
52	2	4
53	2	5
Mean	**2.3**	**4.4**

Table 4.3: Number of optic disc features correctly identified by the Control cohort (n = 20) at baseline ("Pre-intervention") and after a 3-month interval ("Post-intervention"). Scores given are out of a maximum of 5.

Subject ID	Pre	Post
A	5	5
B	2	2
C	1	2
D	2	2
E	3	3
F	2	2
G	3	2
H	1	3
I	3	3
J	4	4
K	3	3
L	4	4
M	4	4
N	2	2
O	3	3
P	2	2
Q	4	4
R	4	5
S	3	3
T	2	3
Mean Score	**2.9**	**3.1**

4.8.2 Clinical Decision Making

For the MSc cohort the mean scores increased from 5.5 (out of 8) pre-intervention to 5.9 post-intervention (Table 4.4). There was no statistically significant improvement in median score, which was 6 both pre- and post-intervention (P = 0.123; Wilcoxon Statistic = 575.5). For the Control group the mean score (5.5) did not change pre- and post-intervention and was identical to the baseline mean for the MSc cohort. There

was no statistically significant difference in median score, which was 5 both pre- and post-intervention (Table 4.5).

Comparing the MSc and Control cohorts there was no statistically significant difference between the medians of the two groups pre-intervention ($p = 0.61$, $U = 572.0$, Mann-Whitney test) or post-intervention ($p = 0.09$, $U = 669.0$).

Table 4.4: Performance in the four clinical decision making scenarios for the MSc Cohort (n = 53) pre- and post-intervention. Scores given are out of a maximum of 8.

Subject ID	Pre	Post
1	5	8
2	4	6
3	4	6
4	7	7
5	5	6
6	7	3
7	6	3
8	6	6
9	7	6
10	3	6
11	7	6
12	6	7
13	6	6
14	6	7
15	4	5
16	3	4
17	5	7
18	7	6
19	7	5
20	5	7
21	7	6
22	8	7
23	4	6

24	4	7
25	3	4
26	4	5
27	5	5
28	7	6
29	6	7
30	7	7
31	6	4
32	5	6
33	5	7
34	7	5
35	6	5
36	6	7
37	5	4
38	5	5
39	7	4
40	5	6
41	6	7
42	2	5
43	6	6
44	7	6
45	7	7
46	6	5
47	6	7
48	6	8
49	4	6
50	5	5
51	6	6
52	6	6
53	5	7
Mean	**5.5**	**5.9**

Table 4.5: Performance in the four clinical decision making scenarios for the Control Cohort (n = 20) at baseline ("Pre-intervention") and after a 3-month interval ("Post-intervention"). Scores given are out of a maximum of 8.

Subject ID	Pre	Post
A	8	8
B	7	6
C	6	5
D	7	7
E	4	5
F	5	4
G	5	6
H	5	5
I	6	5
J	5	5
K	4	6
L	5	5
M	6	5
N	5	5
O	6	6
P	5	6
Q	4	5
R	6	5
S	5	5
T	6	6
Mean	**5.5**	**5.5**

4.8.3 The Discus program for disc evaluation

For each subject the **true positive** (positive response, from a visual field (VF) positive eye), **true negative** (negative response, from a VF negative eye), **false positive** (positive response, from a VF negative eye), and **false negative** (negative response, from a VF positive eye) were calculated. When a subject selected the option "Not sure"

rather than a “damaged” or “healthy” option this has been interpreted as a “damaged” response because an optometrist who is “not sure” about the appearance of an optic disc is more likely to refer the patient on the basis of that disc than not. In addition, the **sensitivity** (expressed here as the percentage of the 20 ‘VF-positive’ discs correctly identified as positive) and **specificity** (expressed here as the percentage of the 80 ‘VF-negative’ discs correctly identified as negative were also calculated for each subject. These data are presented in Tables 4.6 and 4.7.

Table 4.6: Performance in the Discus program for the MSc Cohort (n = 53) pre- and post-intervention. Key: T+ = True Positive, T- = True Negative, F+ = False positive, F- = False negative, Sen = Sensitivity, Spe = Specificity, SD=Standard Deviation.

	PRE						POST					
ID	T+	F-	T-	F+	Sen %	Spe %	T+	F-	T-	F+	Sen %	Spe %
1	11	9	64	16	55	80	15	5	51	29	75	64
2	16	4	61	19	80	76	14	6	38	42	70	48
3	12	8	54	26	60	68	10	10	64	16	50	80
4	14	6	48	32	70	60	17	3	45	35	85	56
5	16	4	58	22	80	73	9	11	59	21	45	74
6	16	4	35	45	80	44	18	2	49	31	90	61
7	11	9	48	32	55	60	18	2	33	47	90	41
8	15	5	45	35	75	56	17	3	47	33	85	59
9	17	3	47	33	85	59	17	3	32	48	85	40
10	11	9	63	17	55	79	17	3	44	36	85	55
11	13	7	58	22	65	73	16	4	41	39	80	51
12	20	0	50	30	100	63	17	3	43	37	85	54
13	14	6	61	19	70	76	18	2	31	49	90	39
14	17	3	59	21	85	74	18	2	20	60	90	25
15	15	5	56	24	75	70	16	4	58	22	80	73
16	16	4	23	57	80	29	11	9	61	19	55	76
17	14	6	46	34	70	58	12	8	57	23	60	71
18	12	8	52	28	60	65	13	7	61	19	65	76
19	16	4	50	30	80	63	19	1	61	19	95	76
20	13	7	61	19	65	76	15	5	55	25	75	69
21	15	5	55	25	75	69	17	3	38	42	85	48
22	11	9	59	21	55	74	19	1	40	40	95	50
23	15	5	49	31	75	61	16	4	23	57	80	29
24	9	11	61	19	45	76	14	6	57	23	70	71
25	17	3	50	30	85	63	16	4	51	29	80	64
26	14	6	60	20	70	75	17	3	48	32	85	60
27	16	4	46	34	80	58	11	9	58	22	55	73

28	12	8	61	19	60	76	18	2	47	33	90	59
29	13	7	59	21	65	74	16	4	33	47	80	41
30	17	3	45	35	85	56	15	5	54	26	75	68
31	14	6	52	28	70	65	18	2	28	52	90	35
32	12	8	55	25	60	69	20	0	25	55	100	31
33	17	3	44	36	85	55	18	2	41	39	90	51
34	15	5	53	27	75	66	15	5	49	31	75	61
35	15	5	56	24	75	70	18	2	39	41	90	49
36	19	1	20	60	95	25	19	1	7	73	95	9
37	16	4	50	30	80	63	15	5	58	22	75	73
38	14	6	58	22	70	73	16	4	61	19	80	76
39	12	8	63	17	60	79	17	3	38	42	85	48
40	13	7	58	22	65	73	16	4	42	38	80	53
41	17	3	47	33	85	59	16	4	45	35	80	56
42	12	8	63	17	60	79	20	0	34	46	100	43
43	15	5	50	30	75	63	13	7	57	23	65	71
44	17	3	52	28	85	65	15	5	42	38	75	53
45	18	2	28	52	90	35	17	3	34	46	85	43
46	17	3	54	26	85	68	18	2	37	43	90	46
47	16	4	45	35	80	56	17	3	43	37	85	54
48	16	4	52	28	80	65	17	3	40	40	85	50
49	19	1	35	45	95	44	17	3	49	31	85	61
50	14	6	39	41	70	49	14	6	55	25	70	69
51	16	4	41	39	80	51	17	3	32	48	85	40
52	17	3	55	25	85	69	18	2	45	35	90	56
53	18	2	42	38	90	53	20	0	35	45	100	44
Mean	**14.8**	**5.2**	**50.9**	**29.1**	**74**	**64**	**16.2**	**3.8**	**44.1**	**35.9**	**81**	**55**
SD					**12.0**	**12.3**					**12.3**	**15.1**

For the MSc cohort the difference between the mean sensitivities pre-intervention (74%) and post-intervention (81%) is statistically significant ($p = 0.0049$, $t = 2.94$, Paired t-test). The difference between the mean specificities pre-intervention (64%) and post-intervention (55%) is also statistically significant ($p = 0.0014$, $t = 3.37$, Paired t-test).

Table 4.7 Performance in the Discus program for the Control Cohort (n = 20) at baseline ("Pre-intervention") and after a 3-month interval ("Post-intervention"). T+ = True Positive, T- = True Negative, F+ = False positive, F- = False negative, Sen = Sensitivity, Spe = Specificity, SD= Standard Deviation.

	PRE						POST					
ID	**T+**	**F-**	**T-**	**F+**	**Sen %**	**Spe %**	**T+**	**F-**	**T-**	**F+**	**Sen %**	**Spe %**
1	19	1	58	22	95	73	19	1	54	26	95	68
2	17	3	38	42	85	48	15	5	42	38	75	53
3	16	4	21	59	80	26	14	6	24	56	70	30
4	5	15	62	18	25	78	5	15	53	27	25	67
5	10	10	42	38	50	53	9	11	45	35	45	56
6	16	4	45	35	80	56	20	0	43	37	100	54
7	13	7	59	21	65	74	11	9	63	17	55	79
8	16	4	30	50	80	38	19	1	29	51	95	36
9	6	14	60	20	30	75	6	14	66	14	30	83
10	5	15	57	23	25	71	7	13	60	20	35	75
11	12	8	32	48	60	40	11	9	46	34	55	58
12	12	8	58	22	60	73	13	7	44	36	65	55
13	6	14	40	40	30	50	8	12	47	33	40	59
14	6	14	48	32	30	60	8	12	50	30	40	63
15	11	9	58	22	55	73	7	13	58	22	35	73
16	5	15	53	27	25	66	6	14	53	27	30	67
17	13	7	57	23	65	71	10	10	53	27	50	67
18	16	4	49	31	80	61	19	1	36	44	95	45
19	14	6	36	44	70	45	11	9	38	42	55	48
20	18	2	53	27	90	66	15	5	59	21	75	74
Mean	**11.8**	**8.2**	**47.8**	**32.2**	**59**	**60**	**11.7**	**8.4**	**48.0**	**31.9**	**58**	**61**
SD					**24.0**	**14.8**					**24.4**	**13.9**

For the Control cohort the difference between the mean sensitivities pre-intervention (59%) and post-intervention (58%) is not statistically significant ($p = 0.78$, $t = 0.29$, Paired t-test). The difference between the mean specificities pre-intervention (60%) and post-intervention (61%) is also not statistically significant ($p = 0.74$, $t = 0.34$, Paired t-test).

The repeatability of responses was analysed for the MSc cohort for both the pre-intervention and post-intervention data by taking the difference between the first score

for each repeated image (where 5 = definitely damaged and 1 = definitely healthy) and the second score. Agreement (zero difference) between the first and second scores occurred in 58% of repeats (c800/1378) both pre-intervention and post-intervention. Discrepancies of at least one category occurred in 42% of repeats both pre- and post-intervention. For the pre-intervention data the distribution of the 42% of discrepancies was almost perfectly symmetrical between discrepancies in the positive (healthier disc on repeat) and negative directions. The 42% comprised 31% with one category difference on repeat (15% a negative difference, and 16% positive), 8% with two categories difference (4% positive and 4% negative), and 2% with three categories difference (1% positive and 1% negative). Two subjects obtained the maximum difference of 4 categories (one positive and one negative) although the numbers are so low that these registered as zero in percentage terms. For the post-intervention data, the distribution of the 42% of repeats was slightly skewed in the positive direction (healthier discs) on repeat. The 42% comprised 28% with one category difference on repeat (15% positive and 14% negative, 10% with two categories difference (6% positive and 4% negative), 2% three categories difference (equally split between positive and negative), and 1% (9 repeats) which had the maximum possible 4 categories difference. All the 9 discs that had four categories of difference were in the positive direction i.e. discs that were rated 5 (definitely damaged) on first presentation but were rated 1 (definitely healthy) on the repeat.

Repeatability was higher for the Controls, with agreement (zero difference) between the first and second scores occurring in 68% of repeats pre-intervention and 71% post-intervention (c360/520). The distribution was almost perfectly symmetrical both pre- and post-intervention, and there were no discs with four categories of difference.

The average **latency** (time taken to reach a clinical decision on an image) for each MSc subject was calculated and these are presented for both pre- and post-intervention in Table 4.8. For the Control cohort the latency data both “pre-“and “post“ are presented in Table 4.9

Table 4.8: The average latency for decision making for the MSc Cohort (n = 53) pre- and post-intervention.

ID	Pre Average (s)	Post Average (s)
1	9.4	13.7
2	10.8	17.4
3	5.0	6.6
4	8.7	7.4
5	9.3	13.4
6	7.3	9.7
7	5.2	7.0
8	6.4	23.6
9	8.1	11.1
10	10.5	11.5
11	7.3	11.7
12	4.9	6.75
13	5.7	7.4
14	9.1	10.2
15	10.1	10.8
16	5.1	8.8
17	6.0	6.3
18	7.1	13.1
19	5.8	4.2
20	5.1	8.0
21	6.9	14.2
22	4.3	12.4
23	8.7	9.6
24	7.2	5.8
25	6.8	11.1
26	6.2	9.8
27	3.2	3.7
28	8.9	9.0
29	7.6	16.9
30	7.5	9.0
31	7.9	11.3

32	7.7	7.7
33	9.6	12.1
34	6.6	9.1
35	9.2	10.2
36	8.4	13.8
37	4.6	3.0
38	6.0	3.5
39	3.4	14.6
40	8.3	12.0
41	9.9	15.7
42	15.7	23.8
43	6.2	3.7
44	8.5	13.6
45	7.5	12.6
46	6.7	23.0
47	6.7	9. 2
48	6.4	10.8
49	6.2	16.0
50	6.6	8.2
51	9.6	12.0
52	4.6	9.2
53	10.8	14.4
Mean	**7.4 secs**	**11.0 secs**
Standard Deviation	**2.21**	**4.69**

For the MSc cohort the difference between the mean latencies pre-intervention (7.4s) and post-intervention (11.0s) is statistically significant ($p < 0.0001$, $t = 6.32$, Paired t-test).

Table 4.9: The average latency for decision making for the Control cohort (n = 20) pre- and post-intervention.

ID	Pre Average (s)	Post Average (s)
1	17.4	9.9
2	8.9	8.2
3	10.1	7.7
4	11.0	9.4
5	17.1	11.0
6	6.0	7.8
7	15.7	22.6
8	31.4	40.2
9	7.8	9.8
10	9.1	8.2
11	16.2	10.0
12	7.5	11.5
13	13.5	12.1
14	10.7	18.5
15	16.5	11.6
16	14.8	11.3
17	11.3	13.6
18	10.2	18.2
19	21.0	8.8
20	16.1	11.8
Mean	**13.6 secs**	**13.1 secs**
Standard Deviation	**5.81**	**7.48**

For the Control cohort the difference between the mean latencies pre-intervention (13.6s) and post-intervention (13.1s) was not statistically significant ($p = 0.70$, $t = 0.40$, Paired t-test).

4.8.4 Comparisons between the MSc and Control cohorts

For pre-intervention sensitivity the difference between mean sensitivities for the MSc cohort (74%) and the Control cohort (59%) was statistically significant ($p = 0.0006$, $t =$

3.61, Unpaired t-test). For post-intervention sensitivity the difference between mean sensitivities for the MSc cohort (81%) and the Control cohort (58%) was also statistically significant ($p < 0.0001$, $t = 5.25$, Unpaired t-test).

For pre-intervention specificity the difference between mean specificities for the MSc cohort (64%) and the Control cohort (60%) was not statistically significant ($p = 0.26$, $t = 1.14$, Unpaired t-test). For post-intervention specificity the difference between mean specificities for the MSc cohort (55%) and the Control cohort (61%) was also not statistically significant ($p = 0.17$, $t = 1.38$, Unpaired t-test).

For pre-intervention latency the difference between mean latencies for the MSc cohort (7.4s) and the Control cohort (13.6s) was statistically significant ($p < 0.0001$, $t = 6.69$, Unpaired t-test). For post-intervention latency the difference between mean latencies for the MSc cohort (11.0s) and the Control cohort (13.1s) was not statistically significant ($p = 0.15$, $t = 1.46$, Unpaired t-test).

4.8.5 ROC curves

For the group data for both cohorts Receiver Operating Characteristic (ROC) curves were plotted using Medcalc software (http://www.medcalc.org/).

A ROC curve is obtained by plotting sensitivity (true positive rate) against 1-specificity (false positive rate) (see Figure 4.4 for an example) (Altman and Bland, 1994a). Each point on the ROC curve represents a sensitivity/specificity pair. The area under the ROC curve (AUROC) is a measure of how well a factor can distinguish between two groups.

A test, investigation or decision that has no value for separating two groups would give a straight line running from the bottom left corner (the point with co-ordinates 0,0) to the top right hand corner of the axis grid of the ROC curve (the point with co-ordinates 1, 1). A ROC plot is useful when comparing two or more measures or interventions and is a means of assessing the accuracy of a test or for comparison of the performance of more than one test, all of which have the same outcome (Zweig & Campbell, 1993; Bewick et al., 2004). A post-intervention result which gives a curve that lies above the curve of the original, i.e. with a shift towards the top left corner, would indicate an improvement in performance (Altman & Bland, 1994a; Whiting et al., 2004). The

results of an ROC analysis must always be considered in conjunction with the clinical implications (Bewick et al., 2004).

Composite ROC curves have been generated for the both cohorts pre- and post-intervention. These are shown in the composite Figure 4.5 and Figure 4.6 below. The areas under the ROC curves were:

MSc Pre-intervention	= 0.85
MSc Post-intervention	= 0.84
Controls Pre-intervention	= 0.84
Controls Post-intervention	= 0.91

These areas under the ROC curves are similar and are comparable to the reference AUROC of 0.87 obtained from the Discus Expert Panel. There are no statistically significant differences between any of the AUROCs either within or between cohorts pre- or post-intervention.

Figure 4.5 Composite ROC curves for MSc cohort pre- and post-intervention.

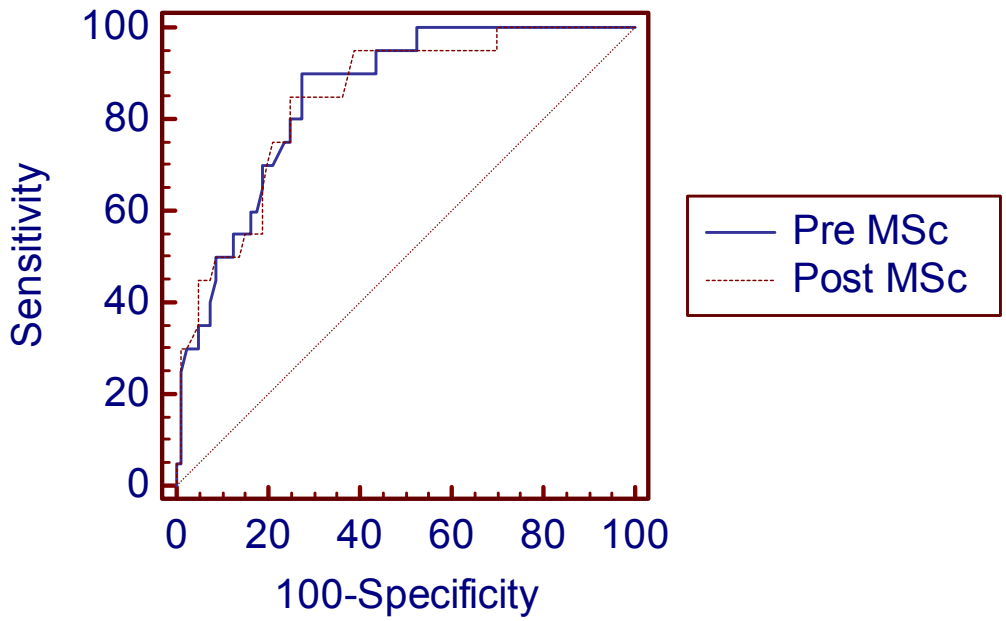
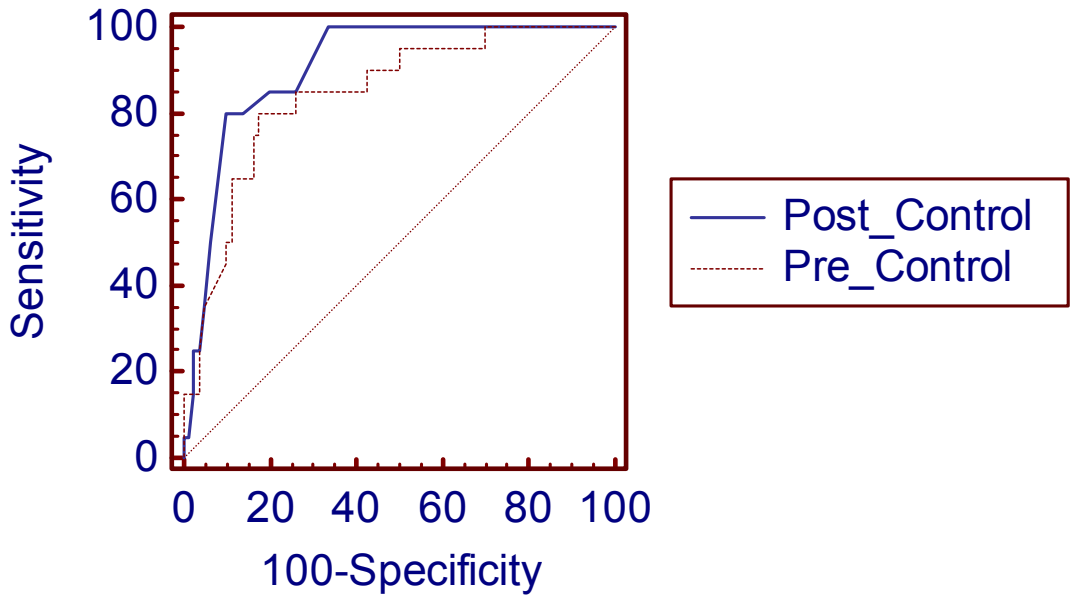


Figure 4.6 Composite ROC curves for the Control cohort pre- and post-intervention.



4.8.6 Distribution of mean scores

In order to generate the composite ROC curves shown in Figures 4.5 and 4.6 it was necessary to calculate a mean score for all subjects in each group for each of the 100 images both pre- and post-intervention. This was a laborious task which involved identifying the 26 repeated images for each subject (which are different each time the Discus program is run), discounting the score for the first presentation of each of the 26 repeated images, and averaging the 53 scores (one for each MSc cohort subject) or the 20 scores (one for each Control cohort subject) for each of the 100 Discus images. In addition to generating the ROC curves, these mean scores allowed an investigation of the distribution of the mean scores for each image for each cohort.

Figure 4.7 shows the distribution of the mean scores pre-intervention for each image for the MSc and Control cohorts. The y-axis scale represents the mean score for the cohort for each image on scale from 1 to 5. There is a striking difference between the

two distributions, with the Control scores tightly bunched around the median of 2.6 and no mean scores above 3.5 or below 1.9. The MSc cohort means have a similar median score of 2.5 but the mean scores are much more evenly distributed between 4.5 and 1.4. The distributions of the mean scores pre- and post-intervention in the Control cohort are shown in Figure 4.8 and there is little change in the range of mean scores post-intervention (median = 2.6, and no mean scores above 3.7 or below 1.9).

Figure 4.7 Box and whisker plots of mean scores for each of 100 images for the pre-intervention Control cohort and pre-intervention MSc cohort. Each circle represents the mean score for one image. The y-axis scale represents the mean score for the cohort for each image on a scale from 1 to 5. The median score is shown by the horizontal green line inside the box and the top and bottom of the box are the upper and lower quartiles respectively.

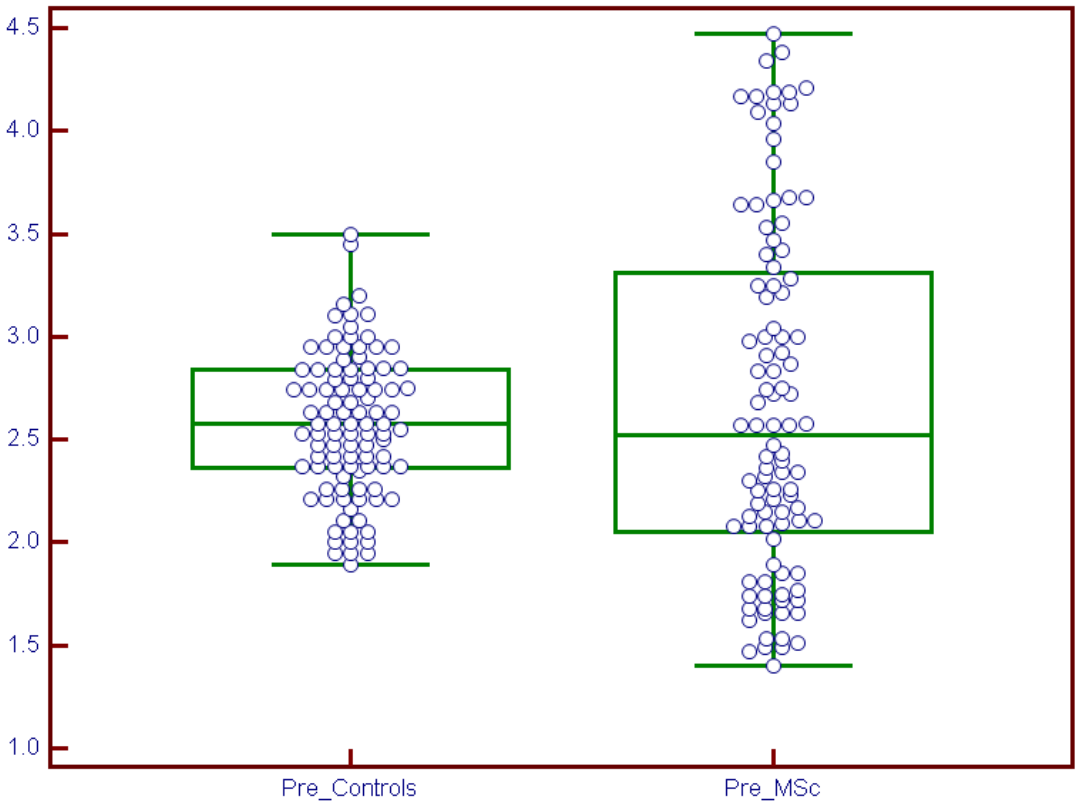
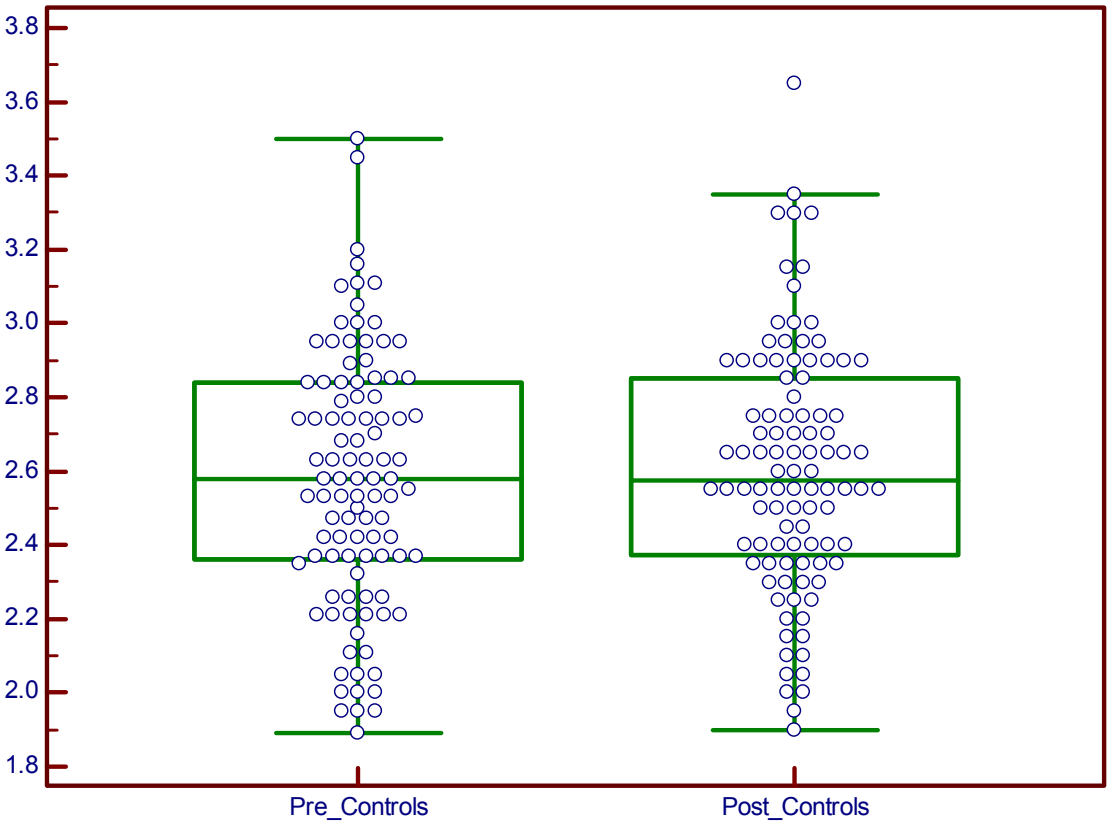


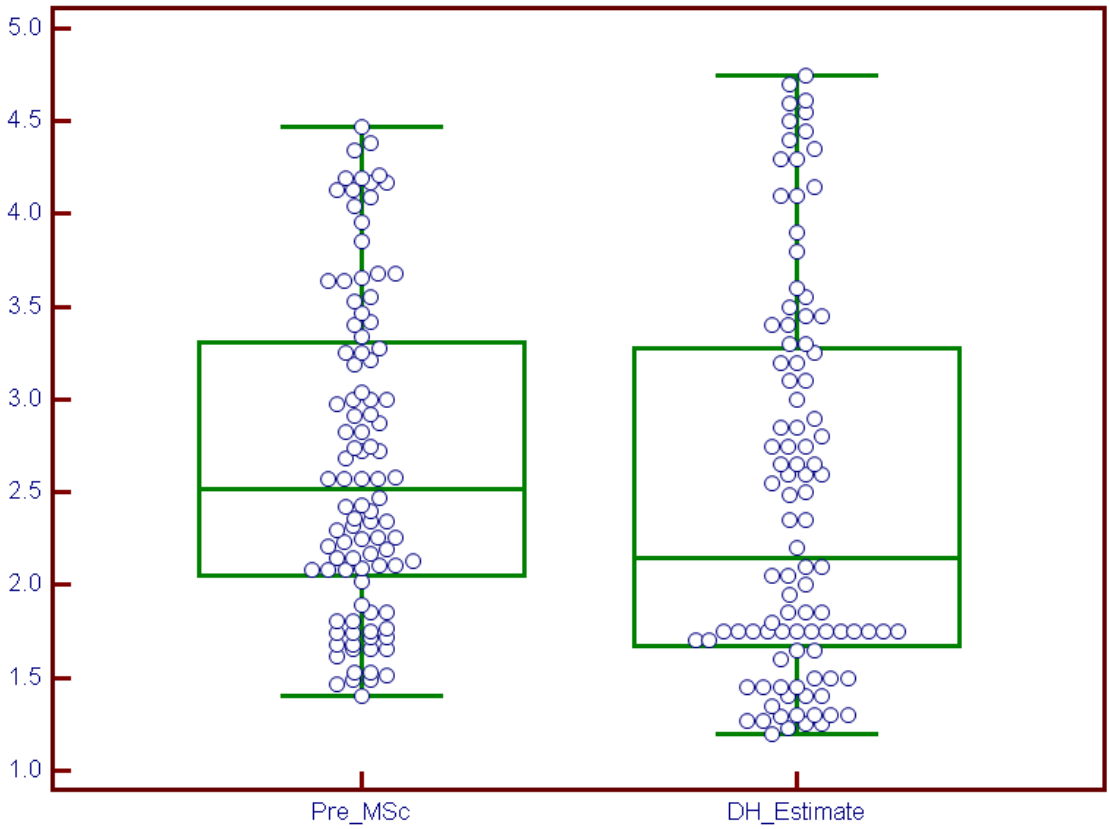
Figure 4.8 Box and whisker plots of mean scores for each of 100 images for the pre- and post-intervention Control cohort. Each circle represents the mean score for one image. The y-axis scale represents the mean score for the cohort for each image on a scale from 1 to 5. The median score is shown by the horizontal green line inside the box and the top and bottom of the box are the upper and lower quartiles respectively.



It is clearly of interest to compare the distribution of mean scores in the current study with the distribution obtained by Denniss et al. for the Discus Expert Panel. These data are not directly available from the published literature. However, it was possible to estimate the mean scores for the Discus Expert Panel for the 100 images from Figure 3 of the published ARVO abstract on the Discus program (Denniss et al., 2008). Based on these estimates Figure 4.9 gives an approximate comparison between the pre-intervention distribution of accurately calculated mean scores for the MSc Cohort and the estimated mean scores for the Discus Expert Panel. The scores above the median line for the Expert Panel could be estimated with a reasonable degree of accuracy from the ARVO figure, as could those in the 1.2 – 1.5 mean score range. But there were a

considerable number of coincident data points for VF negative images in the ARVO abstract figure with mean scores around 1.6 – 1.7. These data points have all been given the mean score of 1.7 to make the numbers up to 80 VF normals. Nevertheless, the overall picture to be gained from Figure 4.9, showing the distribution of the Expert Panel mean scores for each image presented alongside the equivalent data for the pre-intervention MSc cohort, is acceptably accurate. The Expert Panel made greater use of the full range of scores than the MSc cohort.

Figure 4.9: Box and whisker plots of mean scores for each of 100 images for the pre-intervention MSc cohort and estimated mean scores for the Discus Expert Panel (DH_Estimate). Each circle represents the mean score for one image. The y-axis scale represents the mean score for the cohort for each image on a scale from 1 to 5. The median score is shown by the horizontal green line inside the box and the top and bottom of the box are the upper and lower quartiles respectively.



4.9 Discussion

The aim of Chapter 4 was to evaluate the impact of a glaucoma-centred educational intervention, the City University Glaucoma MSc module, on three important aspects of glaucoma detection and management; knowledge of key disc features in glaucoma, clinical decision making and disc evaluation.

4.9.1 Knowledge of important features of the optic disc in glaucoma detection

The study demonstrated that there was increased awareness of clinical signs of optic disc changes in OAG in the MSc cohort post-intervention, with mean scores increasing from 2.3/5 to 4.4/5, and the increase in median scores in this cohort (from 2 to 5) was statistically significant. In simple terms, a typical member of the MSc cohort would achieve two or three more correct answers out of five after the educational intervention. For the Control cohort there was a marginal increase in mean scores post-intervention (from 2.9 to 3.1) but no statistically significant difference between medians (3 pre- and post-intervention). This is to be expected for the Controls, of course, but is a reassuring finding which lends support to the validity of the study design. Overall, these findings support the value of the educational intervention for the acquisition of knowledge. This was, however, a desktop-based exercise rather than one which reflects the application of knowledge to a clinical practice-based situation. In Miller's pyramid of clinical competence (see Figure 3.1, Section 3.1.1) this 'features of the optic disc' exercise is firmly rooted in the "knows" section, consisting of factual knowledge, which lies at the base of the pyramid (Miller, 1990). Nevertheless, this method of evaluation demonstrated that post-registration optometrists retain the ability, acquired in school and university, to memorise and recall information provided in lectures. The didactic, taught lecture component of the Glaucoma module was high and the improvement in scores may reflect this. Furthermore, this important information relating to the optic disc in glaucoma was significantly less well known by those in the Control cohort post-intervention. Interestingly, the Control group had a higher mean score for this exercise than the MSc cohort pre-intervention (2.9 and 2.3 respectively) though the difference in medians was not significant.

4.9.2 Clinical decision making (CDM)

The four case scenarios covered a range of possible diagnoses (Normal, NTG, COAG, and suspect COAG) and management options (referral, monitor in practice etc), featuring cases which included one patient of mixed race (half African-Caribbean) and one of Japanese origin. Discs and fields ranged from the probably normal to the almost certainly damaged and featured asymmetries between right and left eyes. Although the mean scores increased for the MSc group from 5.5 pre-intervention (out of a maximum of 8) up to 5.9, there was no significant difference in median scores (6 both pre- and post-intervention). For the Control group there was, as could be expected, no change in mean scores pre- and post-intervention (5.5 for both) and no significant difference in median scores (5 for both). There were no significant differences between the MSc and Cohort groups' performance on the CDM assessment exercise either pre- or post-intervention. It is clear that any improvement in the MSc group at this task was marginal, and their overall performance was little better than that of the Control cohort.

The use of this clinical scenario approach in the assessment of these skills is regularly used in UK undergraduate optometry courses and in the final examination of the Scheme for Registration for UK optometrists (College of Optometrists, 2010b). Scenarios can be paper-based or can be made available online. According to Miller's pyramid, this CDM task belongs in the "knows how" region, one level up from the "knows" region in which the disc features exercise resides. The "knows how" level describes the ability of the clinician, in this context the optometrist, to use their knowledge in a particular context. An optometrist operating at this level would be using clinical reasoning and problem solving. Based on the current study, the results of the "knows how" exercise are rather disappointing, suggesting that the intervention did not significantly improve the students' performance at these tasks. This suggests that the Glaucoma module had too little focus on developing the "knows how" skills of participants.

4.9.3 The Discus program for disc evaluation

The Discus program presents 80 VF-normal disc images and 20 VF-damaged disc images (ignoring repeated images). The task for the clinician is to decide from the appearance of the image of each optic disc whether the disc is damaged or healthy. This allows the calculation of a figure for sensitivity and specificity for each subject

based on how they interpret the optic disc images. This represents a somewhat unorthodox use of sensitivity and specificity, which are more commonly used to indicate the validity of a medical diagnostic test, rather than the outcome of an educational intervention (Altman & Bland, 1994b; Harper et al., 2000b). However, a similar approach has been used previously for interpretation of the results from the Discus program (Denniss et al., 2011). Based on this analysis for the MSc cohort, there was a significant increase in mean sensitivity for the whole cohort from pre-intervention (74%) to post-intervention (81%). This was at the price of reduced specificity, which fell from 64% to 55%, a reduction that was also statistically significant. The intervention, although improving the correct identification of damaged discs, could result in an increased number of false positive referrals if undamaged discs are being incorrectly identified as damaged. A similar analysis for the Control cohort revealed little or no change in mean sensitivity (59% pre- to 58% post-) or mean specificity (60% pre- to 61% post-) over time. This was to be expected and acts as an internal check on the validity of the method.

Even at baseline (pre-intervention) there is evidence to suggest that the two cohorts had a different approach to disc image interpretation. The pre-intervention mean sensitivities were significantly higher in the MSc cohort (74%) compared with the Controls (59%), differences that were even greater post-intervention (81% versus 58%). Interestingly, the MSc cohort also had a higher mean specificity pre-intervention than the Controls (64% versus 60%) but this was reversed post-intervention with the MSc mean specificity falling to 55% compared with 61% for the Controls. Neither difference was statistically significant. It is arguable whether, on the basis of these results, the MSc cohort gained anything from the intervention. Glaucoma is a disease with low prevalence, and it can be argued that the clinician would need to have a markedly increased sensitivity post-intervention if their specificity is to be reduced, as happened on average to the MSc cohort. However, it must be borne in mind that this was a very difficult sample of discs to interpret (see later).

The repeatability of the MSc subjects' responses was moderate, with 42% of repeats showing a difference of at least one category, and 9 of the 1378 repeats post-intervention revealing a discrepancy of 4 categories. However, assessment of discs is a challenging clinical task. Interestingly, when repeatability was assessed in the same way as in this thesis for the Discus Expert Panel, agreement was again moderate; "on average, discrepancies of one category were seen in 44% of [the] 26 repeated images"

(Denniss et al., 2011). This figure is similar to that obtained for the MSc cohort (42%). It is not clear from the Denniss et al. (2011) paper if any of the experts had differences of more than one category. Repeatability was higher for the Control cohort, with around 30% of repeats showing a difference of at least one category.

There is evidence from the data collected via the Discus program to suggest that post-intervention, the members of the MSc cohort may have been adopting a more critical approach to their assessment of discs for glaucomatous features. This evidence comes from the statistically significant increase in mean latency (the average time taken to take a decision on an optic disc image) post-intervention (11.4s) compared with pre-intervention (7.4s). Assuming that this extra time was spent analysing each image, it may reflect a more intense scrutiny of the images for more subtle indications of glaucoma. The overall time taken for the Discus program for the MSc cohort, which included the time taken in giving instructions etc, increased from an average of 27.5 minutes to 34.2 minutes pre- and post-intervention respectively. The equivalent data for the Discus Expert Panel were an average of 7s to respond to the presentation of the disc image and a mean of 29 minutes, very similar to the pre-intervention results for the MSc cohort. The Control cohort took significantly longer on average to respond to the presented images pre-intervention (13.6s) compared with the MSc cohort, but the longer latencies of the MSc cohort post-intervention resulted in the difference between them and the Controls (13.1s) failing to reach statistical significance.

The ROC curves revealed an impressive composite performance by both cohorts when considered in isolation and when compared with the results from the Discus Expert Panel. There was no significant difference between the AUROCs for the two cohorts pre-intervention (MSc 0.85 and Controls 0.84) and both AUROCs were close to that achieved by the experts (0.87). Indeed the post-intervention Control group achieved a higher AUROC (0.91) than the experts, with the MSc cohort's AUROC essentially unchanged post-intervention (0.84). The improvement in the AUROC in the Controls over time, illustrated by the shift to the left of the ROC curve in Figure 4.6, is not statistically significant and could possibly be the result of familiarity with the process. However, if familiarity were the cause of this improvement there was no evidence of familiarity producing a similar improvement for the MSc cohort. All these AUROC results may well reflect the overall smoothing effects of using composite data from a reasonably large cohort but, nevertheless, they also reflect well on the decision-making skills of both optometrist cohorts in this aspect of assessment for glaucoma.

Figures 4.7 to 4.9 reveal fascinating information about how bold, rather than necessarily how accurate, the different cohorts were in their grading of the disc images. Although both the MSc and Control groups have almost identical areas under their ROC curves pre-intervention they are very different in their approach to grading the Discus images (Figure 4.7). The MSc pre-intervention cohort were much more prepared to use the full range of the 1 – 5 scale, while the Controls were much more reluctant to use the definitely normal (1) and definitely abnormal grades (5). Yet the ROC curves indicate that both cohorts graded the images with equal facility overall.

When the mean scores were plotted for each image for the Controls both pre- and post-intervention (Figure 4.8), there was no major change (as might have been expected) in the range of mean scores though, if anything, from inspection of the post-intervention data from the Controls it appears as if they might be even more reluctant to use the extremes of the ranges. The Controls were less confident in their grading abilities than the MSc cohort but equally good at the grading.

From the estimated distribution of the Discus Expert Panel (Figure 4.9) it is clear that the experts made greater use of the full range of scores, particularly at the lower end of the range (1 = definitely healthy) than the MSc cohort, and made much greater use of the full range of scores than the Control cohort. The experts were more confident of their decision-making processes on an optic disc assessment task of the type presented by the Discus program, particularly in comparison with the Control cohort.

Overall, these results demonstrate that the educational intervention increased awareness of disc changes in glaucoma, but produced marginal improvements in clinical decision making and performance in the Discus program. This may reflect the fact that the MSc cohort was a “high baseline” sample for some of these evaluations. Furthermore, the didactic, lecture-based nature of the module is designed to develop and reinforce knowledge but does not encourage improvement in clinical performance, for which peer review and group workshops are more effective (Cantillon and Jones, 1999; Davis et al., 1999; Downs et al., 2006).

Other studies have shown benefits from training in glaucoma-detection skills. The Bristol Shared Care Glaucoma Study remains the only randomised clinical trial to investigate the effectiveness of community-based optometrists compared with routine HES care in the management of glaucoma suspects and those with OAG (Spry et al.,

1999). Participating optometrists underwent a training program which involved a didactic element of 15 hours of lectures plus 10 hours of practical “hands on” examination experience at Bristol Eye Hospital. This practical experience was gained on volunteer glaucoma patients attending the Hospital (Gray et al., 2000). During the study, comparisons were made between the community optometrists’ measurements of C/D ratio, IOP and visual fields and the same measurements taken in the HES either in routine glaucoma outpatient clinics or in the research clinic. Both the average differences in the C/D ratio, IOP and fields and the variability in these measurements were similar in the three clinical settings, from which it was concluded that, with appropriate training, community optometrists can make reliable measurements using this triad of tests (Spry et al., 1999). Having followed the patients for two years in both the community-optometrist and hospital-based arms of the study it emerged that there did not appear to be any significant differences in patient outcomes between the two modes of care (Gray et al., 2000).

More recently, a study in Scotland, which evaluated the effects of the new GOS contract on glaucoma referrals, indirectly assessed whether educational interventions improve optometrists’ clinical making decision skills, because all optometrists in Scotland had to attend four two-hour workshops in applanation tonometry, slit lamp examination, disc assessment, and fields assessment before they could be accredited (Azuara- Blanco et al., 2007). There was a statistically significant improvement in true positive referrals for glaucoma and a significant decrease in false positive referrals under the new contract.

The educational intervention in the current study consisted of a three-day intensive training course followed by an assessment three months later. A less intensive but more continuous training regime may be more effective. A study in Ealing (West London) examined whether a continued intervention of lectures and practicals delivered every 4 months would improve the quality of glaucoma referrals (Patel et al., 2006b). Optometrists’ referrals to the HES were monitored over a 12-month period and the intervention increased the number of referrals by 58% compared with an equivalent 12-month period, with the PPV of these referrals maintained at 45%.

4.10 Limitations of the study

The MSc cohort was not a representative sample of UK optometrists. Some were taking the Glaucoma module as one of the 8 modules required to complete the modular MSc in optometry. Others took the module through personal interest in glaucoma and wished to broaden their knowledge in that area. All the participants attended through their own choice and all were fee-paying participants, therefore the incentive to engage with the course material was likely to be high, and some may also have completed some preliminary study (Peyton, 1998). Nevertheless, the comparisons between pre- and post-intervention are valid for this cohort.

The Control cohort all volunteered to participate and by virtue of being prepared to volunteer for such a study may be more confident of their clinical skills than the average UK community optometrist (Ramsey et al., 1998). It is therefore possible that their results overestimate the performance of UK optometry as a whole. Also, a sample of 20 is small and it is unlikely that the Control cohort is representative of UK optometry as a whole.

The assessment of clinical competence in this study was limited to the two lowest levels of Miller's pyramid: "knows" (Disc features) and "knows how" (CDM and Discus). However, there was no assessment at the key levels ("shows how" and "does"). It is possible that subjects who perform well on the Discus program when looking at discs on a computer screen may perform less when assessing a disc with an ophthalmoscope in practice, and vice versa. The logistics of assessing these higher levels of Miller's pyramid, which would involve an assessment of ability to perform in a practical clinical situation, both pre- and post-intervention, are challenging and go beyond the scope of this thesis.

The assessment of the MSc cohort took place under controlled, almost examination conditions. This ensured that subjects could not consult notes or confer with their colleagues. The Control cohort took their assessments in their homes or practices with no checks on how the assessment was conducted. Instructions were issued to the Control subjects on how the assessment was to be undertaken but any violations of these instructions could not have been detected.

Denniss et al. (2011) point out a number of limitations of the Discus program:

- The sample of 100 images was “highly selected”, comprising patients who were all attending a glaucoma clinic, many of whom were glaucoma suspects without visual field loss. It is possible that a number of these patients without field defects (the VF-negatives) did, in fact have discs that showed glaucomatous damage. The Discus images were undoubtedly a difficult set but, as Denniss et al. point out, this allows the clinician to assess their performance on discs that are likely to cause difficulties in practice when it comes to diagnosis.

- Definitely healthy discs were undoubtedly under-represented in the sample when compared with the normal population. Similarly, very damaged discs were also excluded, as any patients with HFA mean deviation worse than -10dB were excluded from the image set. Denniss et al. note that, because of the unrepresentative nature of the sample, their experts’ ROC curves are likely to underestimate clinicians’ abilities in detecting glaucomatous disc changes in a community-based optometry practice. If this is correct, the performance of both optometrist cohorts on the Discus program is even more impressive.

- The Discus program uses non-stereoscopic images, and there is evidence that features of optic disc damage in glaucoma are easier to visualize from a stereoscopic view of the disc. Optometrists in UK community practice are making greater use of binocular indirect ophthalmoscopy, however direct ophthalmoscopy is still very common and, as recently as 2009, Shah et al. reported in a study using a standardized patient at risk of glaucoma that 22% of optometrists used binocular indirect methods to view the fundus while 86% used direct ophthalmoscopy (9% used both methods) (Shah et al., 2009a). Therefore, although a non-stereoscopic image was used in the Discus program, this is likely to reflect the view of the disc obtained by most UK community optometrists at that time. However, it may not reflect the clinical practice of the two cohorts in this study as their method of assessing the optic disc was not known.

4.11 Conclusion

The educational intervention was effective in increasing awareness of disc changes in glaucoma, but much less effective for clinical decision making or for improving performance in the Discus program for disc assessment.

The traditional didactic approach is unlikely to be suited to training optometrists in the clinical competencies required for glaucoma detection and management. As a result, the MSc Glaucoma module has been completely re-designed and subsequently accredited for the CoO's Professional Certificate in Glaucoma. All this was possible as a result of the development of the competency framework described in Chapter 3.

Chapter 5: Summary and Directions for Future Work

Because formal screening programmes for COAG have not so far been adopted in any country, current detection strategies for glaucoma rely on opportunistic case-finding from a self-selected population. In the UK, community optometrists play the major role in the detection of COAG and account for the majority (>90%) of referrals for suspect glaucoma. In England, Wales and Northern Ireland, optometrists carry out state-funded (NHS) Sight Tests on particular at-risk groups (everyone over 60 years and those over 40 with a family history of glaucoma), whereas in Scotland 'free' eye examinations are available to all. There is no mandatory case-finding protocol for the detection of COAG, although guidance is provided by the College of Optometrists regarding the examination of those at risk of glaucoma. Chapter 2 described the results of a national web-based survey of glaucoma case-finding that provided data on diagnostic tests used, referral behaviour and reported barriers to case-finding. The survey demonstrated that UK optometrists are well equipped to carry out COAG case-finding. All survey respondents had access to a tonometer, a perimeter with threshold control and a means of assessing the optic nerve head. In agreement with other studies approximately 80% of optometrists used a non-contact method for measuring IOP. Guidance from the College of Optometrists states that non-contact tonometry is acceptable for routine case-finding, however it suggests that contact applanation tonometry should be performed when the results are equivocal (College of Optometrists, Code of Ethics and Guidelines for Professional Conduct, Section D3 Examining patients at risk from glaucoma, 2005). In 2010, the College of Optometrists and the Royal College of Ophthalmologists produced joint guidance on the referral of glaucoma suspects by community optometrists (College of Optometrists, 2010a). This document provides advice on best practice when performing NCT and recommends taking the mean of 4 readings. Our survey was completed between April and July 2008, approximately a year before the publication of the NICE clinical guideline on the diagnosis and management of COAG and OHT. Although case-finding and screening were specifically excluded from the guideline, immediately following its publication the optical representative bodies (AOP, ABDO & FODO) issued advice based on the diagnostic criteria within the guideline which resulted in a dramatic change in referral behaviour (Sparrow, 2012). Based on a separate survey, conducted a few months following the publication of the NICE guideline, we found that optometrists were referring approximately 3 additional referrals for suspect COAG or OHT per month. A subsequent study by Shah and Murdoch (2011) reported that the change in

optometrists' referral behaviour was associated with increased rates of false positive referrals. The development of the Glaucoma Quality Standard by NICE provided an opportunity to address case-finding and referral (NICE, 2011). The Quality Standard recommended that arrangements should be put in place for referral filtering. This could take two forms: 'repeat measures' and 'referral refinement'. Repeat measures involves the repeat measurement of IOP by contact applanation tonometry and/or visual fields prior to referral. The term 'referral refinement' describes an enhanced clinical assessment that adds value beyond that achieved through repeat measures. In the last few years here has been a wide uptake of repeat measures schemes across England. Although optometrists receive an additional clinical fee for the repeat testing of fields and tonometry, the scheme is associated with significant cost savings due to the large reduction in rates of referral (Parkins & Edgar, 2011). Although our 2008 survey identified that only 16% of optometrists were using a Perkins or Goldmann tonometer to routinely measure IOP, the College of Optometrists Clinical Practice survey conducted in 2007, identified that approximately 50% of practices had access to one of these tonometers. Contact applanation tonometry is a core competency for optometry in the UK, however it is recognised that in some cases refresher training may need to be given.

Demographic changes in the population have led to an increased prevalence of COAG and OHT, and consequently the number of people requiring monitoring for glaucoma is likely to exceed existing hospital capacity. Fifteen per cent of all new and 30% of all ophthalmology outpatient consultations are for glaucoma or OHT. A number of community-based monitoring schemes using specialist optometrists have been developed to address these capacity issues (Bourne et al, 2012; Ratnarajan et al., 2013a; Ratnarajan et al., 2013b). These models of glaucoma shared-care have needed to address the issue of standardisation of equipment. Our survey found a lack of consistency in field testing equipment used by community optometrists. For example, only 22% of practices were equipped with a Humphrey VFA, which has become the reference standard for COAG diagnosis and monitoring glaucomatous progression. This problem can be overcome by ensuring that each participating practice is equipped with the same standardized equipment used in the hospital glaucoma clinic (Bourne et al, 2010). Significantly, as part of the introduction of the new enhanced GOS contract, in many cases the cost of equipment is incurred by the practice. However, as part of the introduction of the enhanced GOS contract in Scotland, the Scottish Executive

provided each participating practice with funding of £10,000 for the provision of new equipment.

Accurate measurement of the clinical practice of healthcare professionals is increasingly being used to highlight variability in performance, identify gaps in the quality of healthcare provision and to guide health policy. Although a variety of direct and indirect assessments of the quality of practice have been used, clinician self-reporting methods, including surveys and face-to-face interviews, have gained popularity since they are easy to administer and are able to gather data from a large number of participants. However, concern has been expressed that clinicians' self-reports may overestimate performance of some clinical actions and underestimate others (Hrisos et al., 2009). Significantly, substantial overestimation has been observed when investigating adherence to best practice guidelines (Lomas et al., 1989; Adams et al., 1999). A recent study used the reported experiences of standardised normal volunteers who visited community optometry practices *incognito* to measure the validity of a questionnaire to investigate routine glaucoma case-finding practice (Theodossiades et al., 2012). Standardised patients (SP) are widely accepted as the gold standard for assessing clinical practice (Shah et al., 2010). A comparison between questionnaire responses and SP reports highlighted important differences between reported practices and actual practices. Significantly, although there was a high degree of correspondence for questions relating to tests that are mandatory under the optometrist's terms of service with the NHS e.g. refraction and ophthalmoscopy, there was poor correspondence for questions concerning discretionary tests. In the current study, there was similarly a lack of correspondence between survey findings and a national sample of referral letters obtained from consultant ophthalmologists. Correspondence was obtained for IOP only. No correspondence was found for disc assessment, visual fields or family history of glaucoma.

The competency-based approach to medical training has become increasingly popular worldwide over the past 25 years, and has become common in UK Optometry in recent years. For example, the current "*Scheme for registration*" for pre-registration optometrists is largely competency based. The first stage in devising competency-based training in any discipline is to develop a competency framework which has been agreed by all significant stakeholders. Chapter 3 describes the development of a competency framework for optometrists with a specialist interest in glaucoma, utilising the Delphi methodology, a novel approach in optometry.

A two–round, web-based Delphi process was devised and executed, with responses to a questionnaire relating to potential competencies obtained from a 15-strong multidisciplinary expert panel. This was followed by a workshop, attended by the entire expert panel, at which borderline competencies were discussed and consensus reached regarding their inclusion or exclusion from the framework. These iterations led to the development of a draft competency framework. The next stage was to undertake a consultation period, during which the draft framework was circulated to all stakeholders inviting their comments. Responses were generally most favourable and resulted in minor editorial changes to the wording of 3 competencies; however, the final published competency framework did not differ significantly in content from that agreed at the workshop. A feature of the new framework was the breadth of its scope, encompassing both hospital-based and primary care optometry in community practice.

As a result of this research and the publication of the framework, the College of Optometrists commissioned City University London to develop the specialist curricula and accreditation standards for optometrists involved in referral refinement, diagnosis and management of glaucoma. These have led to the College of Optometrists developing frameworks for the Professional Certificate, Professional Higher Certificate and Professional Diploma courses for glaucoma. These developments have been timely, given the publication of the NICE guideline on glaucoma which has informed the entire Delphi process described in this thesis. The competency framework was also used as the basis for the completely revised Glaucoma module offered as one of the modules that form the City University London modular MSc in Clinical Optometry.

Optometrists were the main focus of the framework developed via this research but the impact of the framework could extend to other non-medical healthcare professionals. For example, with minor adaptations the framework could be used by nurses and orthoptists who are often involved in glaucoma service delivery. This could lead to a coordinated training and development model for all professionals involved in glaucoma detection and management.

There are a number of possible limitations to this study. Using a convenience sampling method for the selection of the expert panel could have introduced bias, although in an effort to minimise any potential bias from this source the draft framework was distributed widely during the stakeholder consultation. The initial selection of

competencies could also cause bias, although the nature of the Delphi process is such that inappropriate competencies are filtered out or modified and new competencies can be introduced as required. The Delphi approach relies on achieving consensus but without offering any clear definition of what constitutes consensus. This is ultimately left to the panel to decide, but it can be argued that this is both an advantage, because of the flexibility it allows, and a disadvantage because this flexibility may result in the choice of a less than optimal view of what consensus should be for a particular exercise. Nevertheless, the study described in Chapter 3 demonstrates that the Delphi technique is a robust method for gaining autonomous expert opinion. The approach has led to the development of an accepted competency framework for optometrists with a special interest in glaucoma.

Training in the diagnosis and management of COAG and OHT was a recurring theme in the recommendations regarding the provision of services published in the NICE glaucoma guideline (2009). There is currently a wide range of training opportunities and requirements for optometrists involved in glaucoma referral refinement/shared care schemes. The nature of this training is often location-specific, such as the training mechanisms that have evolved in the HES and those that are developed locally for optometrists in repeat measures schemes. Chapter 4 reports on the evaluation of one training scheme – the City University London Glaucoma module. The research in Chapter 4 aimed to assess the impact of the Glaucoma module by evaluating participants' knowledge of important optic disc features in glaucoma, their clinical decision making using case scenarios, and their performance on the Discus program. Discus is a software package which allows clinicians to make a subjective judgement on the appearance of potentially glaucomatous optic discs. The effectiveness of the educational intervention was assessed on two cohorts of postgraduate registered UK optometrists both before (pre-intervention) and after (post-intervention) completing the module. The same assessment was carried out on a Control group who had not undertaken any additional glaucoma training.

There was significantly increased knowledge of signs of optic disc changes in OAG in the MSc cohort post-intervention, with a typical member of this cohort achieving two or three more correct answers out of five following the educational intervention. For the control group the improvement was marginal. These findings support the value of the educational intervention for the acquisition of knowledge, although this was an evaluation of factual knowledge, which lies at the base of Miller's competency pyramid

(Miller, 1990), in the “knows” basement layer. For the case scenarios, there was a slight increase in mean scores in the MSc cohort following the module, although there was no significant difference in median score (6/8 both pre- and post-intervention). Any improvement in the performance of the MSc cohort after the module was marginal, and the MSc group performed little better at this exercise than the Control cohort. This clinical scenario approach to evaluating skills is assessing how optometrists perform at the “knows how” level of Miller’s pyramid, one level higher than the “knows” basement. The disappointing results from the MSc cohort at this “knows how” exercise suggest that the Glaucoma module was not significantly improving the students’ performance at these important tasks.

Using the Discus program it is possible to calculate a sensitivity and specificity figure based on the ability of each participant to correctly identify disc images as coming from eyes with or without glaucomatous field loss. The MSc cohort increased their mean sensitivity significantly post-intervention but at the price of significantly reduced specificity, with implications for possibly increased numbers of false positive referrals. The Controls had little or no change in sensitivity or specificity over time.

One advantage of using the Discus program was that the program had been attempted by an expert panel of 12 glaucoma specialists, which gave the author access to data on their performance using the program for comparison purposes (Denniss et al., 2008, Denniss et al., 2011). Repeatability of the MSc subjects’ responses was moderate but on a par with the expert panel, although repeatability was higher in the control group. This is one indication of the differences that emerged between the two study cohorts. Another example was the significantly higher pre-and post-intervention mean sensitivities in the MSc cohort compared with the Controls.

The average time taken for the MSc cohort to reach a decision on an optic disc image was significantly greater post-intervention (11.4s) compared with pre-intervention (7.4s), an increase which may be attributable to more intense scrutiny of the images. As a result, the MSc cohort took significantly longer to complete the Discus program post-intervention when compared with pre-intervention and, interestingly, the expert panel took a similar time to complete the program as the pre-intervention MSc participants.

ROC curves were generated, and the composite performances by both cohorts were impressive when considered on their own and when compared with the results from the Manchester-based expert panel. Although both the MSc and Control groups have almost identical areas under their ROC curves pre-intervention they are very different in their approach to grading the Discus images, with the MSc cohort being much more prepared to use the full range of the scale. The Controls appear to be less confident in their grading abilities than the MSc cohort but equally good at the grading. The expert panel, as would be expected given their experience and training, were most prepared to use the full range of scores.

The assessment of the MSc cohort took place under carefully controlled conditions, unlike the Controls who were advised how to conduct the tests but were unmonitored during the process. This ensured that MSc subjects could not consult notes or confer with their colleagues. A limitation of this study is that neither the MSc nor Control cohorts were representative samples of UK optometrists. Furthermore, the Discus program itself has a number of limitations, including the highly selected nature of the 100 Discus images, making them a difficult set to interpret, the under-representation of normal and very damaged discs in the sample, and the use of non-stereoscopic images.

Overall our results demonstrate that the educational intervention increases awareness of disc changes in glaucoma, but produces marginal improvements in clinical decision making and performance in the Discus program. This could be because the MSc cohort was a “high baseline” sample for some of these evaluations.

The traditional didactic approach to learning is unlikely to be suited to training optometrists in the clinical competencies required for glaucoma detection and management. As a result, the MSc Glaucoma module has been completely re-designed to become more focused on clinical competencies. With these revisions it has now been accredited for the CoO’s Professional Certificate in Glaucoma.

5.1 Plans for future work

Although the work described in Chapter 2 provides valuable information on diagnostic tests used by optometrists for glaucoma detection, referral behaviour, and perceived barriers to case-finding, the data reflects that situation that pertained in the UK prior to the publication of the NICE glaucoma guideline and the subsequent Joint College Guidance on Referral of Glaucoma Suspects. Given their potential impact on case-finding practice, there is considerable merit in exploring changes to optometrists' referral behaviour that may have occurred post-NICE. Furthermore, the widespread adoption of repeat measures and glaucoma referral refinement schemes have also provided an opportunity to compare the practice of optometrists involved in these schemes to those conducting regular GOS sight tests. This analysis may also identify differences in perceived barriers to case-finding, since the schemes provide an itemised fee for performing the additional screening tests.

Although paper-based or web-based surveys, such as that reported in this thesis, provide a convenient proxy method for measuring clinical practice, the potential for self-reporting bias must be considered when interpreting the results. Although studies using SPs provide an unbiased assessment of actual practice, this method is expensive and time consuming and consequently is generally limited to a small number of practitioners. Clinical vignettes are an alternative method of assessing clinical decision-making that can overcome many of these limitations. Vignettes are written or computerized simulations of fictitious patients that reflect authentic clinical scenarios. Although vignettes are not the same as actual clinical practice, they have been validated in two prospective studies for the assessment of clinical decision making against the 'gold standard' of unannounced standardized patients (Peabody et al., 2000; Peabody et al., 2004). As an extension of the work described in this thesis we are currently using this 'virtual' approach to further explore optometrists' case-finding practice for COAG and OHT to identify potential practice variation.

The development of the College of Optometrists professional qualifications in glaucoma (informed by the competency framework described in this thesis) has created a new model for training and accreditation within this speciality. City University London is currently running a revised College-accredited module leading to a Professional Certificate in Glaucoma. This has involved a radical restructuring of the original glaucoma MSc module that provided the educational intervention described in Chapter

4. The delivery of the new module has been informed by the findings of the present study showing that didactic teaching methods may not be the most appropriate for the development of clinical competency in this area. We are planning to repeat the educational intervention study to evaluate the effectiveness of the new glaucoma module and to extend the educational research to study a more representative sample of community optometrists.

References

Adams, A.S., Soumerai, S.B., Lomas, J., Ross-Degnan, D. (1999) Evidence of self-report bias in assessing adherence to guidelines. *International Journal for Quality in Health Care*, 11(3), pp. 187–92.

Allingham, R.R., Damji, K.F., Freedman, S., Morois, S.E., Shafranov, G. (2005). Shields' Textbook of Glaucoma 5th Edition. Philadelphia: Lippincott Williams and Wilkins, (LWW).

Alm, A. (2000). Uveoscleral outflow. *Eye (Lond),* 14(part 3B), pp.448 – 491.

Altman, D. G., Bland, J. M. (1994a) Diagnostic tests 3: receiver operating characteristic plots. *British Medical Journal*, 309(6948), p. 188.

Altman, D. G. and Bland, J. M. (1994b) Diagnostic tests 1: sensitivity and specificity. Britis*h Medical Journal*, 308(6943), p. 1552.

Anderson, D. R. (1989) Glaucoma: The damage caused by pressure. XLVI Edward Jackson Memorial Lecture. *American Journal* of *Ophthalmology,* 108(5), pp. 485-95.

Anderson D. (2003). Collaborative normal tension glaucoma study. *Current Opinion in Ophthalmology,* 14(2), pp. 86-90.

Andersson, S., Heijl, A., Bengtsson, B. (2011). Optic disc classification by the Heidelberg Retina Tomograph and by physicians with varying experience of glaucoma. *Eye (Lond),* 25(11), pp. 1401-7.

Ang, G.S., Ng, W.S., Azuara-Blanc, A. (2009) The influence of the new general ophthalmic services (GOS) contract in optometrist referrals for glaucoma in Scotland. *Eye (Lond),* 23(2), pp. 351–5.

Association of Optometrists (2003) *Sight Test Resource Pack*. Association of Optometrists, London.

Association of Optometrists (2007) *Making Accurate Claims in Wales* [Online] Available from:
http://www.aop.org.uk/uploads/regulatory/wales/making_accurate_claims_wales.pdf

Association of Optometrists (2009) *Advice on NICE glaucoma guidelines.* [Online] Available from http://www.aop.org.uk/uploaded_files/
glaucoma_advice_and_faqs_01.06.09.pdf [Accessed 23 November 2009].

Azuara-Blanco, A., Burr, B., Thomas, T., Maclennan, G., McPherson, S. (2007) The accuracy of accredited glaucoma optometrists in the diagnosis and treatment recommendation for glaucoma. *British Journal of Ophthalmology* 9(12), pp. 1639–43.

Baker, H., Murdoch, I.E. (2008) Can a public health intervention improve awareness and health-seeking behaviour for glaucoma? *British Journal of Ophthalmology*, 92(12) pp.1671-5.

Banes, M.J., Culham, L.E., Bunce, C., Xing, W., Viswanathan, A., Garway-Heath, D. (2006) Agreement between optometrists and ophthalmologists on clinical management decisions for patients with glaucoma. *British Journal of Ophthalmology*, 90(5), pp. 579-85.

Bathija ,R., Gupta, N., Zangwill, L., Weinreb, R.N. (1998) Changing definition of glaucoma. *Journal of Glaucoma*, 7(3), pp. 165-9.

Bell, R.W., O'Brien, C. (1997) Accuracy of referral to a glaucoma clinic. *Ophthalmic and Physiological Optics*, 17(1), pp. 7-11.

Bengtsson, B., (1980) Findings associated with glaucomatous visual field defects. *Acta Ophthalmologica*, 58(1), pp. 20 - 31.

Bewick, V., Cheek, L., Ball, J. (2004). Statistics review 13: Receiver operating characteristic curves. *Critical Care,* 8(6), pp. 508-12.

Boland, M., Quigley, H. (2007). Risk factors and Open-angle Glaucoma: Classification and Application. *Journal of Glaucoma,* 16(4), pp. 406-18.

Bonomi, L., Marchini, G., Marraffa, M., Morbio, R. (2001) The relationship between intraocular pressure and glaucoma in a defined population. Data from the Egna-Neumarkt glaucoma study. *Ophthalmologica,* 215(1), pp. 34-8.

Bosanquet, N. (2006) Developing a new partnership contract for community eye care in England, Imperial College.

Bourne, R.R., French, K.A., Chang, L., Borman, A.D., Hingorani, M., Newsom, W.D. (2010) Can a community optometrist-based referral refinement scheme reduce false-positive glaucoma hospital referrals without compromising quality of care? The community and hospital allied network glaucoma evaluation scheme (CHANGES). *Eye (Lond), pp.* 24(5), pp. 881-7.

Bowling, B., Chen, S.D., Salmon, J.F. (2005) Outcomes of referrals by community optometrists to a hospital glaucoma service. *The British Journal of Ophthalmology*, 89(9), pp. 1102-4.

Brandt, J.D., Gordon, M.O., Gao, F., Beiser, J.A., Miller, J.P., Kass, M.A. (2012) Ocular Hypertension Treatment Study Group, Adjusting intraocular pressure for central corneal thickness does not improve prediction models for primary open-angle glaucoma. *Ophthalmology*, 119(3), pp 437-42.

Breusegem, C., Fieuws, S., Stalmans, .I, Zeyen, T. (2011) Agreement and accuracy of non-expert ophthalmologists in assessing glaucomatous changes in serial stereo optic disc photographs. *Ophthalmology*, 118(4), pp. 742-6.

Broman, A.T., Quigley, H.A., West, S.K., Katz, J., Munoz, B., Bandeen-Roche, K., Tielsch, .JM., Friedman, D.S., Crowston, J., Taylor, H.R., Varma, R., Leske, M.C., Bengtsson, B., Heijl, A., He, M., Foster, P.J. (2008) Estimating the rate of progressive visual field damage in those with open-angle glaucoma, from cross-sectional data. *Investigative Ophthalmology and Visual Science*, 49 (1), pp. 66-76.

Budde, W.M., Jonas, J.B. (2004) Enlargement of parapapillary atrophy in follow-up of chronic open-angle glaucoma. *American Journal of Ophthalmology,* 137(4), pp. 646–54.

Bunce, C., Wormald, R. (2006) Leading causes of certification for blindness and partial sight in England and Wales. *BMC Public Health,* 6, pp. 58-65.

Bunce, C., Xing, X., Wormald, R., (2010) Causes of blind and partial sight certifications in England and Wales: April 2007–March 2008. *Eye (Lond)*, 24(11), pp. 1692-9.

Burr, J.M., Mowatt, G., Hernández, R.A., Siddiqui, M.A.R., Cook, J.A., Lourenco, T., Ramsay, C.R., Vale, L.D., Fraser, C.M., Azuara-Blanco, A., Deeks, J., Cairns, J., Wormald, R., McPherson, S., Rabindranath, K., Grant, A.M., (2007) The clinical effectiveness and cost-effectiveness of screening for open angle glaucoma: a systematic review and economic evaluation. *Health Technology Assessment*, 11(41), pp. iii-iv, ix-x, 1-190.

Burr, J.M., Botello-Pinzon, P., Takwoingi, Y., Hernández, R., Vazquez-Montes, M., Elders, A., Asaoka, R., Banister, K., van der Schoot, J., Fraser, C., King, A., Lemij, H., Sanders, R., Vernon, S., Tuulonen, A., Kotecha, A., Glasziou, P., Garway-Heath, D., Crabb, D., Vale, L., Azuara-Blanco, A., Perera, R., Ryan, M., Deeks, J., Cook J. (2012) Surveillance for ocular hypertension: an evidence synthesis and economic evaluation. *Health Technology Assessment*, 16(29), pp. 1-271, iii-iv.

Cantillon, P., Jones, R. (1999) Does continuing medical education in general practice make a difference? *British Medical Journal*, 318(7193), pp. 1276-9.

Caprioli, J., Prum, B., Zeyen, T. (1996) Comparison of methods to evaluate the optic nerve head and nerve fiber layer for glaucomatous change. *American Journal of Ophthalmology*, 121(96), pp. 659–67.

Carbonaro, F., Hammond, C. (2007) Genetics in ophthalmology and its relevance to Optometry. *Optometry in Practice,* 8(3), pp. 81-90.

Chang, R., Budenz, D.L. (2008) New developments in optical coherence tomography for glaucoma. *Current Opinion in Ophthalmology,* 19(2), pp. 127-35.

Clancy, M., Kilroy, D., Driscoll, P. (2009) Content prioritisation of the College of Emergency Medicine speciality curriculum: an exploratory study using a modified Delphi approach. *Emergency Medicine Journal*, 26(3), 180–2.

Coffey, M., Reidy, A., Wormald, R., Xian, W.X., Wright, L., Courtney, P. (1993) Prevalence of glaucoma in the west of Ireland. *The British Journal of Ophthalmology,* 77(1), pp. 7-21.

Coleman, A. L., Miglior, S. (2008) Risk factors for glaucoma onset and progression. *Survey of Ophthalmology*, 53(Suppl1), S3-10.

Collaborative Normal-Tension Glaucoma Study Group (1998a) Comparison of glaucomatous progression between untreated patients with normal-tension glaucoma and patients with therapeutically reduced intraocular pressures. *American Journal of Ophthalmology,* 126(4), pp. 487-97.

Collaborative Normal-Tension Glaucoma Study Group. (1998b) The effectiveness of intraocular pressure reduction in the treatment of normal-tension glaucoma. *American Journal of Ophthalmology,* 126(4), pp. 498-505.

College of Optometrists (2001) Clinical practice survey: full report. London: College of Optometrists.

College of Optometrists (2005) Code of Ethics and Guidelines for Professional Conduct, Section D3 Examining patients at risk of glaucoma. [Online] Available from: http://www.college-optometrists.org/download.cfm/docid/D15DFBC3-5146-432D-BEFE9681ED555393 [Accessed 23 March 2009].

College of Optometrists (2009a) Members Handbook: Examining the Patient at Risk from Primary Open Angle Glaucoma [Online] Available from http://www.college-optometrists.org/index.aspx/pcms/site.publication.Members_Handbook [Accessed 1 September 2009].

College of Optometrists (2009b) Clinical Management Guidelines Glaucoma (primary angle closure) (PACG) http://www.college-optometrists.org/en/utilities/document-summary.cfm/docid/A292CCFD-42BE-4A3B-9B663C886D463F00 [Accessed 27 February 2013].

College of Optometrists (2010a) Scheme for registration update June 2010 [Online] Available at: http://www.college-optometrists.org/download.cfm/docid/311D8E38-1C4F-4CEF-AA16117F7A7747E0. [Accessed 28 February 2013].

College of Optometrists (2010b) Guidance on the referral of Glaucoma subjects by community optometrists. Issued by College of Optometrists and The Royal College of Ophthalmologists.

College of Optometrists (2011) Higher Qualifications Update [Online] Available at: http://www.college-optometrists.org/en/utilities/document-summary.cfm/docid/B2C25602-1CF0-4616-BD8DA6A8B1039387 [Accessed 18 January 2013].

College of Optometrists (2011) Revised Modular Framework for Professional Higher Qualifications accredited by the College of Optometrists [Online] Available at: http://www.college-optometrists.org/en/utilities/document-summary.cfm/2E04330D-91F6-48DB-B39DC69D6737EF6A [Accessed 18 January 2013].

College of Optometrists (2012) Code of Ethics and Professional Conduct: D03: Examining the patient at risk from glaucoma [Online] Available from: http://www.college-optometrists.org/en/utilities/document-summary.cfm/docid/D15DFBC3-5146-432D-BEFE9681ED555393.

Competency framework for prescribing optometrists. National Prescribing Centre and General Optical Council. May 2004. [Online] Available at: http://www.med-support.org.uk/IntegratedCRD.nsf/NPC%20Prescribing%20Framework.pdf [Accessed 2 February 2013].

Congdon, N.G., Friedman, D.S., Lietman, T. (2003) Important causes of visual impairment in the world today. *The Journal of the American Medical Association,* 290(15), pp. 2057-60.

Crick, R.P. (1994) Epidemiology and screening of open-angle glaucoma. *Current Opinion in Ophthalmology*, 5(2), pp. 3-9.

Czudowska, M.A., Ramdas, W.D., Roger C.W., Wolfs, R.C., Hofman, A., De Jong, P.T., Vingerling, J.R., Jansonius, N.M. (2010) Incidence of Glaucomatous Visual Field Loss: A Ten-Year Follow-up from the Rotterdam Study, *Ophthalmology*, 117(9) pp. 1705-12.

Dalkey, N. C., Helmer, O. (1963) An experimental application of the Delphi method to the use of experts. *Management Science, 9*(3), 458-67.

Davis, D., O'Brien, M.A., Freemantle, N., Wolf, F.M., Mazmanian, P., Taylor-Vaisey, A. (1999) Impact of formal continuing medical education: do conferences, workshops, rounds, and other traditional continuing education activities change physician behaviour or health care outcomes? *Journal of the American Medical Association*, 282(9), pp. 867-74.

Day, F., Buchan, J.C., Cassells-Brown, A., Fear, A., Dixon, R, Wood, F. A. (2010) A glaucoma equity profile: correlating disease distribution with service provision and uptake in a population in Northern England, UK. *Eye (Lond),* 24(9), pp. 1478–85.

de Voogd, S. M., Ikram, M.K., Wolfs, R.C.W., Jansonius, N.M., Witteman, J.C.M., Hofman. A., de Jong, P.T.V.M., (2006) Is Diabetes Mellitus a Risk Factor for Open-Angle Glaucoma? The Rotterdam Study. *Ophthalmology*, 113(10), pp. 1827–31.

Deleón-Ortega, J.E., Arthur, S.N., McGwin, G, Jr, Xie, A., Monheit, B.E., Girkin, C.A. (2006) Discrimination between glaucomatous and nonglaucomatous eyes using quantitativeimaging devices and subjective optic nerve head assessment. *Investigative Ophthalmology and Visual Science,* 47(8), pp. 3374-80.

Denniss, J., Henson, D.B., Echendu, D., Artes, P.H. (2008) The Interpretation of optic disc images for glaucomatous damage by specialist clinicians. The Association for Researchin Vision and Opthalmology, Poster Presentation. Poster D1016.

Denniss, J., Echendu, D., Henson, D.B., Artes, P.H. (2011) Discus: investigating subjective judgment of optic disc damage. *Optometry and Visual Science*, 88(1), E93-101.

Dielemans, I., de Jong, P.T.V.M., Stolk, R,, Vingerling, J,R,, Grobbee, D,E., Hofman, A. (1996) Primary open-angle glaucoma, intraocular pressure, and diabetes mellitus in the general elderly population. The Rotterdam Study. *Ophthalmology*, 103(8), pp. 1271-75.

Dielemans, I., Vingerling, J.R., Wolfs, R.C., Hofman, A., Grobbee, D.E., de Jong, P.T. (1994) The prevalence of primary open-angle glaucoma in a population-based study in The Netherlands. The Rotterdam Study. *Ophthalmology*, 101(11), pp. 1851-5.

Diwarkar, V. (2002) Commentary: The baby is thrown out with the bath water. *British Medical Journal,* 325, pp. 695-6.

Downs, M., Turner, S., Bryans, M., Wilcock, J., Keady, J., Levin, E., O'Carroll, R., Howie, K., Iliffe, S. (2006) Effectiveness of educational interventions in improving detection and management of dementia in primary care: cluster randomised controlled study. *British Medical Journal*, 332(7543), pp. 692-6.

Drance , S.M. (1989) Disc hemorrhages in the glaucomas. *Survey of Ophthalmology,* 33(5), pp. 331–7.

Drance, S. M. (1997) Glaucoma; A look beyond intraocular pressure. *American Journal of Ophthalmology,* 123(6), pp. 817-9.

Ehlers, N., Bramsen, T., Sperling, S. (1975). Applanation tonometry and central corneal thickness. *Acta Ophthalmologica*, 53(1), pp. 34-43.

European Glaucoma Society (2003) *European Glaucoma Society, Terminology and Guidelines for Glaucoma 3rd ed.* [Online] Available http://www.eugs.org/eng/EGS_guidelines.asp. [Accessed 21 January 2011].

Evans, J. (1995) Causes of blindness and partial sight in England and Wales 1990–1991. *Studies on Medical and Population Subjects No. 57*. London: HMSO.

Evans, J. R., Fletcher, A. E., Wormald, R. P. (2004). Causes of visual impairment in people aged 75 years and older in Britain: an add-on study to the MRC trial of assessment and management of older people in the community. *The British Journal of Ophthalmology,* 88(3), pp. 365–70.

Federation of Ophthalmic and Dispensing Opticians (2008) Optics at a glance [Online] Available from: http://www.fodo.com/fckextras/File/OAAG%202008,%20FINAL%20FINAL.pdf [Accessed 23 November 2009].

Foster, P.J., Buhrmann, R., Quigley, H.A., Johnson, G.J. (2002) The definition and classification of glaucoma in prevalence surveys. *The British Journal of Ophthalmology,* 86(2), pp. 238-42.

Frank, J.R., Snell, L.S, Cate, O.T., Holmboe, E.S., Carraccio, C., Swing, S.R., Harris, P., Glasgow, N.J., Campbell, C., Dath, D., Harden, R.M., Iobst, W., Long, D.M., Mungroo, R., Richardson, D.L., Sherbino, J., Silver, I., Taber, S., Talbot, M., Harris, K.A. (2010) Competency-based medical education: theory to practice. *Medical Teacher*, 32(8), pp.638-45.

Fraser, S., Bunce, C., Wormald, R., Brunner, E. (2001) Deprivation and late presentation of glaucoma: case-control study. *The British Medical Journal,* 322(7287), pp. 639-43.

Friedman, D.S., Wolfs, R.C., O'Colmain, B.J., Klein, B.E., Taylor, H.R., West, S., Leske, M.C., Mitchell, P., Congdon, N., Kempen, J; Eye Diseases Prevalence Research Group (2004) Prevalence of open-angle glaucoma among adults in the United States. *Archives of Ophthalmology*, 122(4), pp. 532–8.

General Optical Council Stage 2 Core Competencies for Optometry. June 2005. [Online] Available from http://www.optical.org/goc/.../root/.../core_competencies/Optometrists.pdf [Accessed on 20 February 2013].

General Optical Council (2008a) Annual Report 2007-8 [Online] Available from http://www.optical.org/goc/filemanager/root/site_assets/publications/ annual_reports/final_goc_ar.pdf [Accessed on 4 February 2010].

General Optical Council (2008b) Consultation on proposed amendments to the competencies for optometrists and dispensing opticians. [Online] Available from [Accessed 14 January 2013].

General Optical Council (2009) Annual Report 2008-9 [Online] Available from: http://annualreport08-09.optical.org/ [Accessed 1 March 2013].

General Optical Council (2010) Annual Report 2009-10 [online] Available from: http://annualreport09-10.optical.org/ [Accessed 1 March 2013].

General Ophthalmic Services Activity Statistics for England and Wales, NHS Information Centre, Dental and Eye Care Team. (2010) [Online] Available from http://www.ic.nhs.uk/webfiles/publications/Primary%20Care/Eye%20care/gosactivity0910/General_Ophthalmic_Services_Activity_Statistics_for_England_and_Wales_2009_10.pdf [Accessed 18 October 2010].

Gordon, M., Beiser, J.A., Brandt, J.D., Heuer, D.K., Higginbotham, E.J., Johnson, C.A., Keltner, J.L., Miller, J.P., Parrish, R.K. 2nd, Wilson, M.R., Kass, M.A.; for the Ocular Hypertension Treatment Study Group. (2002) The Ocular Hypertension Treatment Study. Baseline factors that predict the onset of primary open-angle glaucoma. *Archives of Ophthalmology*, 120(6), pp.714-20.

Gray, S.F., Spry, P.G., Brookes, S.T., Peters, T.J., Spencer, I.C., Baker, I.A., Sparrow, J.M., Easty, D.L. (2000) The Bristol shared care glaucoma study: outcome at follow up at 2 years. *The British Journal of Ophthalmology*, 84(5), pp. 456–63.

Greenhalgh, T., Wong, G., Westhorp, G. and Pawson, R. (2011) Protocol - realist and meta-narrative evidence synthesis: Evolving Standards (RAMESES) *BMC Medical Research Methodology*, 11 (115) http://www.biomedcentral.com/1471-2288/11/115. [Accessed on 7 March 2013].

Grødum, K., Heijl, A., Bengtsson, B. (2001) Refractive error and glaucoma. *Acta Ophthalmologica Scandinavica,* 79(6), pp. 560-6.

Grolman, B. (1972) A new tonometer system. *American Journal of Optometry and Archives of the American Academy of Optometry*, 49(8), pp. 646-60.

Harper, R. (2011) Glaucoma and optometry: recognition, challenges and opportunities. *Ophthalmic and Physiological Optics*, 31(4), pp. 327-9.

Harper, R., Henson, D. and Reeves, B. C. (2000b) Appraising evaluations of screening/diagnostic tests: the importance of the study populations. *British Journal of Ophthalmology*, 84(910), pp. 1198–1202.

Harper, R., Reeves, B. (2000) The sensitivity and specificity of direct ophthalmoscopic optic disc assessment in screening for glaucoma: a multivariate analysis. *Graefes Archives for Clinical and Experimental Ophthalmology*, 238(12), pp. 949-55.

Harper, R., Reeves, B., Smith, G. (2000a) Observer variability in optic disc assessment: implications for glaucoma shared care. *Ophthalmic and Physiological Optics*, 20(4), pp. 265-73.

Harrison, R.J., Wild, J.M., Hobley, A.J. (1988) Referral patterns to an ophthalmic outpatient clinic by general practitioners and ophthalmic opticians and the role of these professionals in screening for ocular disease. *British Medical Journal,* 297(6657), pp 1162–7.

Hasson, R., Keeney, S., McKenna, H. (2000) Research guidelines for the Delphi survey technique. *Journal of Advanced Nursing*, 32(4), pp. 1008 – 15.

Hatt, S., Wormald, R., Burr, J. (2006) Screening for prevention of optic nerve damage due to chronic open angle glaucoma*. Cochrane Database of Systemic Reviews (online)*.http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD006129.pub2/abstract [Accessed 1 February 2013].

Hay, E.M., Campbell, A., Linney, S., Wise, E. (2007) Development of a competency framework for general practitioners with a specialist interest in musculoskeletal/rheumatology practice. *Rheumatology*, 46(2), pp. 360–362.

He, Z., Vingrys, A. J., Armitage, J. A., Bui, B. V. (2011) The role of blood pressure in glaucoma. *Clinical and Experimental Optometry*, 94(2), pp. 133–49.

Healey, P., Mitchell, P. (2000). The relationship between optic disc area and open-angle glaucoma. *Journal of Glaucoma,* 9(2), pp. 203-204.

Healey, P.R., Mitchell, P., Smith, W., Wang, J.J. (1997). Relationship between cup-disc ratio and optic disc diameter: the Blue Mountains Eye Study. *Australian and New Zealand Journal of Ophthalmology*, 25 (Suppl), pp. S99–101.

Health and Social Care Information Centre. General Ophthalmic Services: Workforce Statistics for England and Wales 31 December 2011 [Online] Available from http://www.ic.nhs.uk/statistics-and-data-collections/primary-care/eye-care/general-ophthalmic-services-workforce-statistics-for-england-and-wales-31-December-2011 [Accessed 14 April 2012].

Heijl, A., Leske, M., Bengtsson, B., Hyman, L., Bengtsson, B., Hussein, M. (2002). Early Manifest Glaucoma Trial Group. Reduction of intraocular pressure and glaucoma progression: results from the Early Manifest Glaucoma Trial. *Archives of Ophthalmology,* 120(10), pp. 1268-79.

Henson, D.B., Spencer, A.F., Harper, R., Cadman, E.J. (2003) Community refinement of glaucoma referrals. *Eye (Lond),* 17(1), pp. 21-6.

Hitchings, R. (2000) *Glaucoma,* London, BMJ Publishing Group.

Hrisos, S., Eccles, M.P., Francis, J.J., Dickinson, H.O., Kaner, E.F., Beyer, F., Johnston, F. (2009) Are there valid proxy measures of clinical behaviour? A systematic review. *Implementation Science*, 4 p. 37.

Ieong, A., Murdoch, I., Cousens, S., Healey, P., Theodossiades, J. (2003) Sensitivity and specificity of two glaucoma case-finding strategies for optometrists. *Ophthalmic and Physiological Optics*, 23(4), pp. 341-6.

Jampel, H.D., Singh, K., Lin, S.C., Chen, T.C., Francis, B.A., Hodapp, E., Samples, J.R., Smith, S.D. (2011) Assessment of Visual Function in Glaucoma : A Report by the American Academy of Ophthalmology. *Ophthalmology*, 118(5), pp. 986-2002.

Jonas, J.B., Gusek, G.C., Naumann, G.O. (1988) Optic disc, cup and neuroretinal rim size, configuration and correlations in normal eyes. *Investigative Ophthalmology and Visual Science,* 29 (7), 1151–8 [published errata appear in *Investigative Ophthalmology and Visual Science* 1991, 32(6), p.1893 and 1992, 32(2), pp.474–5.

Jonas, J.B., Nguyen, X.N., Gusek, G.C., Naumann, G.O. (1989) Parapapillary chorioretinal atrophy in normal and glaucoma eyes. I. Morphometric data. *Investigative Ophthalmoogy and Visual Science,* 30(5), pp. 908–18.

Kass, M.A., Heuer, D.K., Higginbotham, E.J., Johnson, C.A., Keltner, J.L., Miller, J.P., Parrish, R.K. 2nd, Wilson, M.R., Gordon, M.O. (2002). The ocular hypertension treatment study: A randomized trial determines that topical ocular hypotensive medication delays or prevents the onset of primary open-angle glaucoma. *Archives of Ophthalmology,* 120(6), pp. 701-13.

Kass, M. A., Gordon, M.O. (2000) Intraocular pressure and visual field progression in open-angle glaucoma. *American Journal of Ophthalmology,*130(4), pp. 490-1.

Katz, J., Sommer, A. (1988) Risk factors for primary open angle glaucoma. *American Journal of Preventative Medicine*, 4(2), pp. 110–4.

Kelly, D.H. (1981) Nonlinear visual responses to flickering sinusoidal gratings. *Journal of the Optical Society of America*, 71(9), pp. 1051-5.

Keltner, J.L., Johnson, C.A., Anderson, D.R., Levine, R.A., Fan, J., Cello, K.E., Quigley, H.A., Budenz, D.L., Parrish, R.K., Kass, M.A., Gordon, M.O. (2006) The association between glaucomatous visual fields and optic nerve head features in the Ocular Hypertension Treatment Study. *Ophthalmology,* 113(9), pp. 1603–12.

Kerrigan-Baumrind, L.A., Quigley, H.A., Pease, M.E., Kerrigan, D.F., Mitchell, R.S. (2000) Number of ganglion cells in glaucoma eyes compared with threshold visual field tests in the same persons. *Investigative Ophthalmology and Visual Science*, 41(3), pp. 741–8.

Kiely, P.M. (2009) Optometrists Association Australia Universal (entry-level) and Therapeutic Competency Standards for Optometry 2008. *Clinical and Experimental Optometry*, 92(4), pp.366-86.

Klein, B.E., Klein, R., Jensen, S.C. (1994) Open-angle glaucoma and older-onset diabetes. The Beaver Dam Eye Study. *Ophthalmology*, 101(7), pp. 1173-7.

Klein, .B.E, Klein, R., Meuer, .SM., Goetz, L.A. (1993) Migraine headache and its association with open-angle glaucoma: the Beaver Dam Eye Study. *Investigative Ophthalmology and Visual Science,* 34 (10), pp. 3024-7.

Klein, B. E., Klein, R., Sponsel, W. E., Franke, T., Cantor, L. B., Martone, J., Menage, M.J. (1992) Prevalence of glaucoma. The Beaver Dam Eye Study. *Ophthalmology*, 99(10), pp. 1499-1504.

Kong, Y.X., Coote, M.A., O'Neill, E.C., Gurria, L.U., Xie, J., Garway-Heath, D., Medeiros, F.A., Crowston, J.G. (2011) Glaucomatous optic neuropathy evaluation project: a standardized internet system for assessing skills in optic disc examination. *Clinical and Experimental Ophthalmology,* 39(4), pp. 308-17.

Kotecha, A. (2009) Detection of Glaucoma by the Primary Care Optometrist. *Optometry in Practice*, 10(2), pp. 56 – 64.

Kroese, M., Burton, H. (2003). Primary open angle glaucoma. The need for a consensus case definition. *Journal of Epidemiology and Community Health*. 57(9), pp. 752-754.

Kroese, M., Burton, H., Vardy, S., Rimmer, T., McCarter, D. (2002).Prevalence of primary open angle glaucoma in general ophthalmic practice in the United Kingdom. *The British Journal of Ophthalmology,* 86(9), pp. 978–80.

Lash, S.C. (2003) Assessment of information included on the GOS 18 referral form used by optometrists. *Ophthalmic and Physiological Optics,* 23(1), pp. 21–3.

Lawrenson (2007) Production and Drainage of Aqueous Humour. In: Edgar, D., Rudnicka, A. (Eds.) Glaucoma: identification and co-management. Edinburgh: Butterworth-Heinemann Elsevier, pp. 17-26.

Lawrenson, J. (2013) Glaucoma: the challenge of early case detection. *Ophthalmic and Physiological Optics*, 33(1), pp. 3–6.

Lemij, H.G., Reus, N.J. (2008) New developments in scanning laser polarimetry for glaucoma. *Current Opinion in Ophthalmology*, 19 (2), pp. 136-40.

Leske, M. C., Connell, A. M., Schachat, A. P. Hyman, L. (1994) The Barbados Eye Study. Prevalence of open angle glaucoma. *Archives of Ophthalmology*, 112(6), pp. 821-9.

Leske, M.C., Connell, A.M.S, Wu, S.Y., Hyman, L.G., Schachat, A.P; the Barbados Eye Study Group. (1995) Risk factors for open-angle glaucoma. The Barbados Eye Study. *Archives of Ophthalmology,* 113(7), pp. 918-24.

Leske, M.C., Heijl, A., Hussein, M., Bengtsson, B., Hyman, L., Komaroff, E., Early Manifest Glaucoma Trial Group. (2003) Factors for glaucoma progression and the effect of treatment. The Early Manifest Glaucoma Trial. *Archives of Ophthalmology,* 121(1), pp. 48–56.

Leske, M.C., Hyman, L., Hussein, M., Heijl, A., Bengtsson, B. Collaborative Normal-Tension Glaucoma Study Group (1999) The effectiveness of intraocular pressure reduction in the treatment of normal-tension glaucoma. *American Journal of Ophthalmology*, 127(5), pp. 6498-505.

Leske, M.C., Rosenthal, J. (1979) Epidemiological aspects of open angle glaucoma. *American Journal of Epidemiology*, 109(3), pp. 250–72.

Leung, W.C. (2002) Competency based medical training: review. *British Medical Journal*, 325(7366), pp.693-6.

Lichter, P.R. (1977) Variability of expert observers in evaluating the optic disc. *Transactions of the American Ophthalmological Society*, 74, pp. 532–72.

Linstone, H. A., Turoff, M. (1975). Introduction. In: Linstone, H.A., Turoff, M. (Eds.). *The Delphi method: Techniques and applications* (pp. 3-12). Reading, MA: Addison-Wesley Publishing Company.

Lockwood, A.J., Kirwan, J.F., Ashleigh, Z. (2010) Optometrists referrals for glaucoma assessment: a prospective survey of clinical data and outcomes. *Eye (Lond)*, 24(9), pp. 1515–9.

Lomas, J., Anderson, G.M., Domnick-Pierre, K., Vayda, E., Enkin, M.W., Hannah, W.J. (1989) Do practice guidelines guide practice? The effect of a consensus statement on the practice of physicians. *The New England Journal of Medicine*, 321(19), pp. 1306–11.

Malik, R., Swanson, W. H. and Garway-Heath, D. F. (2012), 'Structure–function relationship' in glaucoma: past thinking and current concepts. *Clinical and Experimental Ophthalmology*, 40(4), pp. 369–80.

Mandalos, A., Bourne, R., French, K., Newsom, W., Chang, L. (2012) Shared care of patients with ocular hypertension in the Community and Hospital Allied Network Glaucoma Evaluation Scheme (CHANGES). *Eye (Lond),* 26(4), pp. 564-7.

Marcus, M.W., de Vries, M., Junoy Montolio, F., Jansonius, N. (2011). Myopia as a Risk Factor for Open-Angle Glaucoma: A Systematic Review and Meta-Analysis. Ophthalmology, 118(10), pp. 1989-94.

Marks, J.R. (2007) An optometric led glaucoma service. *Optometry Today,* 8, pp. 57 – 62.

Marks, J.R., Harding, A.K., Harper, R.A., Williams, E., Haque, S., Spencer, A.F., Fenerty, C. (2012) Agreement between specially trained and accredited optometrists and glaucoma specialist consultant ophthalmologists in their management of glaucoma patients. *Eye (Lond),* 26(6), pp. 853-61.

McKendrick, A.M., Badcock, D.R., Morgan, W.H. (2004) Psychophysical measurement of neural adaptation abnormalities in magnocellular and parvocellular pathways in glaucoma. *Investigative Ophthalmology and Visual Science,* 45(6), pp. 1846–53.

McNaught, A.I., Allen, J.G., Healey, D.L., McCartney, P.J., Coote, M.A., Wong, T.L., Craig, J.E., Green, C.M., Rait, J.L., Mackey, D.A. (2000) Accuracy and implications of a reported family history of glaucoma: experience from the Glaucoma Inheritance Study in Tasmania. *Archives of Ophthalmology*, 118(7), pp. 900-4.

Medix UK and College of Optometrists (2008) *The College of Optometrists Clinical Practice Survey: Market Research Report*. London: Medix UK.

Memarzadeh, F., Ying-Lai, M., Chung, J., Azen, S.P., Varma, R; Los Angeles Latino Eye Study Group 3 (2010) Blood pressure, perfusion pressure, and open-angle glaucoma: The Los Angeles Latino Eye Study. *Investigative Ophthalmology and Visual Science,* 51(6), pp. 2872–7.

Miglior, S., Pfeiffer, N., Torri, V., Zeyen, T., Cunha-Vaz, J., Adamsons, I. (2007) Predictive factors for open-angle glaucoma among patients with ocular hypertension in the European Glaucoma Prevention Study. *Ophthalmology*, 114(1), pp. 3–9.

Miller, G. E. (1990) The assessment of clinical skills/competence / performance. *Academic Medicine; Journal of the Association of American Medical Colleges,* 65(Suppl. 9) S63–7.

Mitchell, P., Hourihan, F., Sandbach, J., Wang, J.J. (1999) The relationship between glaucoma and myopia: the Blue Mountains Eye Study. *Ophthalmology*, 106(10), pp. 2010–5.

Mitchell, P., Smith, W., Attebo, K., Healey, P.R. (1996) Prevalence of open-angle glaucoma in Australia – The Blue Mountain Eye Study. *Ophthalmology*, 103(10), pp. 1661–9.

Mitchell, P., Smith, W., Chey, T., Healey, P.R. (1997) Open angle glaucoma and diabetes: the Blue Mountains Eye Study, Australia. *Ophthalmology*, 104(4), pp. 712–8.

Mowatt, G., Burr, J. M., Cook J. A., Siddiqui, M. A. R., Ramsay C., Fraser, C., Blanco, A. A. and Deeks, J. J. (2008) Screening Tests for Detecting Open-Angle Glaucoma: Systematic Review and Meta-analysis. *Investigative Ophthalmology and Visual Science*, 49(12), pp. 5373-85.

Myint J., Edgar D.F., Kotecha, A., Crabb D.P., Lawrenson J.G. (2010) Development of a competency framework for optometrists with a specialist interest in glaucoma. *Eye (Lond),* 24, pp. 1509-14.

National Institute of Clinical Excellence (2009) Glaucoma: Diagnosis and management of chronic open angle glaucoma and ocular hypertension. National Collaborating Centre for Acute Care: London [Online] Available from http://www.nice.org.uk/Guidance/CG85/Guidance/pdf/English [Accessed on 23 November 2009].

National Institute of Clinical Excellence (2011) Glaucoma Quality Standard. National Collaborating Centre for Acute Care: London [Online] Available from: http://publications.nice.org.uk/glaucoma-quality-standard-qs7 [Accessed 11 March 2013].

National Prescribing Centre and General Optical Council (2004) Competency framework for prescribing optometrists - May 2004 [Online] Available from: http://www.npc.co.uk/prescribers/competency_frameworks.htm [Accessed on 30 September 2009].

Nemesure, B., He, Q., Mendell, N., Wu, SY, Hejtmacil, J.F., Hennis, A., Leske, M.C. (2001). Inheritance of open-angle glaucoma in the Barbados family study. *American Journal of Medical Genetics,* 103(1), pp. 36-43.

Ng, W.S., Agarwal, P.K., Sidiki, S., McKay, L., Townend, J., Azuara-Blanco, A. (2010) The effect of socio-economic deprivation on severity of glaucoma at presentation. *British Journal of Ophthalmology*, 94(1), pp. 85-7.

Nicolela, M.T. (2008). Clinical clues of vascular deregulation and its association with glaucoma. *Canadian Journal of Ophthalmology,* 43(3), pp. 337-41.

O'Connor, D.J., Zeyen, T., Caprioli, J. (1993) Comparison of methods to detect glaucomatous optic nerve damage. *Ophthalmology,* 100 (10), pp. 1498 –503.

Office of Public Sector Information (1989) The Opticians Act 1989. Published by HMSO, London.

Owen, C.G., Carey, I.M., De Wilde, S., Whincup, P.H., Wormald, R., Cook, D.G. (2006) The epidemiology of medical treatment for glaucoma and ocular hypertension in the United Kingdom: 1994 to 2003. *The British Journal of Ophthalmology,* 90(7), pp. 861–8.

Pache, M., Flammer, J. (2006). A sick eye in a sick body? Systemic findings in patients with Primary Open-angle Glaucoma. *Survey of Ophthalmology*. 51(3), pp. 179-212.

Parkins, D.J., Edgar, D.F. (2011) Comparison of the effectiveness of two enhanced glaucoma referral schemes. *Ophthalmic and Physiological Optics*, 31(4), pp. 343-52.

Pasquale, L.R., Kang, J.H., Manson, J.E., Willet, W.C., Rosner, B.A., Hankinson, S.E. (2006) Prospective study of type 2 diabetes mellitus and risk of primary open-angle glaucoma in women. *Ophthalmology*, 113(7), pp. 1081-6.

Patel, U.D., Murdoch, I,E, Theodossiades, J. (2006) Glaucoma detection in the community: does ongoing training of optometrists have a lasting effect? *Eye (Lond),* 20(5), pp. 591-4.

Peabody, J.W., Luck, .J, Glassman, P., Dresselhaus, T.R., Lee, M. (2000) Comparison of vignettes, standardized patients, and chart abstraction: a prospective validation study of 3 methods for measuring quality. *Journal of the American Medical Association*, 283(13), pp. 1715-22.

Peabody, J.W., Luck, J., Glassman, P., Jain, S., Hansen, J., Spell, M., Lee, M. (2004) Measuring the quality of physician practice by using clinical vignettes: a prospective validation study. *Annals of Internal Medicine*, 141(10), pp. 771–80.

Peyton, J.W.R. (1998) Teaching and Learning in Medical Practice, Rickmansworth: Manticore Europe Ltds.

Pohjanpelto, P.E.J., Plava, J. (1974) Ocular hypertension and glaucomatous optic nerve damage. *Acta Ophthalmologica,* 52(2), pp. 194-201.

Quigley, H.A. (1993) Open-angle glaucoma. *The New England Journal of Medicine,* 328(15), pp. 1097 – 106.

Quigley, H.A., Broman, A.T. (2006) The number of people with glaucoma worldwide in 2010 and 2020. *The British Journal of Ophthalmology*, 90(3), pp. 262-7.

Quigley, H.A., Dunkelberger, .G.R, Green, W.R. (1998) Chronic human glaucoma causing selectively greater loss of large optic nerve fibers. *Ophthalmology*, 95(3), pp. 357-6.

Quigley, H.A., Hohman, R.M., Addicks, E.M., Massoff, R.W., Green, W.R. (1983) Morphologic changes in the lamina cribrosa correlated with neural loss in open-angle glaucoma. *American Journal of Ophthalmology,* 95(5), pp. 673–91.

Quigley, H., Varma, R., Tielsch, J.M., Katz, J., Sommer, A., Gilbert, D.L. (1999). The relationship between optic disc area and open-angle glaucoma: the Baltimore Eye Survey. *Journal of Glaucoma,* 8(6), pp. 347-52.

Ramsey, P.G., Curtis, J.R., Paauw, D.S., Carline, J.D., Wenrich, M. D. (1998) History-taking and preventive medicine skills among primary care physicians: an assessment using standardized patients. *American Journal of Medicine*, 104(2), pp. 152–158.

Rao, H.L., Puttaiah, N.K., Babu, J.G., Maheshwari, R., Senthil, S., Garudadri, C.S. (2010) Agreement among 3 methods of optic disc diameter measurement. *Journal of Glaucoma*, 19(9), pp. 650-4.

Ratnarajan, G., Newsom, W., French, K., Kean, J., Chang, L., Parker, M., Garway-Heath, D.F., Bourne, R.R.A. (2013a) The impact of glaucoma referral refinement criteria on referral to, and first-visit discharge rates from, the hospital eye service: the Health Innovation and Education Cluster (HIEC) Glaucoma Pathways project. *Ophthalmic and Physiological Optics*, 33(2), pp, 183–9.

Ratnarajan, G., Newsom, W., French, K., Kean, J., Chang, L., Parker, M., Garway-Heath, .D.F., Bourne, R.R. (2013b) The effect of changes in referral behaviour following NICE guideline publication on agreement of examination findings between professionals in an established glaucoma referral refinement pathway: the Health Innovation and Education Cluster (HIEC) Glaucoma Pathways project. *British Journal of Ophthalmology*, 97(2), pp. 210-4.

Reidy, A., Minassian, D.C., Vafidis, G., Joseph, J., Farrow, S., Wu, J., Desai, P., Conolly, A. (1998) Prevalence of serious eye disease and visual impairment in a north London population: population based, cross sectional study. *British Medical Journal*, 316(7145), pp. 1643-6.

Reus, N.J., Lemij, H.G., Garway-Heath, D.F., Airaksinen, P.J., Anton, A., Bron, A.M., Faschinger, C., Holló, G., Lester, M., Jonas, J.B., Mistlberger, A., Topouzis, F., Zeyen, T.G. (2010) Clinical assessment of stereoscopic optic disc photographs for glaucoma: the European Optic Disc Assessment Trial. *Ophthalmology,* 117(4), pp. 717-23.

Rivera, J.L., Bell, N.P., Feldman, R. M. (2008) Risk factors for primary open angle glaucoma progression: what we know and what we need to know. *Current Opinion in Ophthalmology,* 19(2), pp. 102-106.

Rudnicka, A.R., Mt-Isa, S., Owen, C.G., Cook, D.G., Ashby, D. (2006). Variations in primary open-angle glaucoma prevalence by age, gender, and race: a Bayesian meta-analysis. *Investigative Ophthalmology and Visual Science*, 47(10), pp. 4254-61.

Rudnicka, A., Owen, C. (2007) Glaucoma Identification and Co-Management. In: Edgar, D.F., Rudnicka, A. (Eds) Glaucoma: identification and co-management. Edinburgh: Butterworth-Heinemann Elsevier.

Sack, J., Healey, D.L., de Graaf, A.P., Wilkinson, R.M., Wilkinson, C.H., Barbour, J.M., Coote, M.A., McCartney, P.J., Rait, J.L., Cooper, R.L., Ring, M.A., Mackey, D.A. (1996) The problem of overlapping glaucoma families in the Glaucoma Inheritance Study in Tasmania (GIST). *Ophthalmic Genetics,* 17(4), pp. 209-14.

Salmon, N. J., Terry, H. P., Farmery, A. D, Salmon, J. F. (2007) An analysis of patients discharged from a hospital-based glaucoma case-finding clinic over a 3-year period. *Ophthalmic and Physiological Optics,* 27(4), pp. 399–403.

Scully, N.D., Chu, L., Siriwardena, D., Wormald, R., and Kotecha, A. (2009) The quality of optometrists' referral letters for glaucoma. *Ophthalmic and Physiolological Optics,* 29(1), pp. 26-31.

Shah, R., Edgar, D.F., Evans, B.J: (2009c) How well does record abstraction quantify the content of optometric eye examinations in the UK? *Ophthalmic and Physiological Optics,* 29(4), pp. 383-96.

Shah, R., Edgar, D.F., Rabbetts, R., Harle, D.E., Evans, B.J.W. (2009b) Standardized Patient Methodology to Assess Refractive Error Reproducibility. *Optometry and Vision Science,* 86(5), pp. 517–528.

Shah, R., Edgar, D.F., Spry, P.G., Harper, R.A., Kotecha, A., Rughani, S., Evans, B.J. (2009a) Glaucoma detection: the content of optometric eye examinations for a presbyopic patient of African racial descent. *British Journal of Ophthalmology,* 93(4), pp. 492–96.

Shah, R., Evans, B.J.W., Edgar, D. (2007) Measuring Clinical Practice. *Ophthalmic and Physiological Optics,* 27(2), pp. 113 – 25.

Shah, R., Edgar, D.F., Evans, B.J. (2010). A comparison of standardised patients, record abstraction and clinical vignettes for the purpose of measuring clinical practice. *Ophthalmic and Physiological Optics*, 30(3), pp. 209–24.

Shah, S., Murdoch, I.E. (2011) NICE – impact on glaucoma case detection. *Ophthalmic and Physiological Optics,* 31(4), pp. 339-42.

Sharma, A., Jofre-Bonet, M., Panca, M., Lawrenson, J.G., Murdoch, I. (2010) Hospital-based glaucoma clinics: what are the costs to patients? *Eye (Lond),* 24(6), pp. 999-1005.

Sharma, P., Sample, P.A., Zangwill, L.M., Scuman, J.S. (2008) Diagnostic tools for glaucoma detection and management. *Survey of Ophthalmology*, 53(Suppl 1), pp. S17-32.

Sheen, N.J., Morgan, J.E., Poulsen, J.L., North, R.V. (2004) Digital stereoscopic analysis of the optic disc: evaluation of a teaching program. *Ophthalmology,* 111(10) pp. 1873-9.

Sihota, R., Srinivasan, G., Dada, T., Gupta, V., Ghate, D., Sharma, A. (2008) Is the ISNT rule violated in early primary open-angle glaucoma--a scanning laser tomography study. *Eye (Lond),* 22(6), pp. 819-24.

Sinclair, A. (2012) A wider view of glaucoma. A review of functional vision loss in glaucoma patients. *Optometry in Practice*, 13(2), pp. 85-96.

Smeeth, L. (1998) Assessing the likely effectiveness of screening older people for impaired vision in primary care. *Family Practice*, 15(Suppl 1), S24-9.

Sommer, A., Tielsch, J.M., Katz, J., Quigley, H.A., Gottsch, J.D., Javitt, J., Singh, K. Baltimore Eye Survey Research Group (1991) Relationship between intraocular pressure and primary open-angle glaucoma among white and black Americans. The Baltimore Eye Study. *Archives of Ophthalmology*, 109(8), pp. 1090-5.

Spalding, J.M., Litwak, A.B., Shufelt, C.L. (2000) Optic nerve evaluation among optometrists. *Optometry and Visual Science*, 77(9), pp. 446-52.

Sparrow, J.M. (2013) How nice is NICE? *British Journal of Ophthalmology*, 97(2), pp. 116-117.

Sponsel, W.E. (1989) Tonometry in question: Can visual screening tests play a more decisive role in glaucoma diagnosis and management? *Survey of Ophthalmology*, 33(Suppl) pp. 291 – 300.

Spry (2007) Glaucoma co-management in Edgar, D., Rudnicka, A. (Eds.) Glaucoma identification and co-management. Edinburgh: Butterworth-Heinemann Elsevier, pp. 181-90.

Spry, P. (2008) Glaucoma Co-Management at Bristol Eye Hospital*:* Translating Clinical Research into Practice. *Optometry in Practice*, 9(3), pp.103–16.

Spry, P., Harper, R. (2010) The Glaucomas: Definitions, Classification and Clinical Features. In: Harvey, W. (Ed.) Essential glaucoma handbook: a guide to assessment and management for eye care professionals. London: Optician Journal, pp. 1-26.

Spry, P., Spencer, I., Sparrow, J., Peters, T.J., Brookes, S.T., Gray, S., Baker, I., Furber, J.E., Easty, D.L. (1999) The Bristol shared care glaucoma study: reliability of community optometric and hospital eye service test measures. *British Journal of Ophthalmology,* 83(6), pp. 707–12.

Stevens, F.C., Diederiks, J.P., Grit, F., van der Horst, F. (2007) Exclusive, idiosyncratic and collective expertise in the interprofessional arena: the case of optometry and eye care in The Netherlands. *Sociology of Health and Illness*, 29(4), pp. 481-96.

Stevens, F.J., van der Horst, F., Hendrikse, F. (2002) The gatekeeper in vision care. An analysis of the co-ordination of professional services in The Netherlands. *Health Policy*, 60(3), pp. 285-97.

Stevenson, R. (1999) Automated perimetry by optometrists in patients at low risk of glaucoma. *British Journal of Ophthalmology*, 83(6), pp. 759–60.

Stewart, J., O'Halloran, C., Harriagan, P., Spencer, J.A., Barton, J.R., Singleton, S.J. (1999). Identifying appropriate tasks for the preregistration year: modified Delphi technique. *British Medical Journal*, 319(7204), pp. 224–9.

Strong, N.P. (1992) How optometrists screen for glaucoma: a survey. *Ophthalmic and Physiological Optics*, 12(1), pp. 3-7.

Susanna, R., Vessani, R.M. (2007) New findings in the evaluation of the optic disc in glaucoma diagnosis. *Current Opinion in Ophthalmology*, 18(2), pp. 122–8.

Tamm, E.R. (2009) The trabecular meshwork outflow pathways: structural and functional aspects. *Experimental Eye Research,* 88(4), pp. 648–55.

Taylor, S.P. (1986) Effect of the Health and Social-Security Bill 1984 on the Profession of Optometry in the United-Kingdom. *American Journal of Optometry and Physiological Optics,* 63(5), pp. 377-81.

Taylor, S.P. (1991) The Opticians Act 1989 and UK Optometry. *Ophthalmic and Physiological Optics,* 11(2), pp. 185-190.

Terai, N., Spoerl, E., Pillunat, L. E., Kuhlisch, E., Schmidt, E., Boehm, A. G. (2011) The relationship between central corneal thickness and optic disc size in patients with primary open-angle glaucoma in a hospital-based population. *Acta Ophthalmologica*, 89(6), pp. 556–9.

Theodossiades, J., Murdoch, I. (1999) Positive predictive value of optometrist-initiated referrals for glaucoma. *Ophthalmic and Physiological Optics*, 19(1), pp. 62-7.

Theodossiades, J., Myint, J., Murdoch, I. E., Edgar, D.F., Lawrenson, J.G. (2012) Does optometrists' self-reported practice in glaucoma detection predict actual practice as determined by standardised patients?. *Ophthalmic and Physiological Optics*, 32(3), pp. 234–41.

Thylefors, B., Negrel, A.D., Pararajasegaram, R. (1994) The global impact of glaucoma*., Bulletin of the World Health Organization,* 72(3), pp. 323-6.

Thylefors, B., Négrel, A.D., Pararajasegaram, R, Dadzie, K,Y. (1995).Global data on blindness. *Bulletin of the World Health Organization,* 73(1), pp. 115-21.

Tielsch, J.M., Katz, J., Quigley, H.A., Javitt, J.C, Sommer, A. (1995). Diabetes, intraocular pressure, and primary open-angle glaucoma in the Baltimore Eye Survey. *Ophthalmology*, 102(1), pp. 48-53.

Tielsch, J.M., Katz, J., Singh, K., Quigley, H.A., Gottsch, J.D., Javitt, J., Sommer, A. (1991a). A population based evaluation of glaucoma screening: the Baltimore eye survey. *American Journal of Epidemiology*, 134(10), pp. 102-10.

Tielsch, J.M., Sommer, A., Katz, J., Royall, R.M., Quigley, H.A., Javitt, J. (1991b). Racial variations in the prevalence of primary open-angle glaucoma. The Baltimore Eye Survey. *Journal of the American Medical Association*, 266(3), pp. 369–74.

Tielsch, J.M., Sommer, A., Katz, J., Quigley, H., Ezrine, S. Baltimore Eye Study Research Group. (1991c). Socioeconomic Status and Visual Impairment among Urban Americans*, Archives of Ophthalmology*, 109(5), pp. 637-41.

Traverso, C. E., Walt, J. G., Kelly, S. P., Hommer, A. H., Bron, A. M., Denis, P., Nordmann, J-P., Renard, J-P., Bayer, A., Grehn, F., Pfeiffer, N., Cedrone, C., Gandolfi, S., Orzalesi, N., Nucci, C., Rossetti, L., Azuara-Blanco, A., Bagnis, A., Hitchings, R., Salmon, J. F., Bricola, G., Buchholz, P. M., Kotak, S. V., Katz, L. M., Siegarte, L. R., Doyle, J. J. (2005) Direct costs of glaucoma and severity of the disease: a multinational long term study of resource utilisation in Europe. *British Journal of Ophthalmology*, 89(10), pp. 1245–9.

Tripathi, R.C., Tripathi, B.J. (1982) Functional anatomy of the anterior chamber angle. In: Duane TD, Jaeger EA, Eds. Biomedical Foundations of Ophthalmology. Philadelphia: Lippincott.

Tsatsos, M., Broadway, D. (2007) Controversies in the history of glaucoma: is it all a load of old Greek? *British Journal of Ophthalmology,* 91(11), pp. 1561-2.

Tuck, M.W., Crick, R.P. (1992) Screening for glaucoma: age and sex of referrals and confirmed cases in England and Wales. *Ophthalmic and Physiological Optics,* 12(4), pp. 400–4.

Tuck, M.W., Crick, R.P. (1993) Relative effectiveness of different modes of glaucoma screening in optometrist practice. *Ophthalmic and Physiological Optics*, 13 (3), pp. 227–32.

Tuck, M.W., Crick, R.P. (1994a) Use of visual field tests in glaucoma detection by optometrists in England and Wales. *Ophthalmic and Physiological Optics*, 14(3), pp. 227–31.

Tuck, M.W., Crick, R.P. (1994b) Non-contact tonometry: optometrists' current practice in England and Wales. *Ophthalmic and Physiological Optics,* 14(4), pp. 347–50.

Tuck, M.W, Crick, R.P. (1999).Glaucoma screening by optometrists: ten years on. *Health Trends*, 30(4), pp. 130–4.

Tuck, M.W., Crick, R.P. (2003).The projected increase in glaucoma due to an ageing population. *Ophthalmic and Physiological Optics,* 23(2), pp. 175-9.

Uhler, T.A., Piltz-Seymour, J. (2008) Optic disc hemorrhages inglaucoma and ocular hypertension: implications andrecommendations. *Current Opinion in Ophthalmology,* 19(2), pp. 89–94.

Vernon, S.A. (1998) The changing pattern of glaucoma referrals by optometrists. *Eye (Lond),* 12(Pt 5), pp. 854–7.

Vernon, S.A., Adair, A. (2010) Shared care in glaucoma: a national study of secondary care lead schemes in England. *Eye (Lond)*, 24(2), pp. 265-9.

Vernon, S.A., Henry, D.J .(1989) Do optometrists screen for glaucoma? *Eye (Lond),* 3(Pt 6), pp,743-6.

Vernon, S.A., Jones, S.J., Henry D.J. (1991) Maximising the sensitivity and specificity of non-contact tonometry in glaucoma screening. *Eye (Lond)*, 5(4), pp. 491-3.

Vogel, R., Crick, R. P., Newson, R. B., Shipley, M., Blackmore, H., Bulpitt, C. J. (1990) Association between intraocular pressure and loss of visual field in chronic simple glaucoma. *The British Journal of Ophthalmology,* 74(1) pp. 3-6.

Wanga, D., Huanga, W., Lia, Y., Zhenga, Y., Fosterb, P.J., Congdona, N., Hea, M. (2011) Intraocular pressure, central corneal thickness, and glaucoma in Chinese adults: The Liwan Eye Study. *American Journal of Ophthalmology,* 152(3), pp. 454–62.

Weinreb, R.N., Khaw, P.T. (2004) Primary open-angle glaucoma*. Lancet,* 363(9422), pp. 1711-20.

Wensor, M.D., McCarty, C.A., Stanislavsky, Y.L., Livingston, P.M., Taylor, H.R. (1998) The prevalence of glaucoma in the Melbourne visual impairment project, *Ophthalmology*, Volume 105(4), pp. 733-9.

Whiting, P., Rutjes, A.W.S., Reitsma, J. B., Glas, A.S., Bossuyt, P.M.M., Kleijnen, J. (2004) Sources of Variation and Bias in Studies of Diagnostic Accuracy: A Systematic Review. *Annals of Internal Medicine*, 140(3), pp.189-202.

Winslade, N. (2005) Report: Competency Based Performance Standards for the Canadian Standard Assessment in Optometry. Canadian Examiners in Optometry. Available at; http://docs.ceo-eco.org/dm/cache/documents/CSAOdocs/CBPS_Document.pdf [Accessed 2 January 2013].

Wolfs, R.C.W., Borger, P.H., Ramrattan, R.S., Klaver, C.C.W., Hulsmann, C.A.A., Hoffman, A., Vingerling, J.R., Hitchings, R.A., de Jong, P.T.V.M. (2000) Changing views on open-angle glaucoma: definitions and prevalence. The Rotterdam Study. *Investigative Ophthalmology and Visual Science,* 41(11), pp. 3309–21.

Wolfs, R. C., Klaver, C.C., Ramrattan, R.S., van Duijn, C.M., Hoffman, A., de Jong, P.T.V.M. (1989) Genetic risk of primary open-angle glaucoma. Population-based familial aggregation study. *Archives of Ophthalmology*, 116(12), pp. 1640-5.

Wollstein, G., Heath, D.F.G., Fontana, L., Hitchings, R.A. (2000a) Identifying Early Glaucomatous Changes: Comparison between Expert Clinical Assessment of Optic Disc Photographs and Confocal Scanning Ophthalmoscopy. *American Academy of Ophthalmology*, 107(12), pp. 2272-7.

Wollstein, G., Garway-Heath, D.F., Poinoosawmy, D., Hitchings, R.A. (2000b) Glaucomatous optic disc changes in the contralateral eye of unilateral normal pressure glaucoma patients.
Ophthalmology, 107(12), pp. 2267-71.

Wollstein, G., Kagemann, L., Bilonick, R.A., Ishikawa, H., Folio, L.S., Gabriele, M.L., Ungar, A.K., Duker, J.S., Fujimoto, J.G., Schuman, J.S. (2012) Retinal nerve fibre layer and visual function loss in glaucoma: the tipping point. *British Journal of Ophthalmology*, 96(1), pp. 47-52.

Wong, V.H., Bui, B.V., Vingrys, A.J. (2011) Clinical and experimental links between diabetes and glaucoma. *Clinical and Experimental Optometry*, 94(1), pp. 4-23.

World Council of Optometry (2005) *A global competency-based model of scope of practice in optometry. Pennsylvania: World Council of Optometry*. [Online} Available at: http://www.hkspo.org.hk/wco_upload/261201285975.pdf [Accessed 28 February 2013].

Wu, S.Y., Nemesure, B., Leske, M.C. (1999). Refractive errors in a black adult population: the Barbados Eye Study. *Investigative Ophthalmology and Visual Science*. 40(10), pp. 2179–84.

Yanagi, M., Kawasaki, R., Wang, J. J., Wong, T. Y., Crowston, J., Kiuchi, Y. (2011) Vascular risk factors in glaucoma: a review. *Clinical and Experimental Ophthalmology*, 39(3), pp. 252–8.

Yücel YH, Zhang Q, Gupta N, Kaufman PL, Weinreb RN. (2000) Loss of neurons in magnocellular and parvocellular layers of the lateral geniculate nucleus in glaucoma. *Archives of Ophthalmology*, 118(3), pp. 378-84.

Yucel, Y.H., Zhang, Q., Weinreb, R.N. (2003) Effects of retinal ganglion cell loss on magno-, parvo-, koniocellular pathways in the lateral geniculate nucleus and visual cortex in glaucoma. *Progress in Retinal and Eye Research,* 22(4), pp. 465–81.

Zeyen, T., Miglior, S., Pfeiffer, N., Cunha-Vaz, J., Adamsons, I; European Glaucoma Prevention Study Group. (2003) Reproducibility of evaluation of optic disc change for glaucoma with stereo optic disc photographs. *Ophthalmology*, 110(2) pp. 340-4.

Zweig, M.H., Campbell, G. (1993) Receiver-operating characteristic (ROC) plots: a fundamental evaluation tool in clinical medicine. *Clinical Chemistry*, 39(4), pp. 561-77.

Appendices

Appendix 1

1. GLAUCOMA DETECTION IN THE COMMUNITY

Community optometrists continue to provide a comprehensive eye examination, including tests for the detection of glaucoma, for a fee that is significantly below the cost of providing such a service. The cost of the examination therefore has to be subsidised by the sales of spectacles.

Against the commercial reality of High St practice, a high rate of glaucoma detection is being maintained (>90% of diagnosed cases of primary open angle glaucoma are detected by community optometrists). In the absence of a formal detection programme, the choice of who should be investigated for glaucoma and which tests should be performed are at the optometrist's discretion (although the College of Optometrists offers guidance for its members).

It is many years since the profession was last surveyed regarding the strategies adopted for glaucoma detection. We feel therefore that it is timely to gather information on current practice. This survey will take about 15 minutes to complete and is divided into 5 sections:

1. About your mode of practice (9 questions)
2. About your strategies for glaucoma detection (2 questions)
3. About the equipment you use for glaucoma detection and your practice organisation (9 questions)
4. About your strategies for glaucoma referral (5 questions)
5. About you (2 questions).

The survey is anonymous and your own responses are confidential.

The design of the survey does not allow you to "go back" and change your previous answers so please ensure you have completed your answers to your satisfaction before continuing to the next page.

If you have any queries about the survey, or experience problems in accessing or completing it, please email glaucomasurvey@city.ac.uk.

Many thanks for taking the time to complete this survey. Your participation is very much appreciated.

***1. Are you currently practising as a community optometrist?**

◯ Yes

◯ No (Includes optometrists who work full-time in the HES)

2. THANK YOU

Thank you for taking the time to participate in this questionnaire. We are only seeking responses from practising community optometrists at this time.

3. MODE OF PRACTICE

***2. Which one of the following was your PRINCIPAL mode of practice during the last WORKING month? Please select ONE only.**

- ◯ Independent
- ◯ Multiple/Group
- ◯ Locum
- ◯ Other (please specify)

***3. Please indicate the proportion of your working time (as%) spent working in the practice specified in Q2**

	Percentage
Divisions of time (percentage)	

***4. During the last WORKING month how many days per week did you spend in the practice specified in Q2?**

- ◯ <1
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7

***5. Where is your principal practice located?**

- ◯ England
- ◯ Northern Ireland
- ◯ Scotland
- ◯ Wales

***6. Where is your principal practice located?**

- ◯ Inner City
- ◯ Urban but not inner city
- ◯ Rural

***7. Please input the first part of your postcode for the practice specified in Q2. For example if your postcode in SE22 8SU then input SE22, if your postcode is EC1V 0HB then input EC1V.**

***8. During the last working month, approximately how many eye examinations (both NHS and private) did you perform per week, in your principal practice specified in Q2?**

- ◯ Less than 11
- ◯ 11-35
- ◯ 36-60
- ◯ 61-85
- ◯ 86-110
- ◯ 111-135
- ◯ 136+

***9. What is the approximate average age of the adult patients you examine in your principal practice?**

- ◯ Less than 40 years of age
- ◯ 40-59
- ◯ 60+

4. STRATEGIES FOR GLAUCOMA DETECTION

***10. In the box below (free text entry), please describe in detail how you would investigate for primary open angle glaucoma in your practice.**

Please include all elements of the eye examination that you feel are necessary.

***11. In the box below (free text entry) comment on any potential barriers that compromise effective detection for primary open angle glaucoma in community optometric practice.**

How do these barriers constrain implementation of practice and are there are any routine tests that sometimes have to be carried out selectively because of these barriers/constraints?

5. INSTRUMENTATION FOR PRIMARY OPEN ANGLE GLAUCOMA DETECTION

***12. Is there "Pre-Screening" in your practice?**

- ◯ No
- ◯ Yes

6. PRE-SCREENING

***13. Which of the following functions are delegated to a "pre-screener"?**

	Yes	No
Visual Fields	◯	◯
Tonometry	◯	◯
Fundus Imaging	◯	◯

7. INSTRUMENTATION

***14. Which field testing equipment is normally used routinely for primary open angle glaucoma detection in the principal practice specified in Q2? Choose from (one only):**

- ◯ Humphrey
- ◯ Henson
- ◯ FDT
- ◯ VFA
- ◯ Dicon
- ◯ Oculus Easyfield
- ◯ Other (please specify)

***15. What fundus examination equipment do you use routinely in the principal practice specified in Q2?**

- ◯ Direct Only
- ◯ Indirect Only
- ◯ Direct and Indirect
- ◯ Other (please specify)

***16. Do you use a fundus imaging system routinely in the principal practice specified in Q2?**

- ◯ Yes
- ◯ No

***17. How do you routinely measure intra-ocular pressures in the principal practice specified in Q2? Choose from (one only):**

- ◯ NCT
- ◯ Pulsair
- ◯ Perkins
- ◯ Goldmann
- ◯ Tonopen
- ◯ Schiotz
- ◯ I-Care
- ◯ Other (please specify)

***18. Does your principal practice possess any of the following specialist equipment?**

	Yes	No
OCT	◯	◯
GDX	◯	◯
Pachymetry	◯	◯
HRT	◯	◯
Gonioscopy	◯	◯
Other Scanning Laser	◯	◯
Indirect Binocular Headset	◯	◯

Other (please specify)

***19. Have you completed any postgraduate training specific to primary open angle glaucoma?**

- ◯ No
- ◯ Yes

If Yes please indicate the additional training you have received

***20. Does your principal practice participate in any shared care/direct referral/co-management schemes etc for primary open angle glaucoma?**

◯ Yes

◯ No

If yes please give details below:

8. REFERRALS

***21. In the last working month approximately how many referrals for further investigation have you made?**

	Number of referrals
Number of referrals	

***22. Of those referrals above approximately how many would be primary open angle glaucoma related referrals?**

	Number of referrals
Primary Open Angle Glaucoma	

***23. When referring for further investigation for glaucoma to whom would you normally send the letter to? Tick as many as apply.**

- [ ] GP
- [ ] Ophthalmologist/Hospital
- [ ] ECLO
- [ ] Other Optometrist
- [ ] Other (please specify)

***24. When referring a patient for further investigation for suspect primary open angle glaucoma, what clinical information do you include in your referral letter?**

9. REFERRALS

***25. When referring a patient for further investigation for suspect primary open angle glaucoma, which of the following do you include in your referral letter? Tick as many as required.**

	Yes	No
Family history	◯	◯
IOPS	◯	◯
Discs	◯	◯
Fields	◯	◯

10. PERSONAL INFORMATION

***26. In which year did you register with the GOC?**

***27. Are you:**

- ◯ Male
- ◯ Female

11. THANK YOU

Thank you for taking the time to complete this survey.

Appendix 2

OPSPORING VAN GLAUCOOM IN DE 1E LIJNS GEZONDHEIDSZORG

Optometristen werkzaam in de 1e lijns gezondheidszorg zijn gewend oogfuncties te onderzoeken en bijvoorbeeld glaucoom op te sporen. Dit tegen een vergoeding die belangrijk minder is dan de kosten van deze dienstverlening. De kosten van het onderzoek moeten dus mede gedragen worden door de inkomsten uit de verkoop van brillen.

Ondanks de commerciële realiteit wordt toch een belangrijk deel van de gevallen van glaucoom in de optometrische praktijk vastgesteld. Omdat een formeel opsporingsprotocol ontbreekt, staat het de optometrist vrij zelf te bepalen wie op glaucoom onderzocht dienen te worden en welke onderzoeksmethoden daarbij gebruikt moeten worden.

Het lijkt nuttig informatie in te winnen over de huidige praktijk op dit gebied. Een zelfde onderzoek wordt momenteel in Groot Brittannië uitgevoerd, zodat ook een internationale vergelijking van de uitkomsten van dit onderzoek mogelijk is. Deze vragenlijst kan in ongeveer 15 minuten ingevuld worden en bestaat uit 5 onderdelen, te weten:

1. betreffende Uw praktijkvoering (9 vragen)
2. betreffende de door U toegepaste strategie bij het opsporen van glaucoom (2 vragen)
3. betreffende de door U voor het opsporen van glaucoom gebruikte apparatuur en de organisatorische aspecten van deze opsporing (9 vragen)
4. betreffende de door U toegepaste strategie bij het verwijzen van van glaucoom verdachte personen (5 vragen)
5. betreffende Uzelf (2 vragen).

Het onderzoek is anoniem en Uw antwoorden worden vertrouwelijk behandeld.

De opzet van het onderzoek is zo dat U bij het invullen van de vragenlijst niet terug kunt gaan en vorige antwoorden kunt veranderen, dus overtuig U ervan dat U de vragen juist beantwoord hebt voordat U verder gaat naar de volgende bladzijde.

Als U vragen hebt betreffende de vragenlijst of problemen ondervindt bij het invullen ervan, stuurt U dan een e-mail naar glaucomasurvey@city.ac.uk

Hartelijk dank dat U de tijd hebt willen nemen om deze vragenlijst in te vullen. Uw deelname wordt op hoge prijs gesteld.

*** 1. Bent u momenteel werkzaam als optometrist in de 1e lijns gezondheidszorg?**

◯ Ja

◯ Nee

Dank U

Hartelijk dank U dat U de tijd genomen hebt om aan dit onderzoek deel te nemen. Wij beperken ons in dit onderzoek tot optometristen die als optometrist werkzaam zijn in de 1e lijns gezondheidszorg.

Praktijkvoering

***2. Hoe oefende U de praktijk de laatste maand dat U werkte in HOOFDZAAK uit? Graag slechts EEN antwoord.**

- ◯ In een zelfstandige onderneming die geen lid van een keten is
- ◯ In een onderneming die lid is van een keten
- ◯ Als waarnemer
- ◯ Anders (graag specificeren)

***3. Hoeveel procent van de tijd die U gewerkt hebt, hebt U gewerkt in de praktijk die U bij vraag 2 hebt aangegeven?**

	Percentage
Verdeling van de tijd Percentage(percentage)	

***4. Hoeveel dagen per week hebt U de laatste maand dat U gewerkt hebt, gewerkt in de praktijk die U bij vraag 2 hebt aangegeven?**

- ◯ <1
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7

***5. Waar voert U Uw werkzaamheden in hoofdzaak uit?**

- ◯ Drenthe
- ◯ Flevoland
- ◯ Friesland
- ◯ Gelderland
- ◯ Groningen
- ◯ Limburg
- ◯ Noord-Brabant
- ◯ Noord-Holland
- ◯ Overijssel
- ◯ Utrecht
- ◯ Zeeland
- ◯ Zuid-Holland

***6. Waar voert U Uw werkzaamheden in hoofdzaak uit?**

- ◯ In het centrum van een stad
- ◯ In een stad, maar buiten het centrum
- ◯ In een dorp

***7. Wilt U het eerste deel van de postcode van de praktijk die U bij vraag 2 hebt aangegeven invullen? Dus als de postcode 3526 BT is, vul dan 3526 en als de postcode 2015 CJ is, 2015 in.**

***8. Ongeveer hoeveel oogonderzoeken hebt U de laatste maand dat U gewerkt hebt, per week uitgevoerd in de praktijk waar U in hoofdzaak Uw werkzaamheden uitvoert, zoals aangegeven bij vraag 2?**

- ◯ Minder dan 11
- ◯ 11-35
- ◯ 36-60
- ◯ 61-85
- ◯ 86-110
- ◯ 111-135
- ◯ 136+

***9. Wat is globaal de gemiddelde leeftijd van de volwassen patiënten die U in de praktijk waar U in hoofdzaak werkzaam bent, onderzoekt?**

- ◯ Minder dan 40
- ◯ 40-59
- ◯ 60+

TOEGEPASTE STRATEGIEEN VOOR DE OPSPORING VAN GLAUCOOM

***10. Wilt U in de volgende omkaderde ruimte (in eigen woorden) in detail beschrijven hoe U in Uw praktijk een onderzoek naar primair open kamerhoekglaucoom (POAG) uitvoert?**
Wilt U alle onderdelen van het oogonderzoek die U noodzakelijk vindt aangeven?

***11. Wilt U in de volgende omkaderde ruimte (in eigen woorden) alle potentiële belemmeringen die een effectieve opsporing van primair open kamerhoekglaucoom in de 1e lijns optometrische praktijk in de weg staan aangeven?**

Welke beperkingen leveren deze belemmeringen in de praktijk op en zijn er routineonderzoeken die vanwege deze belemmeringen soms selectief, dus slechts in bepaalde gevallen, uitgevoerd kunnen worden?

APPARATUUR GEBRUIKT BIJ DE OPSPORING VAN PRIMAIR OPEN KAMERHOEKGLAUCOOM

*** 12. Wordt in Uw praktijk een vooronderzoek door een niet-optometrist uitgevoerd?**

- ◯ Nee
- ◯ Ja

VOORONDERZOEK

***13. Welke van de volgende onderzoeken worden gedelegeerd aan de persoon die het vooronderzoek verricht?**

	Ja	Nee
Gezichtsvelden	◯	◯
Tonometrie	◯	◯
Opname van de fundus	◯	◯

APPARATUUR

***14. Welke apparatuur voor het testen van de gezichtsvelden wordt in de praktijk aangegeven in vraag 2 als routine gebruikt voor het opsporen van primair open kamerhoekglaucoom (POAG)? Kies uit de volgende mogelijkheden (slechts één alternatief aangeven):**

- ◯ Humphrey
- ◯ Henson
- ◯ Zeiss Frequency Doubling Technology
- ◯ Friedmann Visual Field Analyser
- ◯ Dicon
- ◯ Oculus Easyfield
- ◯ Andere (graag specificeren)

***15. Welke methode gebruikt U als routine voor het onderzoek van de fundus in de praktijk aangegeven bij vraag 2?**

- ◯ Alleen direct
- ◯ Alleen indirect
- ◯ Direct en indirect
- ◯ Andere (graag specificeren)

***16. Wordt in de praktijk, aangegeven bij vraag 2, routinematig met behulp van apparatuur een fotografische afbeelding van de fundus gemaakt?**

- ◯ Ja
- ◯ Nee

***17. Hoe meet U als routine de intraoculaire druk in de praktijk aangegeven bij vraag 2? Kies uit de volgende mogelijkheden (slechts één alternatief aangeven):**

- ◯ Non-Contact Tonometer (Reichart/AO Principe)
- ◯ Keeler Pulsair Hand-Held Tonometer
- ◯ Perkins (Applanation)
- ◯ Goldmann (Applanation)
- ◯ Tonopen
- ◯ Schiotz
- ◯ I-Care
- ◯ Anders (graag specificeren)

***18. Beschikt de praktijk waar U in hoofdzaak Uw werkzaamheden uitvoert, over één of meer van de volgende specialistische onderzoeksmogelijkheden?**

	Ja	Nee
OCT	◯	◯
GDX	◯	◯
Pachymetrie	◯	◯
HRT	◯	◯
Gonioscopie	◯	◯
Andere scanning laser	◯	◯
Indirect binoculaire headset	◯	◯

Andere (graag specificeren)

***19. Hebt U enige bij- of nascholingscursus gericht op primair open kamerhoekglaucoom gevolgd?**

- ◯ Nee
- ◯ Ja

Indien ja, wilt U dan de bij- of nascholingcursus die U gevolgd hebt omschrijven?

***20. Neemt de praktijk waar U in hoofdzaak Uw werkzaamheden uitvoert, deel in enig shared care/directe verwijzing/co-management- of regionaal samenwerkingsverband enz. voor primair open kamerhoekglaucoom?**

◯ Ja

◯ Nee

Indien ja, geef hieronder bijzonderheden:

Verwijzingen

***21. Ongeveer hoeveel patiënten hebt U de laatste maand dat U gewerkt hebt verwezen voor verder onderzoek?".**

	Aantal verwijzingen
Aantal verwijzingen	

***22. Ongeveer hoeveel van deze verwijzingen hadden betrekking op primair open kamerhoekglaucoom (POAG)?**

	Aantal verwijzingen
Primair open kamerhoekglaucoom	

***23. Wanneer U een patiënt verwijst voor nader onderzoek naar glaucoom, naar wie stuurt U dan normaal de verwijsbrief? Kruis zoveel alternatieven aan als van toepassing zijn.**

- ☐ Huisarts
- ☐ Oogarts/ziekenhuis
- ☐ Andere optometrist
- ☐ Ander (graag specificeren)

***24. Welke klinische informatie vermeldt U in Uw verwijsbrief wanneer U een patiënt doorverwijst voor nader onderzoek in verband met een verdenking op primair open kamerhoekglaucoom (POAG)?**

Verwijzingen

***25. Welke van de volgende gegevens vermeldt U in Uw verwijsbrief wanneer U een patiënt verwijst voor nader onderzoek wegens verdenking op primair open kamerhoekglaucoom (POAG)? Kruis zoveel alternatieven als van toepassing zijn aan.**

	Ja	Nee
Familieanamnese	◯	◯
Intraoculaire druk (IOP)	◯	◯
Papil (Discs)	◯	◯
Gezichtsvelden	◯	◯

Persoonlijke gegevens

***26. In welk jaar bent U afgestudeerd?**

***27. Bent U:**

- ◯ Man
- ◯ Vrouw

Dank U

Hartelijk dank dat U de tijd hebt willen nemen om deze vragenlijst te beantwoorden.

Dit formulier is met succes verstuurd

Appendix 3

Delphi Round 1

1. Competencies required for optometrists involved in the diagnosis of glaucom...

Recently published NICE guidance on the diagnosis and management of chronic open angle glaucoma and ocular hypertension recognises the involvement of non-medical healthcare professionals in the diagnosis of ocular hypertension and suspected chronic open angle glaucoma and the formulation of a management plan. The guidance recommends that people with suspected optic nerve damage or repeatable visual field defects, or both, should be referred to a consultant ophthalmologist for consideration of a definitive diagnosis.

Web link to NICE guidance:
http://www.nice.org.uk/Guidance/CG85

Under the Opticians Act 1989, the General Optical Council is required to establish the competencies which a person must be able to demonstrate in order to be granted a qualification as an optometrist. All 82 core competencies, which are organised into 8 subject areas, are formally assessed by the College of Optometrists during the pre-registration period. A number of these competencies relate to the detection and referral of glaucoma. To review these GOC competencies relevant to glaucoma, please refer to the document attached to your email invitation to participate in this Delphi process.

We recognise that optometrists with a specialist interest in glaucoma will need to demonstrate additional knowledge and skills, requiring then to demonstrate competencies that are additional to those already required by the GOC for entry level into the optometry profession. In this section we wish you to rate each of the competency statements provided below, in order to determine its importance for a specialist optometrist involved in the diagnosis of glaucoma (the same set of competencies will be regraded in the next section for a specialist optometrist involved in the monitoring of glaucoma). For each competency, there is a nine point scale of importance ranging from "Not Essential" to "Essential". You will be given an opportunity in the free text boxes provided to suggest a modification to the wording of each competency statement and suggest additional competencies required for the role.

*1. History Taking/Record keeping

	Not Essential				Neutral				Essential
The ability to take a comprehensive ophthalmic history in a patient with diagnosed or suspected glaucoma.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*2. History Taking/Record Keeping

	Not Essential				Neutral				Essential
The ability to maintain clear, accurate and contemporaneous clinical records of ophthalmic history, examination and results of clinical investigations in patients at risk of or suffering from glaucoma.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

Delphi Round 1

*3. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to carry out an appropriate examination of the anterior segment of the eye in a patient with diagnosed or suspected glaucoma and to interpret relevant clinical signs.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*4. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to perform the van Herick technique for the assessment of peripheral anterior chamber depth and to interpret the significance of the results.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*5. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to perform a gonioscopic examination of the anterior chamber angle and to identify anatomical structures, accurately grade the angle width and interpret the significance of clinical findings.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*6. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to perform an assessment of central corneal thickness using appropriate instrumentation and to interpret the significance of the results.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*7. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to recognise the signs and symptoms of a patient suffering from angle-closure glaucoma (or at risk of angle closure) and to refer the patient accordingly (including the instigation of emergency treatment if necessary)	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*8. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to assess the optic nerve head by binocular indirect ophthalmoscopy and to detect the characteristic features of glaucomatous optic neuropathy	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*9. Examination/ Data interpretation

	Not Essential				Neutral				Essential
An understanding of supra-threshold perimetric techniques used in the assessment of a patient with suspected glaucoma including test strategies used, sources of error, interpretation of results and the recognition of glaucomatous field loss	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*10. Examination/ Data interpretation

	Not Essential				Neutral				Essential
An understanding of the use of threshold perimetric techniques used in the assessment of a patient with manifest glaucoma and the ability to detect the progression of disease	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

Delphi Round 1

*11. Examination/ Data interpretation

	Not Essential				Neutral				Essential
An understanding of the imaging techniques used to assess the optic nerve head and retinal nerve fibre layer and the ability to interpret the results of such investigations	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*12. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to differentially diagnose glaucoma through an interpretation and integration of the results of clinical examination and the results of any further investigative techniques.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*13. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to recognise the indications for treatment in glaucoma, the concept of target pressures and risk factors for disease progression	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*14. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to detect a change in clinical status (e.g. visual field status, intra-ocular pressure, assessment of anterior or posterior segments).	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

Delphi Round 1

*15. Management

	Not Essential				Neutral				Essential
The ability to monitor the response to treatment and modify the management plan or consult a more experienced colleague or refer if necessary	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*16. Management

	Not Essential				Neutral				Essential
An understanding of time frames for follow-up of patients with glaucoma taking into account target pressures and the risk of progression	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*17. Management

	Not Essential				Neutral				Essential
Knowledge of the cautions, contraindications, interactions and side effects of anti-glaucoma medication	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*18. Management

	Not Essential				Neutral				Essential
Knowledge of the surgical management of the glaucomas including indications for surgery, surgical techniques, complications and post-operative evaluation	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

Delphi Round 1

***19. Management**

	Not Essential				Neutral				Essential
An awareness of one's own limitations and the ability to make clinical decisions based on the needs of the patient	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

***20. Management**

	Not Essential				Neutral				Essential
The ability to operate within local protocols for the detection and/or management of glaucoma.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

21. Suggestions for additional competencies required for optometrists involved in the diagnosis of glaucoma

Delphi Round 1

2. Competencies required for optometrists additionally involved in the monitor...

NICE guidance on the diagnosis and management of chronic open angle glaucoma and ocular hypertension also recognised the involvement of non-medical healthcare professionals in the monitoring of people with a confirmed diagnosis of ocular hypertension or suspected chronic open angle glaucoma.

In this section we wish you to rate each of the competency statements provided below, to determine its importance for a specialist optometrist additionally involved in the monitoring of glaucoma. Again, you will be given an opportunity in the free text boxes provided below, to suggest a modification to the wording of the competency statement and suggest additional competencies required for the role. You may also wish to review the GOC Stage 2 competencies relevant to glaucoma, in the document attached to your email invitation to participate in this Delphi process.

* 1. History Taking/Record keeping

	Not Essential				Neutral				Essential
The ability to take a comprehensive ophthalmic history in a patient with diagnosed or suspected glaucoma.	◯	◯	◯	◯	◯	◯	◯	◯	◯

Suggested change to the wording of the competency statement

* 2. History Taking/Record Keeping

	Not Essential				Neutral				Essential
The ability to maintain clear, accurate and contemporaneous clinical records of ophthalmic history, examination and results of clinical investigations in patients at risk of or suffering from glaucoma.	◯	◯	◯	◯	◯	◯	◯	◯	◯

Suggested change to the wording of the competency statement

* 3. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to carry out an appropriate examination of the anterior segment of the eye in a patient with diagnosed or suspected glaucoma and to interpret relevant clinical signs.	◯	◯	◯	◯	◯	◯	◯	◯	◯

Suggested change to the wording of the competency statement

Delphi Round 1

*4. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to perform the van Herick technique for the assessment of peripheral anterior chamber depth and to interpret the significance of the results.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*5. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to perform a gonioscopic examination of the anterior chamber angle and to identify anatomical structures, accurately grade the angle width and interpret the significance of clinical findings.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*6. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to perform an assessment of central corneal thickness using appropriate instrumentation and to interpret the significance of the results.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*7. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to recognise the signs and symptoms of a patient suffering from angle-closure glaucoma (or at risk of angle closure) and to refer the patient accordingly (including the instigation of emergency treatment if necessary)	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

Delphi Round 1

*8. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to assess the optic nerve head by binocular indirect ophthalmoscopy and to detect the characteristic features of glaucomatous optic neuropathy	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*9. Examination/ Data interpretation

	Not Essential				Neutral				Essential
An understanding of supra-threshold perimetric techniques used in the assessment of a patient with suspected glaucoma including test strategies used, sources of error, interpretation of results and the recognition of glaucomatous field loss	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*10. Examination/ Data interpretation

	Not Essential				Neutral				Essential
An understanding of the use of threshold perimetric techniques used in the assessment of a patient with manifest glaucoma and the ability to detect the progression of disease	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*11. Examination/ Data interpretation

	Not Essential				Neutral				Essential
An understanding of the imaging techniques used to assess the optic nerve head and retinal nerve fibre layer and the ability to interpret the results of such investigations	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

Delphi Round 1

*12. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to differentially diagnose glaucoma through an interpretation and integration of the results of clinical examination and the results of any further investigative techniques.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*13. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to recognise the indications for treatment in glaucoma, the concept of target pressures and risk factors for disease progression	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*14. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to detect a change in clinical status (e.g. visual field status, intra-ocular pressure, assessment of anterior or posterior segments).	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

*15. Management

	Not Essential				Neutral				Essential
The ability to monitor the response to treatment and modify the management plan or consult a more experienced colleague or refer if necessary	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

Delphi Round 1

***16. Management**

	Not Essential				Neutral				Essential
An understanding of time frames for follow-up of patients with glaucoma taking into account target pressures and the risk of progression	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

***17. Management**

	Not Essential				Neutral				Essential
Knowledge of the cautions, contraindications, interactions and side effects of anti-glaucoma medication	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

***18. Management**

	Not Essential				Neutral				Essential
Knowledge of the surgical management of the glaucomas including indications for surgery, surgical techniques, complications and post-operative evaluation	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

***19. Management**

	Not Essential				Neutral				Essential
An awareness of one's own limitations and the ability to make clinical decisions based on the needs of the patient	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

Delphi Round 1

***20. Management**

	Not Essential				Neutral				Essential
The ability to operate within local protocols for the detection and/or management of glaucoma.	○	○	○	○	○	○	○	○	○

Suggested change to the wording of the competency statement

21. Suggestions for additional competencies required for optometrists additionally involved in the monitoring of glaucoma

Appendix 4

Delphi Round 2

Development of a competency framework for optometrists with a specialist in...

Thank you for your input to round 1 of the Delphi process.

It is most important that you read the round 1 feedback document attached to the invitation email prior to completing this second part.

We have used your detailed comments to modify several competency statements and have introduced three new statements.

In round 2 we are asking you to rate a modified set of statements. As with round 1, the survey is divided into two sections:

Section 1 relates to those competencies that should be demonstrated by an optometrist involved in the diagnosis of glaucoma (e.g. those engaged in community screening or referral refinement). The recently published NICE guidance describes this role as 'diagnosis of OHT and suspect COAG status and preliminary identification of COAG'.

Section 2 relates to those competencies possessed by an optometrist additionally involved in the management of glaucoma. This role is defined by NICE as 'healthcare professionals involved in the monitoring and treatment of people with OHT, suspected COAG and established COAG'.

At the end of each section there will be a free text box for any additional comments.

The intention is that the requisite competencies generated by this Delphi process should be in addition to those already required by all optometrists for initial entry on to the GOC register of optometrists (a document listing those competencies relevant to glaucoma has been attached to the invitation email).

Delphi Round 2

Section 1. Competencies required for optometrists involved in the diagnosis...

*1. History Taking/Record keeping

	Not Essential				Neutral				Essential
The ability to take a comprehensive medical and ophthalmic history in a patient at risk of, or with suspected glaucoma, including the identification of ocular and systemic risk factors for glaucoma.	○	○	○	○	○	○	○	○	○

*2. History Taking/Record Keeping

	Not Essential				Neutral				Essential
The ability to maintain clear, accurate and contemporaneous clinical records of ophthalmic history, examination and results of clinical investigations in patients at risk of, or with suspected glaucoma.	○	○	○	○	○	○	○	○	○

*3. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to carry out an appropriate examination of the anterior segment of the eye in a patient at risk of, or with suspected glaucoma and to interpret relevant clinical signs.	○	○	○	○	○	○	○	○	○

*4. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to perform the van Herick technique for the assessment of peripheral anterior chamber depth and to interpret the significance of the results.	○	○	○	○	○	○	○	○	○

*5. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to perform a gonioscopic examination of the anterior chamber angle and to identify anatomical structures, accurately grade the angle width and interpret the significance of clinical findings.	○	○	○	○	○	○	○	○	○

*6. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to perform an assessment of central corneal thickness using appropriate instrumentation and to interpret the significance of the results.	○	○	○	○	○	○	○	○	○

*7. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to recognise the signs and symptoms of a patient suffering from acute angle-closure glaucoma (or at risk of angle closure) and to refer the patient accordingly (including the instigation of emergency treatment if necessary).	○	○	○	○	○	○	○	○	○

Delphi Round 2

***8. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
The ability to assess the optic nerve head and posterior segment by binocular indirect ophthalmoscopy and to detect the characteristic features of glaucomatous optic neuropathy.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***9. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
An understanding of supra-threshold perimetric techniques used in the assessment of a patient with suspected glaucoma, including test strategies used, limitations, sources of error, interpretation of results and the recognition of glaucomatous field loss.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***10. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
An understanding of the use of threshold perimetric techniques for the assessment of a patient with manifest glaucoma, including test strategies used, sources of error and artefact, and the ability to detect the progression of disease.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***11. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
An understanding of the imaging techniques used to assess the optic nerve head and retinal nerve fibre layer and the ability to interpret the results of such investigations.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***12. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
The ability to differentially diagnose glaucoma through an interpretation and integration of the results of clinical examination and the results of any further investigative techniques.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***13. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
The ability to detect and appreciate the significance of concurrent pathology in the diagnosis of glaucoma.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***14. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
The ability to recognise the indications for treatment in glaucoma in the context of risk factors for disease progression, patient preference and therapeutic aims.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***15. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
The ability to detect a change in clinical status (e.g. visual field status, intra-ocular pressure, assessment of anterior or posterior segments).	◯	◯	◯	◯	◯	◯	◯	◯	◯

Delphi Round 2

***16. Management**

	Not Essential				Neutral				Essential
The ability to monitor the response to treatment and modify the management plan or consult a more experienced colleague or refer if necessary.	○	○	○	○	○	○	○	○	○

***17. Management**

	Not Essential				Neutral				Essential
An understanding of time-frames for follow-up of patients taking into account local preferences, risk of progression, and patient related factors (age, concurrent disease etc).	○	○	○	○	○	○	○	○	○

***18. Management**

	Not Essential				Neutral				Essential
Knowledge of the pharmacology, cautions, contraindications, interactions and side effects of anti-glaucoma medication.	○	○	○	○	○	○	○	○	○

***19. Management**

	Not Essential				Neutral				Essential
Knowledge of the surgical management of the glaucomas, including indications for surgery, surgical techniques, complications and post-operative evaluation.	○	○	○	○	○	○	○	○	○

***20. Management**

	Not Essential				Neutral				Essential
An awareness of one's own limitations and the ability to make clinical decisions based on the needs of the patient.	○	○	○	○	○	○	○	○	○

***21. Management**

	Not Essential				Neutral				Essential
The ability to operate within local protocols for the detection and/or management of glaucoma.	○	○	○	○	○	○	○	○	○

***22. Management**

	Not Essential				Neutral				Essential
An ability to help patients make informed choices about their management and to check their understanding of and commitment to their management and follow up.	○	○	○	○	○	○	○	○	○

***23. Management**

	Not Essential				Neutral				Essential
The ability to counsel patients regarding risks of blindness associated with glaucoma, risk to family members, potential impact of the disease on lifestyle (including driving) and provide information on available sources of help, counselling and support.	○	○	○	○	○	○	○	○	○

Delphi Round 2

24. Additional Comments

Delphi Round 2

Section 2.Competencies required for optometrists additionally involved in t...

*1. History Taking/Record keeping

	Not Essential				Neutral				Essential
The ability to take a comprehensive ophthalmic history in a patient with diagnosed or suspected glaucoma.	○	○	○	○	○	○	○	○	○

*2. History Taking/Record Keeping

	Not Essential				Neutral				Essential
The ability to maintain clear, accurate and contemporaneous clinical records of ophthalmic history, examination and results of clinical investigations in patients with diagnosed or suspected glaucoma.	○	○	○	○	○	○	○	○	○

*3. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to carry out an appropriate examination of the anterior segment of the eye in a patient with diagnosed or suspected glaucoma and to interpret relevant clinical signs.	○	○	○	○	○	○	○	○	○

*4. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to perform the van Herick technique for the assessment of peripheral anterior chamber depth and to interpret the significance of the results.	○	○	○	○	○	○	○	○	○

*5. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to perform a gonioscopic examination of the anterior chamber angle and to identify anatomical structures, accurately grade the angle width and interpret the significance of clinical findings.	○	○	○	○	○	○	○	○	○

*6. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to perform an assessment of central corneal thickness using appropriate instrumentation and to interpret the significance of the results.	○	○	○	○	○	○	○	○	○

*7. Examination/ Data interpretation

	Not Essential				Neutral				Essential
The ability to recognise the signs and symptoms of a patient suffering from acute angle-closure glaucoma (or at risk of angle closure) and to refer the patient accordingly (including the instigation of emergency treatment if necessary).	○	○	○	○	○	○	○	○	○

Delphi Round 2

***8. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
The ability to assess the optic nerve head and posterior segment by binocular indirect ophthalmoscopy and to detect the characteristic features of glaucomatous optic neuropathy.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***9. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
An understanding of supra-threshold perimetric techniques used in the assessment of a patient with suspected glaucoma, including test strategies used, limitations, sources of error, interpretation of results and the recognition of glaucomatous field loss.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***10. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
An understanding of the use of threshold perimetric techniques for the assessment of a patient with manifest glaucoma, including test strategies used, sources of error and artefact, and the ability to detect the progression of disease.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***11. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
An understanding of the imaging techniques used to assess the optic nerve head and retinal nerve fibre layer and the ability to interpret the results of such investigations.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***12. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
The ability to differentially diagnose glaucoma through an interpretation and integration of the results of clinical examination and the results of any further investigative techniques.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***13. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
The ability to detect and appreciate the significance of concurrent pathology in the management of glaucoma.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***14. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
The ability to recognise the indications for treatment in glaucoma in the context of risk factors for disease progression, patient preference and therapeutic aims.	◯	◯	◯	◯	◯	◯	◯	◯	◯

***15. Examination/ Data interpretation**

	Not Essential				Neutral				Essential
The ability to detect a change in clinical status (e.g. visual field status, intra-ocular pressure, assessment of anterior or posterior segments).	◯	◯	◯	◯	◯	◯	◯	◯	◯

Delphi Round 2

***16. Management**

	Not Essential				Neutral				Essential
The ability to monitor the response to treatment and modify the management plan or consult a more experienced colleague or refer if necessary.	○	○	○	○	○	○	○	○	○

***17. Management**

	Not Essential				Neutral				Essential
An understanding of time-frames for follow-up of patients taking into account local preferences, risk of progression, and patient related factors (age, concurrent disease etc).	○	○	○	○	○	○	○	○	○

***18. Management**

	Not Essential				Neutral				Essential
Knowledge of the pharmacology, cautions, contraindications, interactions and side effects of anti-glaucoma medication.	○	○	○	○	○	○	○	○	○

***19. Management**

	Not Essential				Neutral				Essential
Knowledge of the surgical management of the glaucomas, including indications for surgery, surgical techniques, complications and post-operative evaluation.	○	○	○	○	○	○	○	○	○

***20. Management**

	Not Essential				Neutral				Essential
An awareness of one's own limitations and the ability to make clinical decisions based on the needs of the patient.	○	○	○	○	○	○	○	○	○

***21. Management**

	Not Essential				Neutral				Essential
The ability to operate within local protocols for the detection and/or management of glaucoma.	○	○	○	○	○	○	○	○	○

***22. Management**

	Not Essential				Neutral				Essential
An ability to help patients make informed choices about their management and to check their understanding of and commitment to their management and follow up.	○	○	○	○	○	○	○	○	○

***23. Management**

	Not Essential				Neutral				Essential
The ability to counsel patients regarding risks of blindness associated with glaucoma, risk to family members, potential impact of the disease on lifestyle (including driving) and provide information on available sources of help, counselling and support.	○	○	○	○	○	○	○	○	○

Delphi Round 2

24. Additional Comments

Appendix 5

Reference Number

Pre-Course Evaluation

We would be most grateful if you would complete the following pages as instructed. This evaluation is anonymous and will be marked by a third party who is not directly involved with the glaucoma shared care module. Please insert your unique reference number at the top of the page.

The questions below are designed to help us evaluate the course that you are about to complete. You will be asked to repeat the exercise at the end of the course. The results will be incorporated into glaucoma case-finding research being conducted in the Department of Optometry and Visual Science.

Disc Analysis

Please list in bullet point form the top 5 features that should be observed/ considered when assessing a disc for POAG

1.

2.

3.

4.

5.

Clinical Decision Making

For each of the following scenarios please tick the answer you feel is most relevant.

e.g.

1=Definitely Normal	2= Possibly Normal	3= Not sure Normal/Glaucoma	4=Possibly Glaucoma	5=Definitely Glaucoma
☐	☑	☐	☐	☐

If you make a mistake, please erase your answer and indicate clearly your new answer.

e.g.

1=Definitely Normal	2= Possibly Normal	3= Not sure Normal/Glaucoma	4=Possibly Glaucoma	5=Definitely Glaucoma
☑	~~☑~~	☐	☐	☐

There are 4 scenarios in total. Please complete all four scenarios.

Reference Number

Part 2

Disc Analysis

Please list in bullet point form the top 5 features that should be observed/ considered when assessing a disc for POAG

1.
2.
3.
4.
5.

Clinical Decision Making

For each of the following scenarios please tick the answer you feel is most relevant.
e.g.

1=Definitely Normal	2= Possibly Normal	3= Not sure Normal/Glaucoma	4=Possibly Glaucoma	5=Definitely Glaucoma
☐	☑	☐	☐	☐

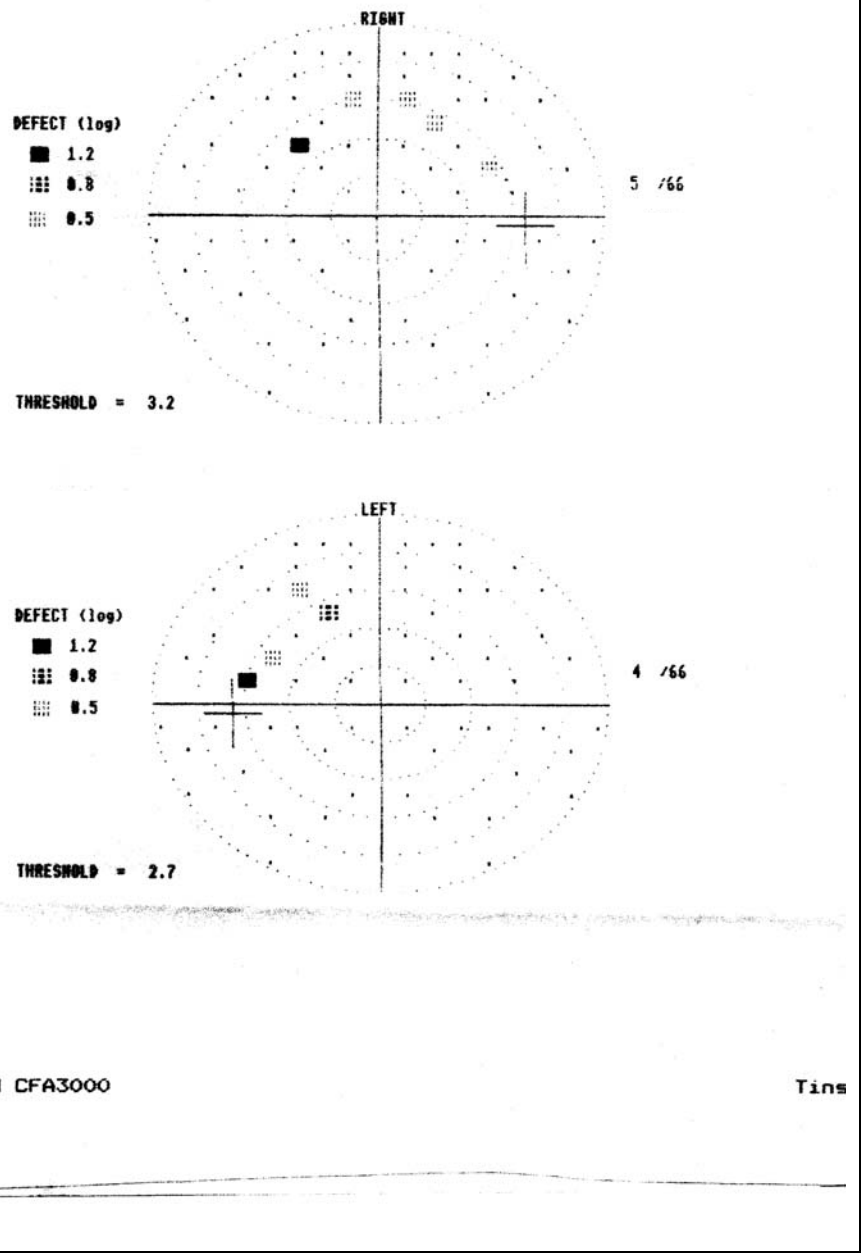
If you make a mistake, please erase your answer and indicate clearly your new answer.

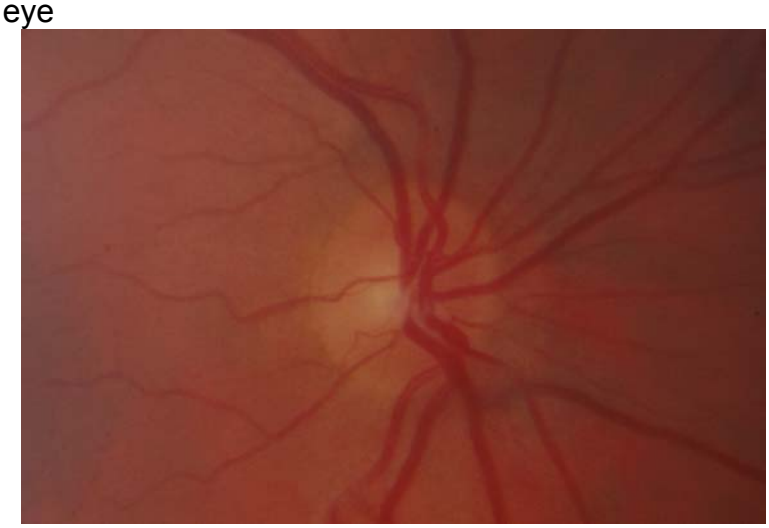
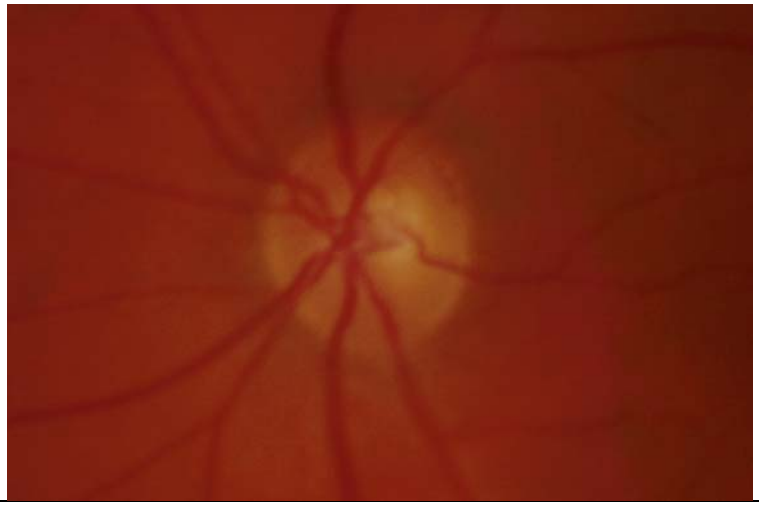
e.g.

1=Definitely Normal	2= Possibly Normal	3= Not sure Normal/Glaucoma	4=Possibly Glaucoma	5=Definitely Glaucoma
☑	~~☑~~	☐	☐	☐

There are 4 scenarios in total. Please complete all four scenarios.

Scenario 1

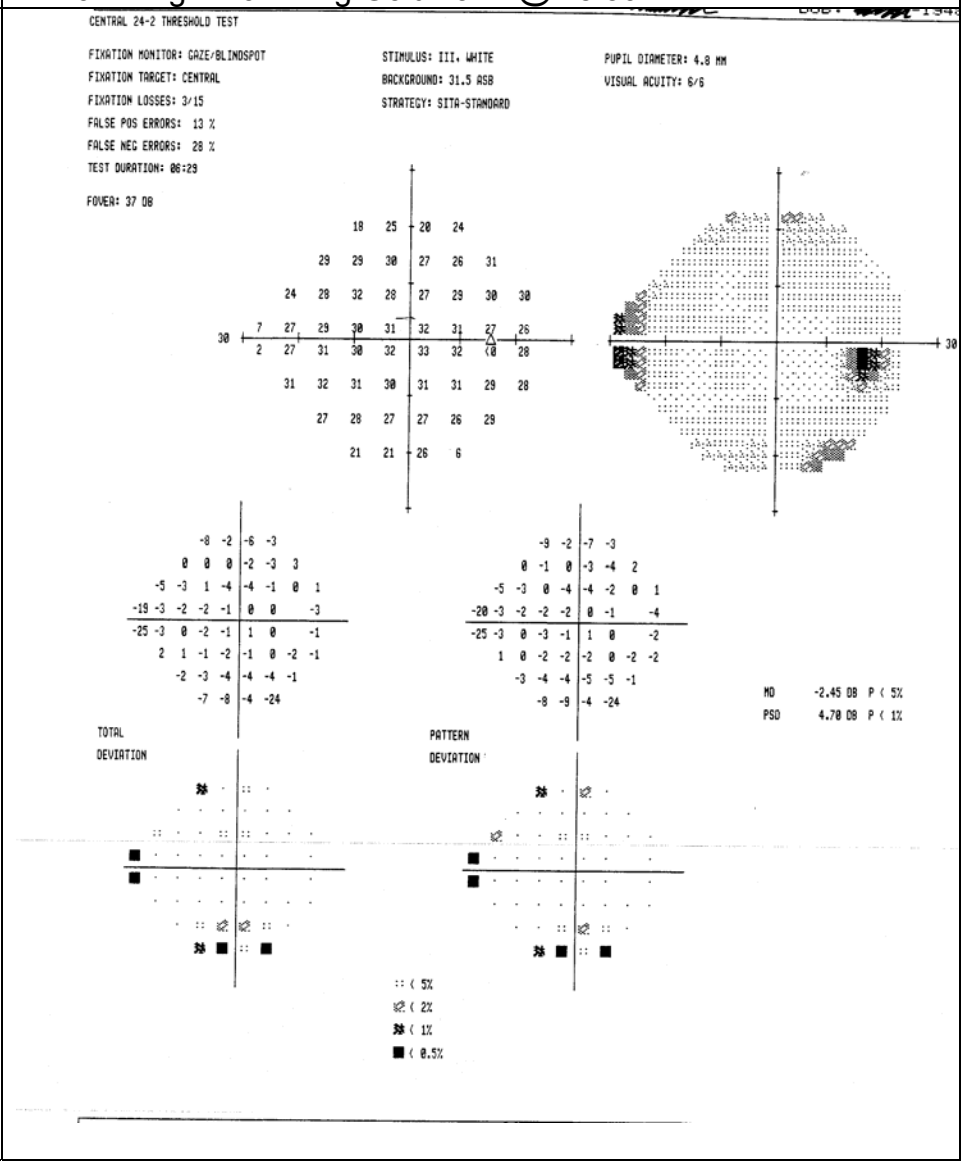
Px Details	Female, 65 years, Mixed Race Afro-Caribbean/White
Symptoms/History	None relevant
Refraction and VA	R: +1.25 L: +0.50/-0.25 VA 6/6 BE
IOPs	R: 17,16,15,16 L: 15, 18, 19,16 Pulsair @ 17:00
Fields	

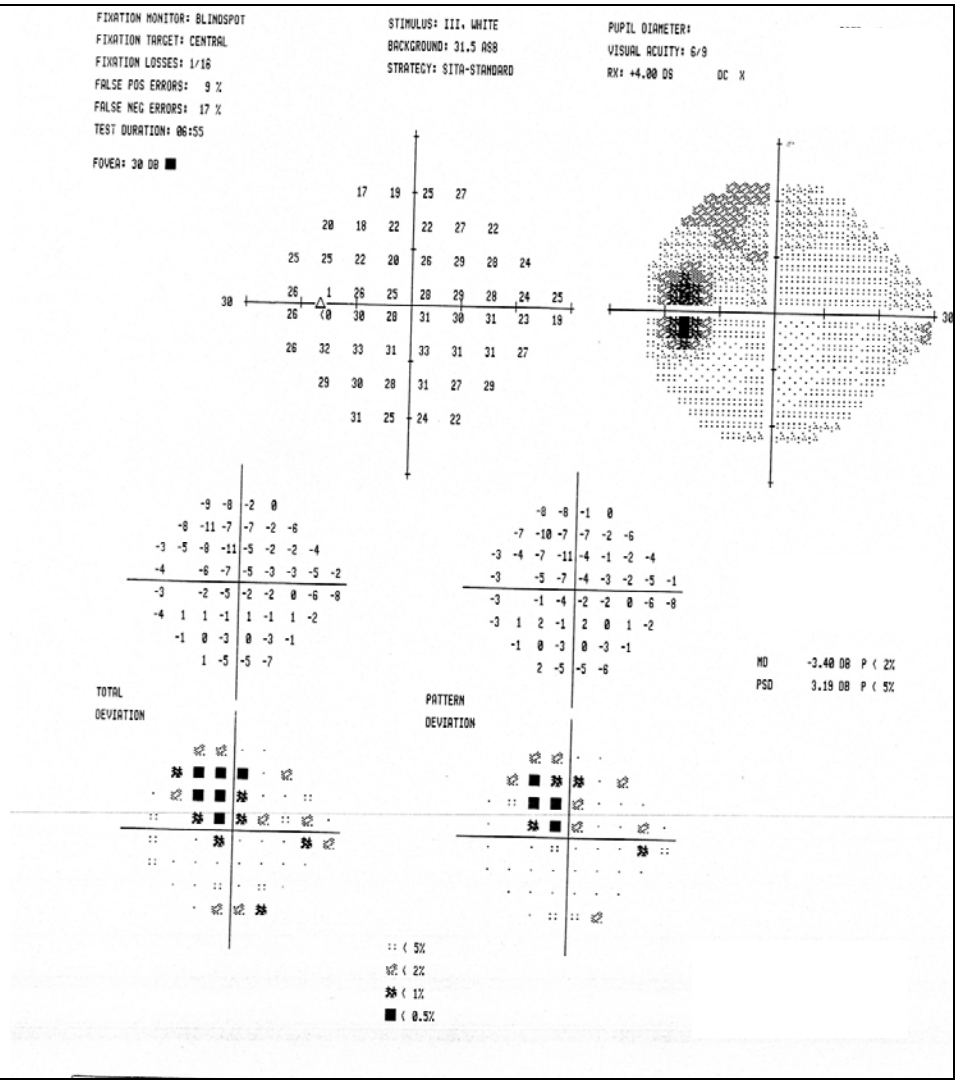
Fundus Photos	Right eye  Left Eye 

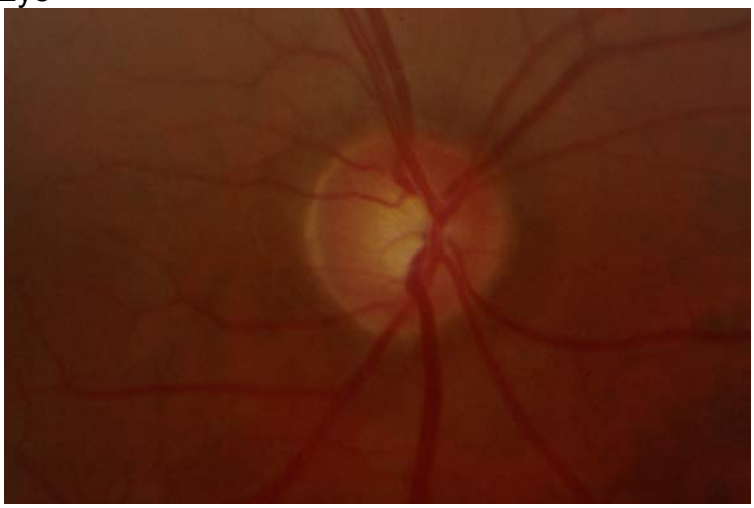
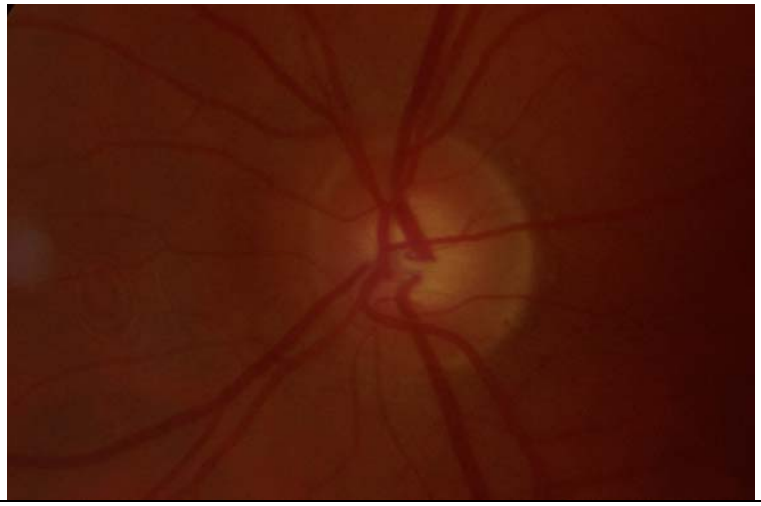
In your professional opinion, based on the information you have been given is this person likely to have Primary Open Angle Glaucoma?

1=Definitely Normal	2= Possibly Normal	3= Not sure Normal/Glaucoma	4=Possibly Glaucoma	5=Definitely Glaucoma
☐	☐	☐	☐	☐

Scenario 2

Px Details	Female, 49 years Japanese
Symptoms/History	History of LASIK 4 years ago
Refraction and VA	R: +0.25/-0.50x35 L: - 1.50DS VA 6/6/ BE
IOPs	R: 20mmHg L:20mmHg Goldmann @ 15:30
Fields	

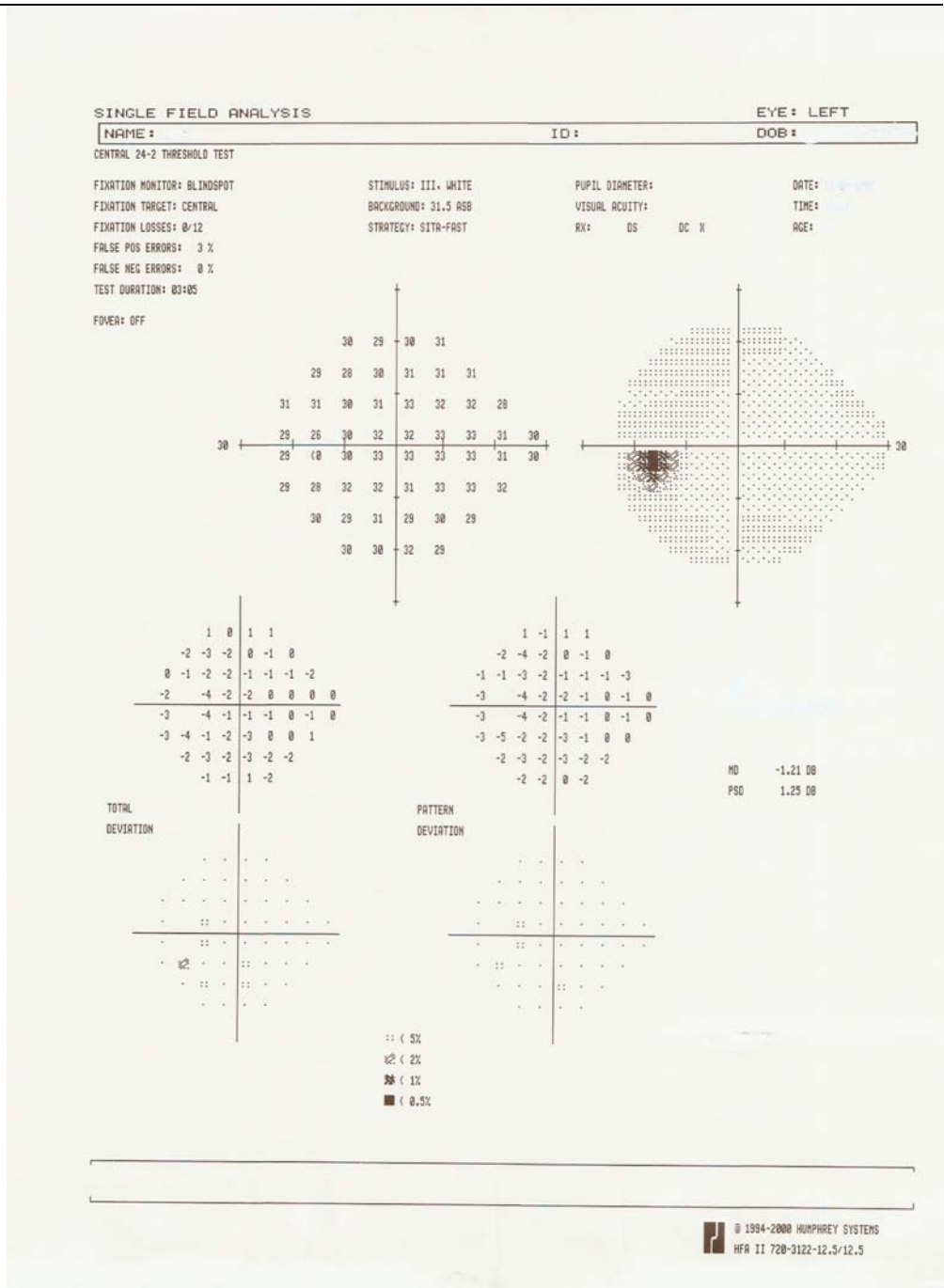

FIXATION MONITOR: BLINDSPOT
FIXATION TARGET: CENTRAL
FIXATION LOSSES: 1/16
FALSE POS ERRORS: 9 %
FALSE NEG ERRORS: 17 %
TEST DURATION: 06:55
FOVEA: 30 DB
STIMULUS: III, WHITE
BACKGROUND: 31.5 ASB
STRATEGY: SITA-STANDARD
PUPIL DIAMETER:
VISUAL ACUITY: 6/9
RX: +4.00 DS DC X
TOTAL DEVIATION
PATTERN DEVIATION
MD -3.40 DB P (2%
PSD 3.19 DB P (5%
:: (5%
:: (2%
:: (1%
■ (0.5%

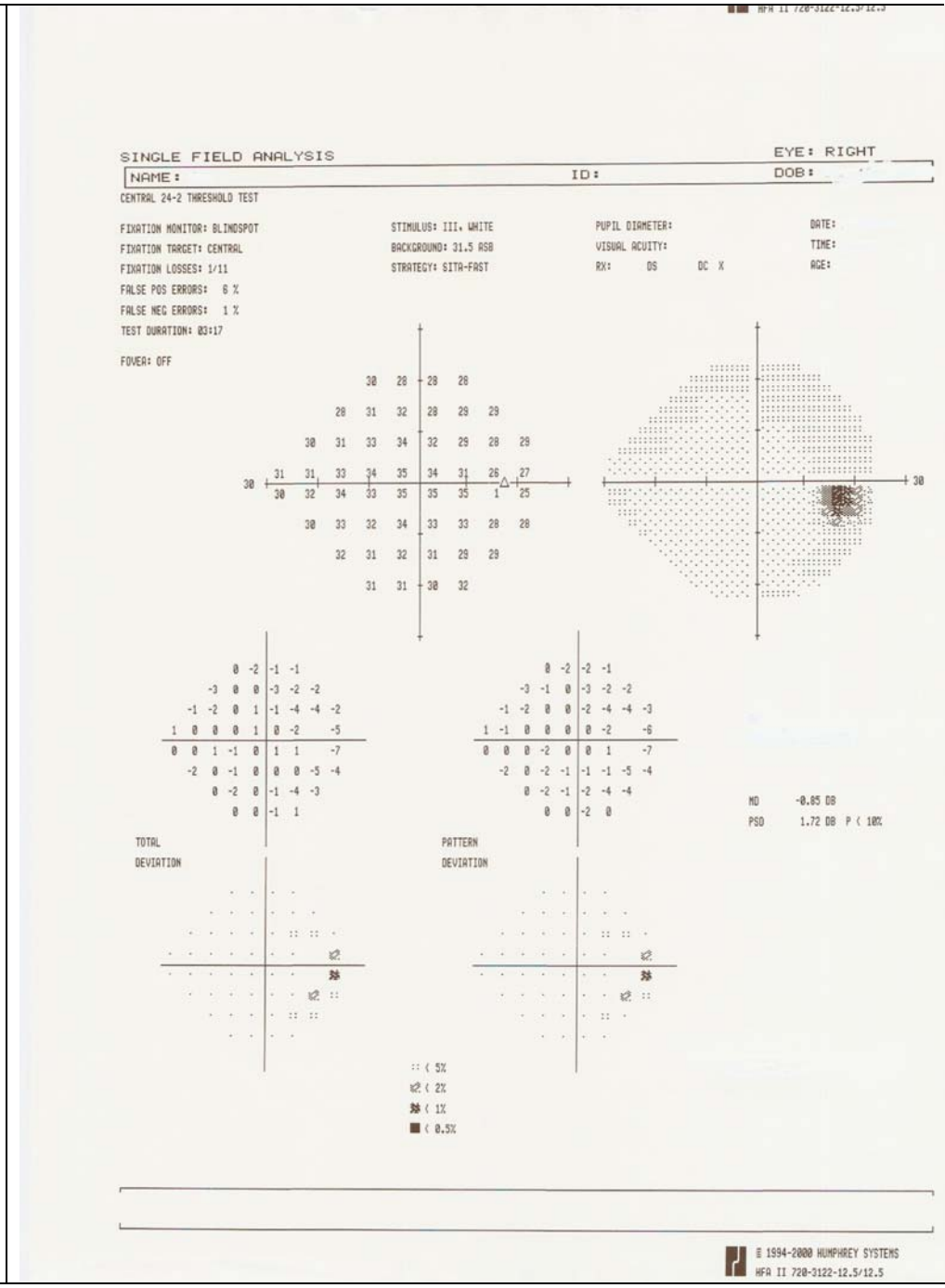
Fundus Photos	Right Eye  Left Eye 

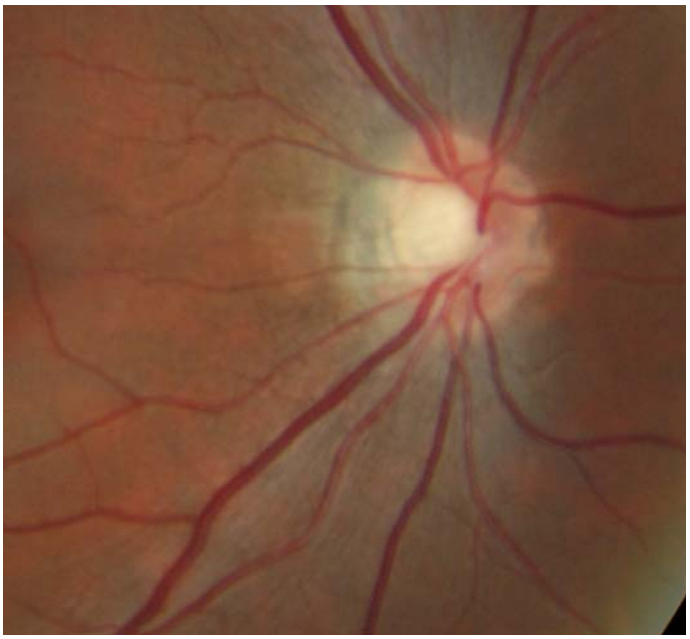
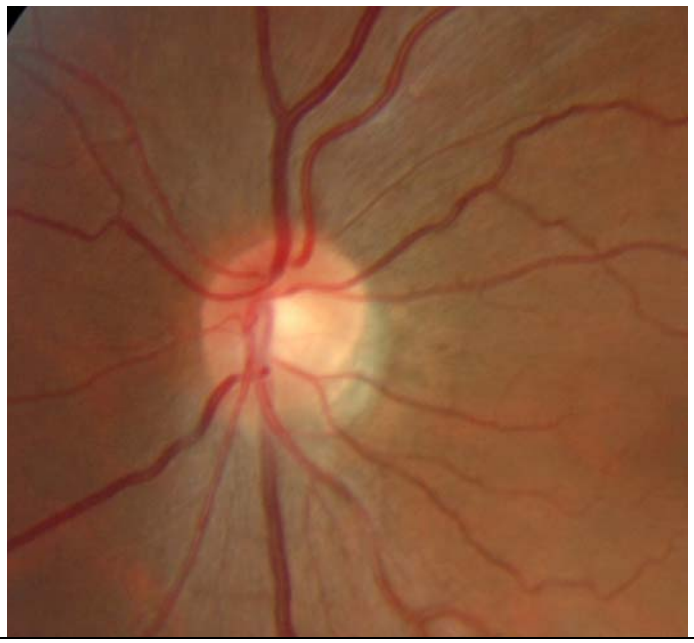
In your professional opinion does this patient need to be referred for investigation for POAG?

1=Definitely No Referral	2= Possibly No Referral	3= Not sure	4=Possibly Referral	5=Definitely Refer
☐	☐	☐	☐	☐

Scenario 3

Px Details	Px aged 55, Caucasian, Female
Symptoms/History	FH of POAG
Refraction and VA	R: -4.00/-1.00x180 L: -3.00/-2.50x 180 VA 6/5 BE
IOPs	R 21 L 20
Fields	

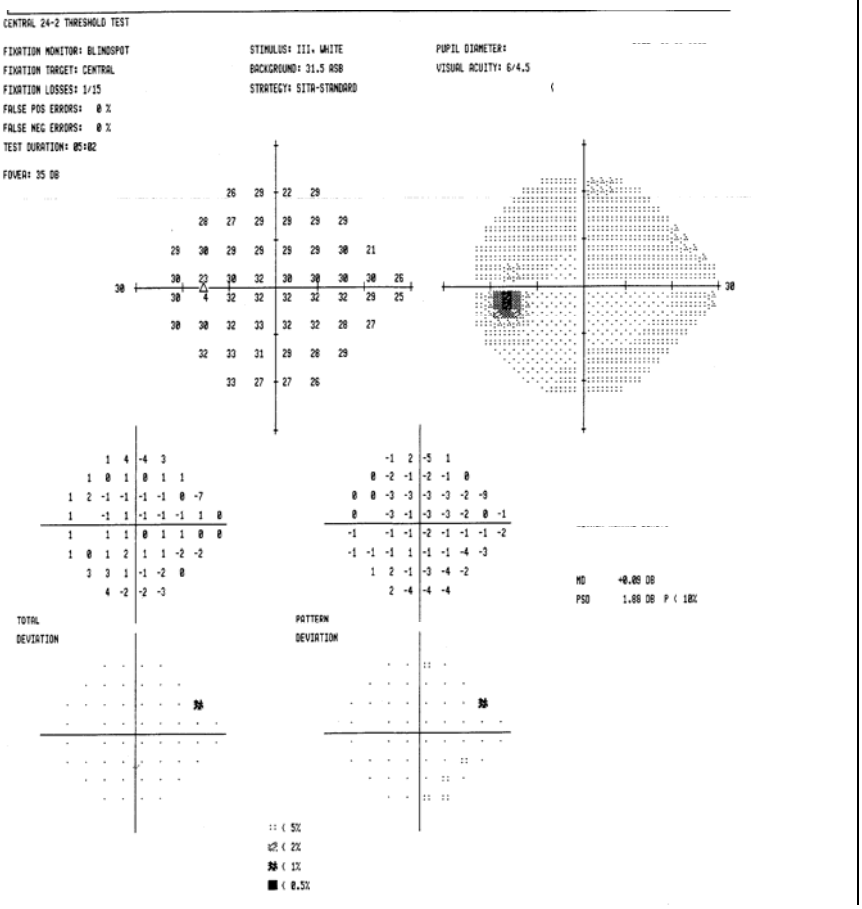

SINGLE FIELD ANALYSIS
EYE: RIGHT
NAME:
ID:
DOB:
CENTRAL 24-2 THRESHOLD TEST
FIXATION MONITOR: BLINDSPOT
FIXATION TARGET: CENTRAL
FIXATION LOSSES: 1/11
FALSE POS ERRORS: 6 %
FALSE NEG ERRORS: 1 %
TEST DURATION: 03:17
FOVEA: OFF
STIMULUS: III, WHITE
BACKGROUND: 31.5 ASB
STRATEGY: SITA-FAST
PUPIL DIAMETER:
VISUAL ACUITY:
RX: OS OC X
DATE:
TIME:
AGE:
MD -0.85 DB
PSD 1.72 DB P < 10%
TOTAL DEVIATION
PATTERN DEVIATION
:: < 5%
< 2%
< 1%
< 0.5%
© 1994-2000 HUMPHREY SYSTEMS
HFA II 720-3122-12.5/12.5

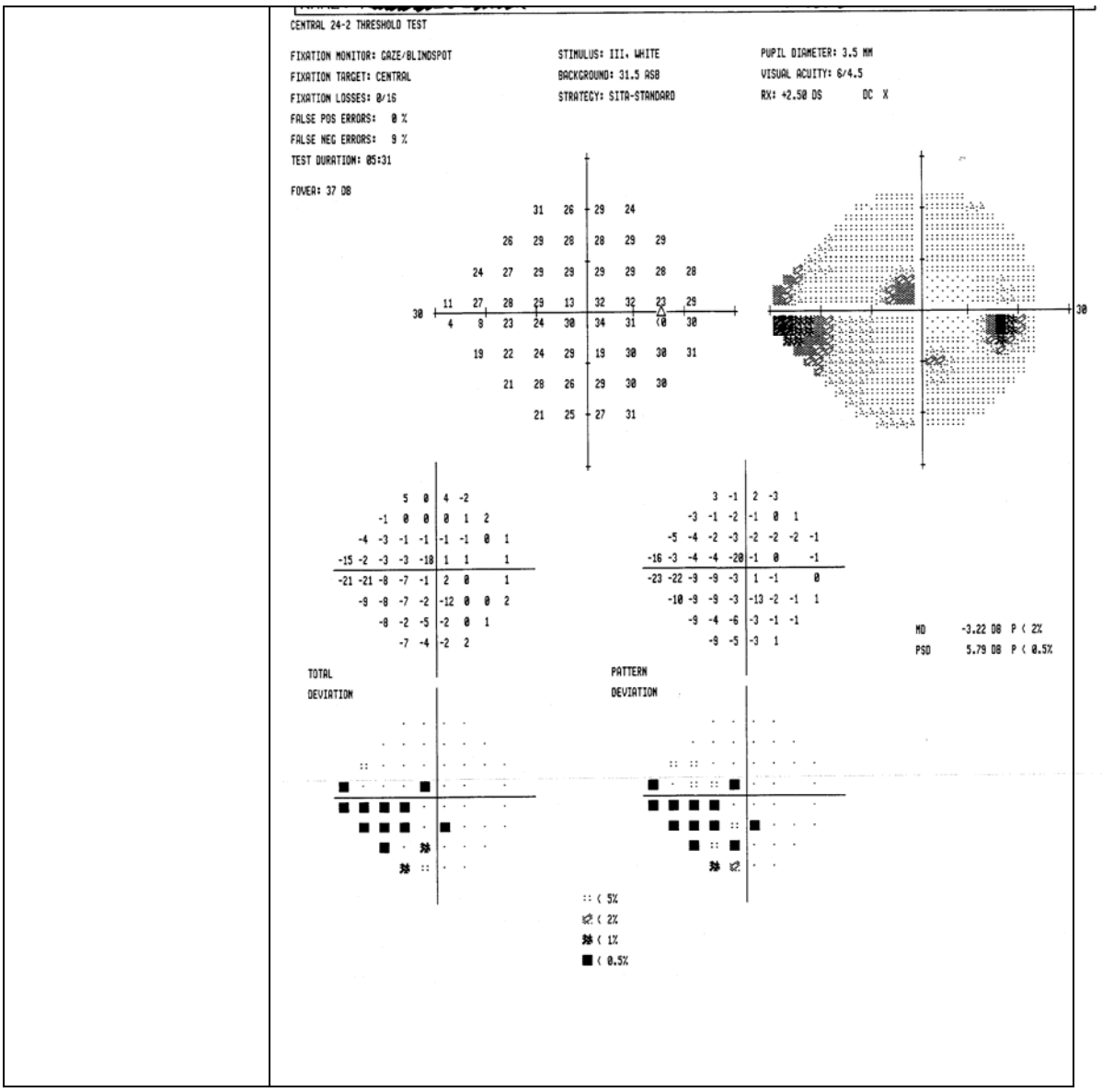
Fundus Photos	Right Eye  Left eye 

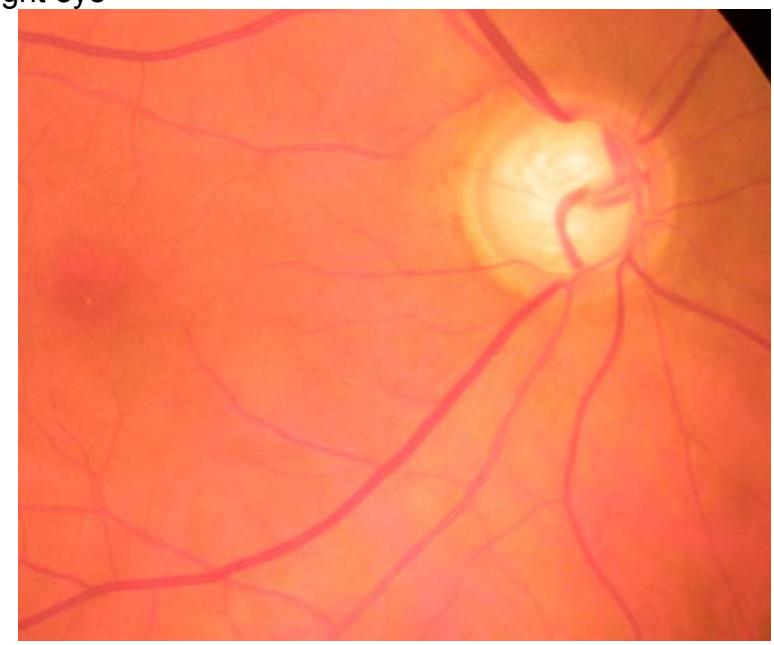
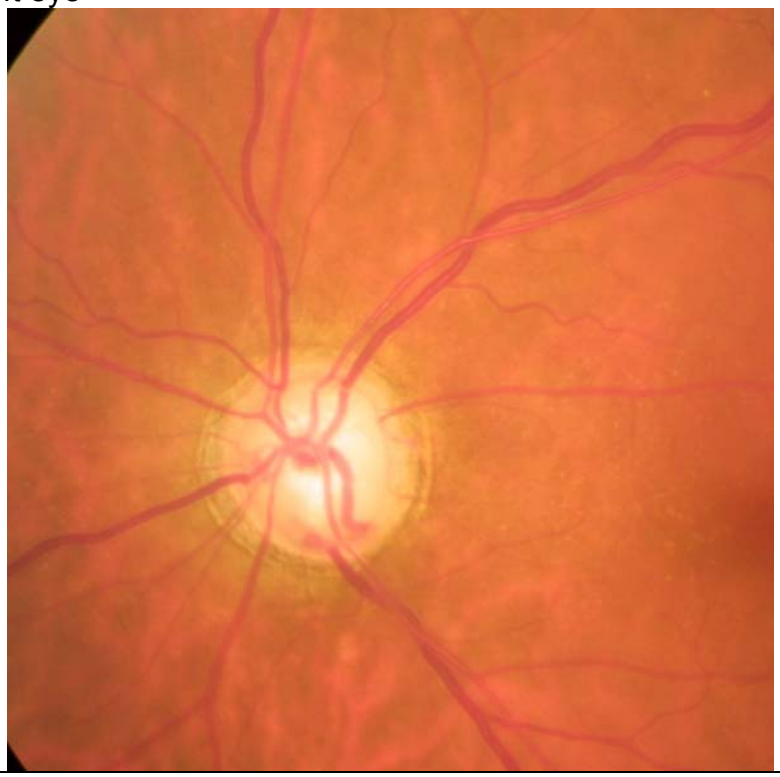
In your professional opinion is this person likely to have Primary Open Angle Glaucoma?

1=Definitely Normal	2= Possibly Normal	3= Not sure Normal/Glaucoma	4=Possibly Glaucoma	5=Definitely Glaucoma
☐	☐	☐	☐	☐

Scenario 4

Px Details	Male age 78 years, Caucasian
Symptoms/History	Mother Glaucoma
Refraction and VA	R: -0.25 DS L +0.25 DS 6/5 BE
IOPs	R: 14 mmHg L: 16 mmHg Applanation @ 2pm
Fields	


CENTRAL 24-2 THRESHOLD TEST
FIXATION MONITOR: GAZE/BLINDSPOT
FIXATION TARGET: CENTRAL
FIXATION LOSSES: 0/16
FALSE POS ERRORS: 0 %
FALSE NEG ERRORS: 9 %
TEST DURATION: 05:31
FOVEA: 37 DB
STIMULUS: III, WHITE
BACKGROUND: 31.5 ASB
STRATEGY: SITA-STANDARD
PUPIL DIAMETER: 3.5 MM
VISUAL ACUITY: 6/4.5
RX: +2.50 DS DC X
MD -3.22 DB P < 2%
PSD 5.79 DB P < 0.5%
TOTAL DEVIATION
PATTERN DEVIATION
: < 5%
: < 2%
: < 1%
■ < 0.5%

Fundus Photos	Right eye  Left eye 

In your professional opinion what is your management of this patient?

1=Recall 2 years	2= Recall 1 year	3= Recall 6 months	4=Routine Referral	5=Urgent Referral
☐	☐	☐	☐	☐

Appendix 6

A competency framework for optometrists with a specialist interest in glaucoma

CITY UNIVERSITY LONDON

Contents

1. Introduction

Glaucoma affects approximately 2% of the population over 40, rising to almost 10% in persons over 75. Once diagnosed, affected individuals require life-long follow up to optimise therapy and reduce the possibility of disease progression.

In the UK, the vast majority of glaucoma cases are detected by community optometrists as a result of a routine eye examination. Individuals detected in this way are usually referred into the hospital eye service (HES) for formal diagnosis and on-going management. Over the past decade, increasing demand for the care of patients with diagnosed glaucoma and the need to monitor an increasing number of glaucoma suspects has lead to the involvement of non-medical healthcare professionals in hospital-based glaucoma services and in some cases in community-based settings[1]. The baseline competencies of optometrists, and their existing role in glaucoma case finding, makes them suitable healthcare professionals to undertake extended roles in the diagnosis and management of the disease.

The recently published NICE guideline[2] on the diagnosis and management of chronic open angle glaucoma (COAG) and ocular hypertension (OHT) made a series of recommendations regarding the involvement of non-medical healthcare professionals in diagnosis, monitoring and treatment. Although NICE recommended that all patients with suspected glaucomatous damage should be referred to a consultant ophthalmologist for consideration of a definitive diagnosis and formulation of a management plan, there was recognition that appropriately trained non-medical healthcare professionals could diagnose OHT, suspect glaucoma and make a preliminary identification of cases of COAG. Furthermore, persons with a diagnosis of OHT, suspect COAG or COAG could also be monitored and treated by trained non-medical healthcare professionals.

The NICE guideline stipulated that healthcare professionals involved in the diagnosis and management of glaucoma should have relevant experience and a specialist qualification, when not working under the supervision of a consultant ophthalmologist. The purpose of this document is to define a competency framework for optometrists with a specialist interest in glaucoma. Competencies build on those required for registration as an optometrist [3]. The production of the *Competency Framework for Optometrists with a Specialist Interest*

in Glaucoma was co-ordinated by the Glaucoma Special Interest Group at City University London. The development of the framework involved a multidisciplinary stakeholder panel to determine those competencies required for the diagnosis of glaucoma and the additional competencies required for monitoring and treatment of the disease. It is envisaged that the framework will be used in the production of curricula for specialist training, the development of accreditation criteria and to guide continuing professional development. It is also hoped that the framework could be adapted by other healthcare professionals involved in glaucoma diagnosis and management.

2. What is a competency framework?

Competencies are a combination of knowledge, skills, motives and personal characteristics that are required to carry out a particular role. A competency framework is a collection of these competencies that are thought to be central to effective performance.
Competency frameworks can be used to:

- Inform the development of curricula for specialist training
- Allow educational providers to identify learning outcomes
- Provide a framework for assessment of skills and knowledge
- Support continuing professional development (CPD) and personal reflection on practice

Competency frameworks have been used extensively in optometry for both pre-registration[3] and specialist post-registration education and training[4].

3. Developing the framework

The methodology for the development of the competency framework consisted of a 6-stage process as shown in the scheme below:

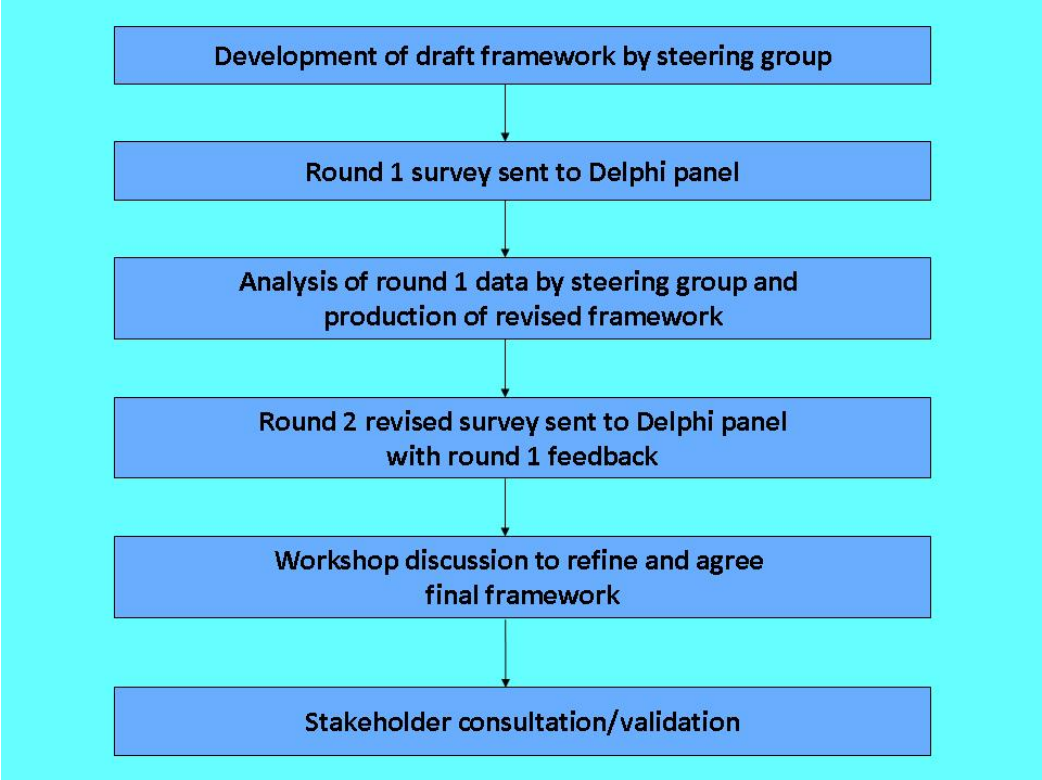


Figure 1. Scheme showing the development process for the competency framework

A modified Delphi approach was used to seek views on the broad content of the framework, followed by a workshop discussion to agree the final framework. The Delphi technique is a well-established method that gathers a consensus of 'expert' opinion[5, 6]. It involves asking a panel of experts their views anonymously, interspersed by controlled feedback. A multi-disciplinary panel, consisting almost exclusively of sub-specialist ophthalmologists and optometrists, was chosen using a convenience sampling technique (see Acknowledgments) and asked to take part in a two round Delphi process. In round 1, the panel members were invited to anonymously comment on, and score a series of competency statements prepared by the project steering group. Panel members scored each statement on a 9-point Likert scale, ranging from 0= 'not essential' to 9= 'essential' for each specialist role (diagnosis and management). Respondents were given an opportunity to suggest modifications to the wording of each statement or to suggest additional competencies. A revised framework incorporating the

suggestions from round 1 was presented to the group for rescoring and comment in a second round. For each statement, the mean rating was calculated, together with the mean percentage of respondents scoring the competency above 5 (the neutral point). Competencies with a mean score greater than 5 with more than a 2/3 majority (66.6%) scoring the statement over 5 were included in the framework without further discussion at the workshop. Competencies with a mean score of <5 with fewer than 66.7% of respondents scoring the competency over 5 were not included in the framework. All borderline competencies were considered in the workshop discussion and a consensus reached on the day regarding their inclusion in the framework. The resulting framework was circulated to relevant stakeholders for a 4-month consultation period, following which minor changes were made to the wording of a few competencies. This report presents the final competency framework.

4. Competency framework for optometrists with a specialist interest in glaucoma

Competencies required for optometrists involved in the diagnosis of glaucoma

1. The ability to take a comprehensive ophthalmic history in a patient with diagnosed or suspected glaucoma, including the identification of ocular and systemic risk factors for glaucoma.

2. The ability to maintain clear, accurate and contemporaneous clinical records of ophthalmic history, examination and results of clinical investigations in patients at risk of or with suspected glaucoma.

3. The ability to carry out an appropriate examination of the anterior segment of the eye in a patient at risk of, or with suspected glaucoma and to interpret relevant clinical signs.

4. The ability to perform the van Herick technique for the assessment of peripheral anterior chamber depth and to interpret the significance of the results.

5. The ability to perform a gonioscopic examination of the anterior chamber angle and to identify anatomical structures, accurately grade the angle width and interpret the significance of clinical findings.

6. The ability to perform an assessment of central corneal thickness using appropriate instrumentation and to interpret the significance of the results.

7. The ability to recognise the signs and symptoms of a patient suffering from angle-closure (or at risk of angle closure) and to refer the patient accordingly (including the instigation of emergency treatment if necessary).

8. The ability to accurately measure intraocular pressure using a slit-lamp mounted Goldmann applanation tonometer and the ability to analyse and interpret the results.

9. The ability to assess the optic nerve head by binocular indirect ophthalmoscopy and to detect the characteristic features of glaucomatous optic neuropathy.

10. An understanding of the use of perimetric techniques for the assessment of a patient with suspected glaucoma, including test strategies used, limitations, sources of error, interpretation of results and the recognition of glaucomatous field loss.

11. An understanding of the imaging techniques used to assess the optic nerve head and retinal nerve fibre layer and the ability to interpret the results of such investigations.

12. The ability to differentially diagnose glaucoma from other ocular and central visual pathway anomalies through an interpretation and integration of the results of clinical examination and the results of any further investigative techniques.

13. The ability to understand treatment options and when they may be appropriate.

14. An understanding of the risk factors for conversion to glaucoma and the ability to detect change in optic nerve parameters.

15. The ability to make clinical decisions based on the needs of the patient.

16. Awareness of one’s own limitations and the ability to consult a more experienced colleague if necessary.

17. The ability to operate within local protocols for the detection and/or management of glaucoma.

18. The ability to help patients make informed choices within the limits of the patient’s and practitioner’s understanding following their diagnosis.

19. The ability to counsel patients regarding risks of blindness associated with glaucoma, risk to family members, and potential

impact of the disease on lifestyle (including driving) and the ability to provide information on available sources of help, counselling and support.

Additional competencies required for optometrists involved in the monitoring and treatment of glaucoma

1. The ability to monitor the response to treatment and modify the management plan if necessary.

2. An understanding of the use of perimetric tests for the assessment of a patient with manifest glaucoma, including test strategies used, limitations, sources of error, interpretation of results and the recognition of glaucomatous field loss.

3. The ability to detect a change in clinical status (e.g. visual field status, intra-ocular pressure, assessment of anterior or posterior segments).

4. Knowledge of the pharmacology, cautions, contraindications, interactions and side effects of anti-glaucoma medication.

5. Knowledge of the indications for, techniques, expected outcomes and complications of laser therapies and surgical interventions used in the management of glaucoma and its related conditions.

6. An understanding of time-frames for follow-up of patients taking into account local preferences, risk of progression, and patient related factors (age, concurrent disease etc).

7. The ability to help patients make informed choices about their management and to check their understanding of and commitment to their management and follow-up.

5. Acknowledgments

Steering Group Members

- David Crabb, Reader, City University London
- David Edgar, Professor of Clinical Optometry, City University London
- Aachal Kotecha, Senior Lecturer, City University London
- John Lawrenson, Professor of Clinical Visual Science, City University London
- Joy Myint, Research Optometrist, City University London

Delphi Panel Members

- David Crabb, Reader, City University London
- David Edgar, Professor, City University London
- Karen French, Optometrist Principal, Hitchingbrook Hospital, Huntington
- Gus Gazzard, Consultant Ophthalmologist, Moorfields Eye Hospital, London
- Robert Harper, Optometrist Consultant, Manchester Royal Eye Hospital
- Lewis Jacobs, Community Optometrist, Essex
- Anthony King, Consultant Ophthalmologist, Queens Medical Centre, Nottingham
- Aachal Kotecha, Senior Lecturer, City University London
- John Lawrenson, Professor, City University London
- Ian Murdoch, Consultant Ophthalmologist, Moorfields Eye Hospital, London
- Joy Myint, Research Optometrist, City University London
- Wendy Newsome, Senior Hospital Optometrist, Hitchingbrook Hospital, Huntington
- Winnie Nolan, Consultant Ophthalmologist, Birmingham and Midland Eye Centre
- Suzanna Ramirez-Florez, Consultant Ophthalmologist, Hitchingbrook Hospital, Huntingdon
- Paul Spry, Optometrist Consultant, Bristol Eye Hospital
- Sheila Urquhart, Community Optometrist, Huntingdon

6. References

1. Vernon, S.A., Adair, A. (2009) Shared care in glaucoma: a national study of secondary care lead schemes in England. Eye advance online publication 5 June 2009; doi:10.1038/eye.2009.118

2. Glaucoma: Diagnosis and management of chronic open angle glaucoma and ocular hypertension. National Collaborating Centre for Acute Care. April 2009.
http://guidance.nice.org.uk/CG85

3. The General Optical Council Stage 2 Core Competencies for Optometry. June 2005.
www.optical.org/goc/.../root/.../core_competencies/Optometrists.pdf

4. Competency framework for prescribing optometrists. National Prescribing Centre and General Optical Council. May 2004.
http://www.npc.co.uk/prescribers/competency_frameworks.htm

5. Stewart, J, O'Halloran, C, Harriagan, P, Spencer, JA, Barton, JR, Singleton, SJ (1999) Identifying appropriate tasks for the preregistration year: modified Delphi technique. BMJ 319: 224-29

6. Hay, E.M., Campbell, A, Linney, S, Wise, E. (2007) Development of a competency framework for general practitioners with a specialist interest in musculoskeletal/rheumatology practice. Rheumatology 46: 360-62

Publications and Conference Presentations

Conference Presentations: Published Abstracts

Myint J, Edgar DF, Kotecha, A, Murdoch IE & Lawrenson JG An evaluation of the impact of a post-registration educational course in glaucoma co-management on strategies for optometric clinical decision making. Presentations: European Academy Optometry and Optics 2010 Copenhagen

Myint J, Edgar DF, Kotecha, A, Crabb DP & Lawrenson JG. Development of a competency framework for optometrists with a specialist interest in glaucoma' (as co-author) Presentations: European Academy Optometry and Optics 2010 Copenhagen

Myint J, Edgar DF, Kotecha, A, Murdoch IE & Lawrenson JG. An evaluation of the impact of a post-registration educational course in glaucoma co-management on strategies for optometric clinical decision making Presentation: The College of Optometrists: 2010 Research Symposium: Optometry Tomorrow, York

Myint J, Edgar DF, Kotecha, A, Murdoch IE & Lawrenson JG A national survey of instrumentation used for COAG case-finding by community optometrists Presentation: The College of Optometrists: 2010 Research Symposium: Optometry Tomorrow, York

Myint J, Edgar DF, Kotecha, A, Murdoch IE & Lawrenson JG A national survey of instrumentation used for COAG case-finding by community optometrists Presentation: UK Vision Strategy Vision UK 2010 Conference, Birmingham

Myint J, Edgar DF, Kotecha, A, Murdoch IE & Lawrenson JG. Barriers to the detection of POAG by UK Optometrists. Invited presentation: Scottish Glaucoma Symposium, June 2009

Myint J, Edgar DF, Kotecha, A, Murdoch IE & Lawrenson JG A survey based investigation into potential barriers to the detection of POAG in UK community optometric practice' Presentation: The College of Optometrists: 2009 Research Symposium: Optometry Tomorrow, Brighton, March 2009

Myint J, Edgar DF, Kotecha, A, Murdoch IE & Lawrenson JG A survey based investigation into potential barriers to the detection of POAG in UK community optometric practice. Presentation: United Kingdom and Eire Glaucoma Society Annual Meeting December 2008

Myint J, Edgar DF, Kotecha, A, Murdoch IE & Lawrenson JG A survey of Primary Open Angle Glaucoma (POAG) case finding strategies used by community optometrists in the UK. Poster presented at the European Glaucoma Society 2008

Other Publications and Presentations

Edgar, D., Romanay, T., Lawrenson, J.G. and Myint, J. Increase in the number of referrals from optometrists in the immediate aftermath of the April 2009 NICE guidelines for the diagnosis and management of COAG and OHT in England and Wales, e-Letter *BJO*published 5th February 2010. http://bjo.bmj.com/content/93/4/492/reply#bjophthalmol_el_8603

Myint J, Edgar DF, Kotecha, A, Crabb DP, Murdoch IE & Lawrenson JG Postgraduate Education in Glaucoma. Invited presentation City University Research Seminar October 2010

Myint J, Edgar DF, Kotecha, A, Murdoch IE & Lawrenson JG An evaluation of the impact of a post-registration educational course in glaucoma co management on strategies for optometric clinical decision making. Presentation: Annual Research Seminar, City University, May 2010

Myint J, Edgar DF, Kotecha, A, Murdoch IE & Lawrenson JG An Evaluation of Case Finding Strategies for Primary Open Angle Glaucoma by Community Optometrists, Presentation Glaucoma Special Interest Group, London 2008

Published Papers

PAGE

OPO OPHTHALMIC & PHYSIOLOGICAL OPTICS
THE JOURNAL OF THE COLLEGE OF OPTOMETRISTS

Ophthalmic & Physiological Optics ISSN 0275-5408

Does optometrists' self-reported practice in glaucoma detection predict actual practice as determined by standardised patients?

Julia Theodossiades[1], Joy Myint[2], Ian E Murdoch[1], David F Edgar[2] and John G Lawrenson[2]

[1]Glaucoma Unit, Moorfields Eye Hospital, London UK, and [2]Henry Wellcome Laboratories for Vision Sciences, Division of Optometry, City University London, UK

Citation information: Theodossiades J, Myint J, Murdoch IE, Edgar DF & Lawrenson JG. Does optometrists' self-reported practice in glaucoma detection predict actual practice as determined by standardised patients? *Ophthalmic Physiol Opt* 2012, **32**, 234–241. doi: 10.1111/j.1475-1313.2012.00898.x

Keywords: case-finding, clinical practice questionnaires, diagnostic techniques, glaucoma

Correspondence: John G. Lawrenson
E-mail address:
j.g.lawrenson@city.ac.uk

Received: 25 October 2011; Accepted: 18 January 2012

Abstract

Purpose: Questionnaires are commonly used as a proxy measure of clinical practice; however their application in a variety of healthcare settings has found significant self-reporting bias. The aim of this study is to estimate the validity of self-reporting as a measure of optometrist case-finding practice for glaucoma and the appropriate referral of suspects.

Methods: Two complementary approaches were used: (1) a sample of optometrists (N = 34) on an ophthalmic list in West London were visited *incognito* by Standardised Patient (SP) volunteers aged over 54 who were trained to identify the components of a standard Sight Test. Optometrists from the same list were then invited to participate in a structured face-to-face interview regarding their case finding practice for glaucoma. The findings from the two sources were compared. (2) as part of a national glaucoma survey of optometrists, respondents (N = 1264) were asked in a free text question for the information that they would include in a referral letter for suspect glaucoma. The responses were compared to the content of a sample of glaucoma referral letters (N = 571) obtained from consultant ophthalmologists across the UK. In each case, the degree of correspondence ('match') between reported practice and actual practice was assessed by chi-square analysis.

Results: For the SP study there was incomplete correspondence between the questionnaire and SP reports in several areas e.g. questions relating to a complete history and symptoms, measurement of intra-ocular pressure and visual fields. Complete correspondence was found for questions asking about the routine assessment of ocular health and refraction. For the referral study, correspondence between survey findings and referral letters was obtained for IOP only. No correspondence was found for disc assessment, visual fields or family history of glaucoma.

Conclusions: The overall findings from both studies indicate that self-reported clinical practice questionnaires overestimate routine tests undertaken by optometrists in practice. Although there was a good correspondence for mandatory tests, correspondence was poor for discretionary tests. These findings should be borne in mind in all questionnaire studies that report current practice in glaucoma case-finding.

Introduction

A recent systematic review evaluating the cost-effectiveness of screening for chronic open angle glaucoma (COAG) concluded that there was insufficient evidence to recommend population screening.[1] Since formal screening programmes for COAG have not so far been adopted in any country, current detection strategies rely on opportunistic case-finding from a self-selected population. In the UK, community optometrists play the major role in the detection of COAG and account for the majority (90%) of referrals for suspect glaucoma.[2] In England, Wales and Northern Ireland, optometrists carry out state-funded (NHS) Sight Tests on particular at-risk groups (everyone over 60 years and those over 40 with a family history of glaucoma), whereas in Scotland 'free' eye examinations are available to all. There is no mandatory case-finding protocol for the detection of COAG, although guidance is provided by the College of Optometrists regarding the examination of those at risk of glaucoma. This guidance states that: 'It is for the practitioner to satisfy him/herself that procedures are included or excluded according to the patient's clinical need but in addition to the guideline on the eye examination, good practice for these patients should normally include:

1 Assessment of the optic nerve head;
2 Tonometry. Where pressures are high or borderline, arrangements should be made for the test to be repeated, noting the time of day of each test; the examination may also include:
3 Central visual field assessment using perimetry with threshold control. Where necessary, practitioners should consider repeating visual fields assessment to obtain a meaningful result.'[3] However, the choice of equipment and the actual tests performed are at the discretion of the individual optometrist, which could potentially lead to significant variability in the quality of screening.

Several studies have used questionnaires as a proxy measurement of glaucoma case-finding practice by community optometrists.[4–6] However, studies of clinical quality assessment and guideline adherence for other healthcare professions have shown that questionnaires can be subject to significant self-reporting bias.[7–9] The aim of this study was to assess the validity of questionnaires to determine optometrists' glaucoma case-finding practice and referral of suspect cases. Comparisons were made with a direct measure of performance using trained volunteers (standardised patients) and an audit of the content of optometrists' referral letters for suspect glaucoma.

Methods

Investigation of strategies for glaucoma case-finding

A structured questionnaire was designed to investigate the approach used by community optometrists for COAG case-finding. The questions were considered carefully so that all the important aspects of glaucoma case-finding were examined. Specific questions relating to the tests employed, and indications for using those tests were included. An optometrist researcher and a consultant glaucoma ophthalmologist drew up the questions. The questionnaire consisted of five domains of assessment: risk factors for glaucoma, refraction, intra-ocular pressure, visual fields and optic disc assessment. Optometric case-finding practice can vary between normals and suspects, with suspects generally undergoing more investigations. The questionnaire addressed case finding practice relating to normals. Open (unprompted) and closed (prompted) questions were used. A draft version of the questionnaire was piloted on a sample of eight optometrists who worked in community practice. Their opinions on the clarity and phrasing (absence of ambiguity and readability) of the questions and the content of the questionnaire were sought and modifications made.

For a questionnaire to be considered useful, it must be proven both reliable as well as valid. A reliable questionnaire produces consistent results on repeated trials. The test: retest reliability of the final version was assessed by administering the questionnaire to a further seven optometrists in community practice) on two occasions, separated by a time interval of 1–3 weeks. The agreement between the first and retested answers was assessed using the kappa statistic, which measures the degree of agreement, corrected for chance. In general, kappa scores >0.75 represent excellent agreement between tests, while values <0.40 indicate poor agreement. The reliability of statistical tests, including the kappa test, is reduced when sample sizes are small so these kappa values should be interpreted with caution.

The questionnaire was delivered via a face-to-face interview by the same researcher (JT) to all consenting optometrists on the Ealing, Hammersmith and Hounslow Ophthalmic List who practice more than 2 days per week.

Standardised Patients (SP) were used as the gold standard measure of clinical practice. Five Caucasian volunteers aged >54 years, who on the basis of a glaucoma specialist's examination showed no evidence of glaucoma, were recruited and underwent a period of training to recognise and report the tests performed at the sight test. These included: history and symptoms, assessment of distance and near vision, refraction, tonometry, ophthalmoscopy and visual field assessment. Following the training each SP was supplied with extensive written information and an *aide memoire*.

Each SP volunteer was asked to visit eight different optometrists out of the 62 on the Ophthalmic List for a routine sight test. Optometrists were unaware of the SP visits and the volunteer did not at any stage divulge the

true nature of their visit. Immediately following the sight test each SP completed a standard proforma recording the tests performed on them.

The SP visits were conducted prior to the commencement of the questionnaire interviews.

Investigation of strategies for referral

As part of a national survey to investigate the practice of UK community optometrists in the detection of COAG conducted between April and July 2008, a section was included on referral strategy; questions were asked on the total number of referrals made by the optometrist for suspect COAG, to whom referrals were made, and what information was included in the referral letter. The survey was delivered online to members of the Association of Optometrists (AOP) who received an email containing a hyperlink to the survey. The survey was anonymous and no incentives were offered to participate. Further details of the survey methodology have been published elsewhere.[10,11]

A national sample of referral letters for suspect glaucoma was obtained. All consultant ophthalmologists on the Royal College of Ophthalmologists membership database were contacted by post and asked to supply copies of the 10 most recent optometrist referral letters for suspect COAG. An instruction was given to remove patient details and the identity of the referring optometrist. Information reported in the referral letters was extracted by the same researcher (JM) and data were transferred to an Excel spreadsheet for descriptive analysis.

Data analysis

The degree of correspondence ('match') between the questionnaires and the volunteer experiences or information contained in the referral letters was assessed by chi-square analysis.

This research was approved by the City University London and Moorfields NHS Trust Research and Ethical committees.

Results

Case-finding practice

The agreement between the test-retest results was very good (Kappa's 0.7–1.0 for all questions).

Fifty seven (92%) of the 62 optometrists on the Ealing, Hammersmith and Hounslow Ophthalmic List agreed to be interviewed.

The SPs attended a total of 38 sight tests performed by 34 optometrists (including an approximately equal number of independent practitioners and those employed by multiple groups) on the Ealing, Hammersmith and Hounslow Ophthalmic List. There was a 76% (26 out of 34) concordance between the optometrists visited by the SPs and those who were interviewed. There were two reasons for the discrepancy; some of the optometrists visited did not meet the inclusion criteria for the interview (they were locum optometrists who only worked 1 day per week in the area), and others did not consent to be interviewed.

There was complete correspondence between the questionnaire and SP volunteer experiences for questions relating to the routine assessment of ocular health and refraction *(Table 1)*. There was also a good correspondence for questions relating to the choice of instruments for the assessment of ocular health and the measurement of IOP. No correspondence was seen for the questions relating to the routine assessment of a full history and symptoms, measurement of intra-ocular pressure or visual fields.

Referral practice

A total of 2044 optometrists entered the online glaucoma survey, which represented a response rate of 27.5% of those AOP members receiving the email. One thousand eight hundred and 75 of these (92%) were currently practicing as community optometrists and therefore eligible to enter the survey. The online format allowed respondents to exit the survey at any point and 611 of those starting the survey dropped out before completing the section on referral strategy. However, an analysis of the demographics of this group did not reveal any differences from the 1264 completing the questions relating to referral. Fifty seven percent of respondents were working in independent practices, 23% in multiples (familiar High Street chains) and the remainder were mainly locums. The demographics of the sample were similar to those of General Optical Council (GOC) registrants in the year 2007–08. The questions on referral included a question on the total number of referrals for suspect glaucoma that were made in the last working month. The majority of optometrists (65.8%) were making 1–3 glaucoma referrals per month.[†] A second question asked for information on the person to whom these referrals were made; 69% were referred for an ophthalmology opinion via the patient's general practitioner, 28% were directly referred to an ophthalmologist and 2% to a glaucoma specialist optometrist. A third question (free text) sought to determine the

[†]The survey was performed prior to the publication of the NICE Guidance on the Diagnosis and Management of Ocular Hypertension and COAG in April 2009.

Table 1. Criterion validity: correspondence between the questionnaire and volunteer experience (normals)

	Questionnaire (57 interviews)	Volunteer reports (34 optometrists visited)	χ^2	Correspondence
What history and symptoms do you usually ask? (for answer 'yes' optometrists asked all five possible questions)[a]	44/57	14/34	$p < 0.001$	No
Do you carry out refraction on all patients attending for a sight test? (for answer yes)	*57/57*	*34/34*	*p = 1.0*	*Yes*
What is your first choice instrument to check ocular health? (for answer direct ophthalmoscope)	57/57	34/34	$p = 1.0$	Yes
Do you routinely check ocular health? (for answer yes)	*56/57*	*34/34*	*p = 0.44*	*Yes*
Are there any groups of patients for whom you routinely check IOPs? (for answer age criterion over 39 years)	52/57	25/34	$p = 0.02$	no
What instrument do you use to measure IOPs? (For answer non-contact tonometry)[b]	47/57	19/25	$p = 0.50$	Yes
How many readings per individual do you take? [for answer three readings or more for non-contact tonometry (NCT)]	36/47	3/19	$p < 0.001$	No
Do you routinely check visual fields in any particular patient groups? (for answer age criterion over 39 years)	11/57	1/34	$p = 0.03$	No

[a]History and symptoms questions included: (1) deterioration/changes to vision, (2) Discomfort in or around the eyes, (3) Headaches, (4) Family history of glaucoma, (5) Current/past general health.
[b]25 out of 34 optometrists performed tonometry on the SPs. 19 out of 25 performed NCT, the remainder performed Goldmann or Perkins applanation tonometry.
The highlighted rows (Italics) indicate mandatory tests.

Table 2. Criterion validity: correspondence between the survey responses and referral letters (suspects)

When referring a patient for suspect primary open angle glaucoma, what information do you include in your referral letter? (free text)	Survey response *N* (% yes) (total = 1245)	Included in referral letters *N* (% yes) (total = 571)	χ^2	Correspondence
IOP	1196 (96)	549 (96)	$p = 0.93$	Yes
Disc	1190 (96)	527 (92)	$p = 0.004$	No
Fields	1192 (96)	406 (71)	$p < 0.0001$	No
All three tests (IOP, disc, fields)	1088 (87)	356 (62)	$p < 0.0001$	No
Family history of glaucoma	658 (53)	165 (29)	$p < 0.0001$	No
Visual acuity	444 (36)	545 (94)	$p < 0.0001$	No
Refraction	402 (32)	536 (94)	$p < 0.0001$	No
Anterior chamber depth	89 (7)	1 (0.2)	$p < 0.0001$	No

information that was included in the referral letter. The results of this analysis are shown in *Table 2*.

In the survey, 87% of respondents reported that they would include the results of all three screening tests in their referral letters: IOP, discs and fields.

A total of 571 referral letters for suspect glaucoma were received from 59 consultant ophthalmologists. 60% of these were written on a standard General Ophthalmic Services (GOS18) referral form, 16% used a local proforma and the remainder were handwritten (14%) or used a bespoke template specific to the practice (6%). A small proportion of referral letters were received from GP's (4%) who included information on the optometrist's findings. Analysis of information extracted from the referral letters allowed for correspondence between survey responses and referral letters to be assessed *(Table 2)*.

62% of letters made reference to all three pieces of information (IOP, discs and fields) with the remainder referring to combinations of two out of three of these. There was correspondence between the survey responses and referral letters for IOP only.

Discussion

Accurate measurement of the clinical practice of healthcare professionals is increasingly being used to highlight variability in performance, identify gaps in the quality of healthcare provision and to guide health policy. Although a variety of direct and indirect assessments of the quality of practice have been used, clinician self-reporting methods, including surveys and face-to-face interviews, have gained popularity since they are easy to administer and are able to gather data from a large number of participants. However, concern has been expressed that clinicians' self-reports may overestimate performance of some clinical actions and underestimate others.[9] Significantly, substantial overestimation has been observed when investigating adherence to best practice guidelines.[7,8]

Several studies have used questionnaires to gain insights into case-finding strategies used by community optometrists.[4–6] However, the validity of this proxy measurement of performance in optometry has not been previously investigated. The present study used the reported experiences of standardised normal volunteers to measure the criterion validity of a questionnaire to investigate routine glaucoma case finding practice. SPs are widely accepted as the gold standard for assessing clinical practice.[12,13] A comparison between questionnaire responses and volunteer reports highlighted important differences between reported practices and actual practices. Although there was a high degree of criterion validity for questions relating to tests that are mandatory under the optometrist's terms of service with the NHS e.g. refraction and ophthalmoscopy,[14] there was poor correspondence for questions concerning discretionary tests. The College of Optometrists have produced detailed guidance on 'Examining the Patient at risk of Primary Open Angle Glaucoma'. The Guidance, which encompasses both statutory requirements imposed by the Opticians Act and contractual duties required by NHS regulations, states that when performing an eye examination on a patient at risk of glaucoma (including those aged 40 and over) good practice should normally include '… (1) assessment of the optic nerve head; (2) tonometry …and that the examination may also include (3) central visual field assessment using perimetry with threshold control.'[3] When questioned, 91% of respondents stated that they would routinely check IOP's in a patient over 39 years, however the SPs reported that tonometry was performed in only 74% of sight tests. Optometrists showed a preference for non-contact methods for the determination of IOP (83% of those interviewed). At the time this study was conducted, the recommendation for those using a non-contact tonometer (NCT) was that an average of three or more readings should be taken to improve measurement accuracy. Although 77% of those using a NCT stated at interview that they would take the recommended three readings[‡], volunteer reports found that three or more readings were taken by only 16% of optometrists visited. With respect to central visual field assessment, 19% of optometrists said that they would perform the test on a patient over 39 years. Only one SP eye examination (3%) included a field test. The low proportion of optometrists performing visual fields routinely in our sample of patients, all of whom were aged >54 years is perhaps surprising. However, all the standardised patients were at low risk of developing glaucoma and there is evidence that optometrists are more likely to perform discretionary tests in patients at higher risk of developing glaucoma (in accordance with College of Optometrists guidance). A recent study using a similar unannounced standardised patient methodology found that 35% of optometrists carried out the recommended triad of tests on a 44-year old patient of African racial descent complaining of near vision difficulties.[15] With respect to visual fields, over 95% of optometrists are equipped with modern automated perimeters that are suitable for glaucoma detection[11]; although there are perceived barriers to the universal adoption of this test including: time and financial pressures and patients failing to return for follow up appointments.[10] There is evidence that these barriers can be overcome; in 2006, Scotland introduced a new GOS contract for community optometrists, which aimed to reduce inappropriate referrals to the HES. The new contract introduced additional remuneration for 'supplementary' examinations, which allowed for repetition of some or all of the triad of tests for glaucoma case finding. Following the introduction of the revised contract, an improvement in the quality of glaucoma referrals from optometrists in Scotland was reported,[16] notably an increase in the percentage of true positive referrals from 18% to 31.7% (defined as definite glaucomatous damage) and a reduction in false positives from 36.6% to 31.7%.

The second part of the study specifically addressed the optometrist's referral practice in relation to glaucoma suspects. A large sample of community optometrists completed an online survey with questions on volume of suspect glaucoma referrals, destination of referred patients

[‡]The recommended number of readings varies with the type of NCT e.g. a minimum of three readings were recommended for the American Optical NCT and 4 for the Keeler Pulsair.

and the information content of referral letters. A sample of referral letters for suspect glaucoma obtained from consultant ophthalmologists throughout the UK was used to measure the criterion validity of the free text survey question relating to information that would be included in a referral letter. Most respondents (66%) reported that they were referring 1–3 glaucoma suspects per month for an ophthalmology opinion. Whilst a large percentage of letters contained information on discs (92%), there was correspondence between the survey findings and referral letters for IOP only. Although 96% of survey respondents reported that they would include visual field results, these were reported in 71% of referral letters. Similarly, 53% completing the survey stated that they would include information on family history of glaucoma, but this was only included in 29% of referral letters. However, it is possible that optometrists may be choosing not to include information in referral letters on negative findings.

Notably, only a small proportion (7%) of survey respondents stated that they would include information on anterior chamber depth and <0.5% of referral letters included this information.

The information content of this national sample of referral letters agreed closely with that reported in local audits; for example, 62% of the current sample of referrals included information on the triad of discs, fields and IOP, which is similar to the 66% found in a recent audit of optometrists' referrals for suspect glaucoma in the Portsmouth area.[17]

The lack of correspondence relating to visual acuity (VA) and refraction may be a function of the design of the generic GOS18 referral form and related templates. These standard referral proformas include sections that require input of VA and refraction. Although this information is potentially useful to an ophthalmologist in the context of a referral for suspect glaucoma, the lack of correspondence may have arisen since the free text question in the survey asked for information specific to a glaucoma referral.

The study of referral practice was conducted immediately prior to the introduction of the NICE guideline on the diagnosis and management of COAG and ocular hypertension.[18] Although the guideline did not specifically address case-finding, it significantly impacted on referral practice due to the recommendation that all patients with repeatable IOP's over 21 mmHg should be assessed by 'a suitably trained healthcare professional with a specialist qualification and relevant experience' in glaucoma. This led to a substantial increase in referral volume together with a reduction in diagnostic accuracy.[19,20] Whilst the publication of the NICE guideline is unlikely to alter the conclusions of this study in relation to the reliability of a questionnaire to predict clinical practice in glaucoma detection, it is likely that current referral practice may differ from that reported here.

Studies of other healthcare professionals have reached similar conclusions regarding self-reporting bias when comparing proxy measures with direct measurements of clinical practice.[7–9] The magnitude of reporter bias is especially pronounced when evaluating adherence to recommendations in clinical practice guidelines. One common cause of bias occurs when an individual does not adhere to a particular recommendation but reports the desired behaviour when questioned. Furthermore, questionnaires often use itemised checklists, which could act as prompts as to what the appropriate action or behaviour should be. The present study attempted to mitigate this bias by the use of free text questions in the online survey and predominantly open-ended questions in the interviewer delivered questionnaire. Shah *et al.*[21] observed that questionnaires in optometry sent to the majority of the profession are subject to sampling bias resulting from the tendency for conscientious practitioners being most likely to become respondents. They also note that human nature plays a role and may result in respondents choosing answers that indicate higher standards of clinical practice than is their norm. Both these factors could have played a part in the current study.

Limitations of this study

It is important to acknowledge the limitations of the current study. In both experimental approaches there is a likely selection bias. In the SP study, the optometrists visited by the volunteers included those interviewed and those not interviewed. This discrepancy arose since SP visits were made *incognito* to community practices prior to conducting the interviews and therefore sight tests were carried out by those who did not subsequently consent to be interviewed and a small number of locum optometrists who were not on the Ealing, Hammersmith and Hounslow Ophthalmic List. It is possible that optometrists who did not consent to be interviewed were less confident about their skills or, of course, they may simply have found it impossible to spare the time for a face-to-face questionnaire session. It is also possible that locum optometrists may have a different mode of practice to those in more full-time positions, though there is no published evidence that we are aware of on this topic.

Only 27.5% of the national sample of AOP optometrists responded to the online survey. It could be reasonably argued that these might represent a sub-population who would be more likely to undertake investigations. Thus the finding could in part be explained by selection bias. The lack of correspondence is, however, still valid

since any questionnaire is very likely to be subject to exactly the same selection bias.

It is not possible to completely exclude the possibility of ambiguity in the wording of clinical practice questionnaires. However, both questionnaires were piloted in a representative sample of optometrists prior to conducting the study and the questions for the face-to-face interviews were piloted and showed very good test:retest validity, albeit in a small sample of optometrists different from the study population.

Although the SP methodology is considered to be the gold standard for the assessment of clinical practice, inevitably SP reports cannot be 100% accurate. In the present study, SP's were well trained and supplied with an *aide memoire* to facilitate recall. Furthermore, to reduce recall bias each volunteer completed a proforma detailing the history and symptoms questions asked and tests performed immediately following the sight test. No post-training audit of SPs' competency was carried out in this study.

The questionnaire used in the face-to-face interviews addressed case finding practice relating to normals. The SPs in the current study had no risk factors for glaucoma apart from their age. This leaves it to the respondents' discretion as to whether they assume the SP to be at high risk or low risk of glaucoma. This could lead to variations in the interpretation of some of the questions that could introduce bias to the results.

The only previous research on eye examinations in optometry that has used SPs was conducted by Shah *et al.*[15,22,23]. They selected a randomised sample of optometrists from the GOC register living within 1.5 h travel time of central London. A total of 111 optometrists agreed to participate and they were aware that they would be visited by the SPs. However, in order to recruit these 111 optometrists a total of 600 were approached, revealing a very high attrition rate. The current study was local in its scope and participating optometrists were drawn from a pool of only 62 potential 'subjects'. If informed consent had been sought, it is most unlikely that it would have been possible to recruit a sufficiently large sample to carry out a worthwhile study. Shah *et al* also audio recorded the eye examinations. However audio recording introduces issues of data protection and confidentiality, and would only have been possible in the current study if informed consent was obtained, with the consequent adverse affect on sample size.

In the SP study all investigations e.g. tonometry and visual fields were performed by the optometrist. However, there is an increasing trend for tests such as NCT and visual fields to be integrated into a pre-screening assessment that is performed by an optical assistant. There is evidence that this may increase the likelihood that a discretionary screening test is performed.[15]

Conclusions

The overall findings in both parts of the study reported here indicate an overestimation of routine tests undertaken in practice. This overestimation is in line with recommendations made in published guidelines and best practice. Actual practice reveals correspondence in mandatory test performance and poor correspondence with discretionary tests. In the case of referral letters, some of this lack of agreement may be accounted for by a failure to record negative findings; however the SP results would suggest that this is a small effect. The strength of agreement of these two methodologies signifies that there is a strong and real effect that should be borne in mind in all questionnaire studies that report current practice.

Acknowledgements

We would like to thank the volunteers who participated in the standardised patient study and the ophthalmologists who supplied anonymous optometrist referral letters. Joy Myint is funded by an unrestricted grant from Pfizer Ophthalmology.

References

1. Hernández R, Rabindranath K, Fraser C *et al.* Screening for open angle glaucoma: systematic review of cost-effectiveness studies. *J Glaucoma* 2008; 17: 159–168.
2. Bowling B, Chen SD & Salmon JF. Outcomes of referrals by community optometrists to a hospital glaucoma service. *Br J Ophthalmol* 2005; 89: 1102–1104.
3. College of Optometrists. Code of ethics and guidelines for professional conduct, section D3 examining patients at risk from glaucoma. http://www.college-optometrists.org/en/utilities/document summary.cfm/docid/D15DFBC3-5146-432D-BEFE9681ED555393, accessed 7/6/11.
4. Strong NP. How optometrists screen for glaucoma: a survey. *Ophthalmic Physiol Opt* 1992; 12: 3–7.
5. Tuck MW & Crick RP. Non-contact tonometry: optometrists' current practice in England and Wales. *Ophthalmic Physiol Opt* 1994; 14: 347–350.
6. Willis CE, Rankin SJ & Jackson AJ. Glaucoma in optometric practice: a survey of optometrists. *Ophthalmic Physiol Opt* 2000; 20: 70–75.
7. Adams AS, Soumerai SB, Lomas J & Ross-Degnan D. Evidence of self-report bias in assessing adherence to guidelines. *Int J Qual Health Care* 1999; 11: 187–192.
8. Lomas J, Anderson GM, Domnick-Pierre K, Vayda E, Enkin MW & Hannah WJ. Do practice guidelines guide practice? The effect of a consensus statement on the practice of physicians *N Engl J Med* 1989; 321: 1306–1311.

9. Hrisos S, Eccles MP, Francis JJ *et al.* Are there valid proxy measures of clinical behaviour? A systematic review *Implement Sci* 2009; 4: 37.
10. Myint J, Edgar DF, Kotecha A, Murdoch IE & Lawrenson JG. Barriers perceived by UK-based community optometrists to the detection of primary open angle glaucoma. *Ophthal Physiol Opt* 2010; 30: 847–853.
11. Myint J, Edgar DF, Kotecha A, Murdoch IE & Lawrenson JG. A national survey of diagnostic tests reported by UK community optometrists for the detection of chronic open angle glaucoma. *Ophthalmic Physiol Opt* 2011; 31: 353–359.
12. Rethans JJ, Sturmans F, Drop R & van der Vleuten C. Assessment of the performance of general practitioners by the use of standardized (simulated) patients. *Br J Gen Pract* 1991; 41: 97–99.
13. Luck J & Peabody JW. Using standardised patients to measure physicians' practice: validation study using audio recordings. *BMJ* 2002; 325: 679–683.
14. Sight testing (examination and prescription) (no2) regulations SI1989/1230. http://www.legislation.gov.uk/uksi/1989/1230/contents/made, accessed 7/6/11.
15. Shah R, Edgar DF, Spry PG *et al.* Glaucoma detection: the content of optometric eye examinations for a presbyopic patient of African racial descent. *Br J Ophthalmol* 2009; 93: 492–496.
16. Ang GS, Ng WS & Azuara-Blanco A. The influence of the new general ophthalmic services (GOS) contract in optometrist referrals for glaucoma in Scotland. *Eye (Lond)* 2009; 23: 351–355.
17. Lockwood AJ, Kirwan JF & Ashleigh Z. Optometrists referrals for glaucoma assessment: a prospective survey of clinical data and outcomes. *Eye* 2010; 24: 1515–1519.
18. National Institute of Clinical Excellence. 2009. Glaucoma: diagnosis and management of chronic open angle glaucoma and ocular hypertension. http://www.nice.org.uk/nicemedia/pdf/CG85QuickRefGuide.pdf, accessed 7/6/11.
19. Edgar DF, Romanay T, Lawrenson JG & Myint J. Increase in the number of referrals from optometrists following the publication of the April 2009 NICE guidelines for the diagnosis and management of COAG and OHT in England and Wales. *Optom Pract* 2010; 11: 33–38.
20. Shah S & Murdoch IE. NICE – impact on glaucoma case detection. *Ophthalmic Physiol Opt* 2011; 31: 339–342.
21. Shah R, Evans BJW & Edgar D. Measuring clinical practice. *Ophthal Physiol Opt* 2007; 27: 113–125.
22. Shah R, Edgar DF, Rabbetts R *et al.* The content of optometric eye examinations for a young myope with headaches. *Ophthalmic Physiol Opt* 2008; 28: 404–421.
23. Shah R, Edgar DF, Harle DE *et al.* The content of optometric eye examinations for a presbyopic patient presenting with symptoms of flashing lights. *Ophthalmic Physiol Opt* 2009; 29: 105–126.

OPO OPHTHALMIC AND PHYSIOLOGICAL OPTICS
THE JOURNAL OF THE COLLEGE OF OPTOMETRISTS

Ophthal. Physiol. Opt. 2010 **30:** 847–853

Barriers perceived by UK-based community optometrists to the detection of primary open angle glaucoma

Joy Myint[1], David F. Edgar[1], Aachal Kotecha[1,2], Ian E. Murdoch[3] and John G. Lawrenson[1]

[1]Department of Optometry and Visual Science, Henry Wellcome Laboratories for Vision Sciences, City University, Northampton Square, London EC1V 0HB, [2]NIHR BMRC for Ophthalmology, Moorfields Eye Hospital NHS Foundation Trust and UCL Institute of Ophthalmology, London, and [3]Glaucoma Unit, Moorfields Eye Hospital, London, UK

Abstract

Purpose: This paper aims to identify the barriers to case-finding for primary open angle glaucoma (POAG) as perceived by community optometrists in the United Kingdom (UK).

Methods: An anonymous, online survey to investigate the current mode of optometric practice for the detection of POAG was developed. The survey included a free-text question relating to barriers to case-finding for the disease. Optometrists on the Association of Optometrists (AOP) electronic database were invited to participate. The survey was open for 16 weeks between April and July 2008.

Results: A total of 1680 responses was received to the survey, of which 1293 (77%) answered the free-text question relating to perceived barriers. Eighty-eight per cent of these reported one or more barriers to the detection of glaucoma in the community, most commonly: time constraints limiting the options for repeat testing and lack of financial remuneration to perform the additional tests required. Barriers were less frequently reported in Scotland, with 23.4% of optometrists reporting no barriers compared to only 12% in England, 6% in Northern Ireland and 4% in Wales.

Conclusion: In general, UK optometrists believed that their ability to detect POAG in the community is hampered by time and financial constraints. However, barriers were significantly fewer in Scotland, where optometrists have different contractual terms of service with the NHS than their counterparts in the rest of the UK.

Keywords: case-finding, glaucoma, optometrist

Introduction

Glaucoma is the world's leading cause of irreversible blindness (Resnikoff *et al.*, 2004), affecting approximately 2% of those over 40 and 5% of those over 65 and increasing in prevalence with advancing age (Quigley and Vitale, 1997; Tuck and Crick, 1998; Friedman *et al.*, 2004). It is responsible for 13% of those registered as having severe sight impairment in the United Kingdom (UK) (Bunce and Wormald, 2006).

In the UK, approximately 95% of referrals for suspected primary open angle glaucoma (POAG) are generated by community optometrists (Bowling *et al.*, 2005). There is no standardised practice or formal screening programme; hence optometrists identify suspects through opportunistic case-finding. The College of Optometrists (CoO) has developed guidelines for 'Examining the Patient at Risk from Primary Open Angle Glaucoma' which recommend that good practice should include a triad of tests; assessment of the optic nerve head, tonometry and central visual field assessment (College of Optometrists, 2009). The guidelines further state that both tonometry and perimetry should be repeated to confirm the validity of the result. However,

Received: 26 February 2010
Revised form: 21 June 2010
Accepted: 22 June 2010

Correspondence and reprint requests to: J. Myint.
Tel.: 020 7040 3988; Fax: 020 7040 8494.
E-mail address: joy.myint.1@city.ac.uk

 doi: 10.1111/j.1475-1313.2010.00792.x

there is no obligation to carry out specific tests during an NHS or private eye examination. Optometrists' terms of service with the NHS specify that they should carry out an external and internal examination of the eye, and any 'additional examinations' that appear to be 'clinically necessary' [see The Sight Testing (Examination and Prescription) (No2) Regulations SI1989/1230]. An optometrist's terms of service and the CoO guidelines create an expectation that a sight test will include the triad of tests for glaucoma, however the discretionary nature of additional examinations leads to potential variation in clinical practice within the profession (Shah *et al.*, 2009a–c).

A proportion of referrals for glaucoma by optometrists are subsequently found to be false positives (Bell and O'Brien, 1997; Theodossiades and Murdoch, 1999; Bowling *et al.*, 2005). Bell and O'Brien found that only 17% of 295 referrals were subsequently diagnosed with glaucoma (Bell and O'Brien, 1997). Tuck and Crick had previously concluded that a third of all referrals were confirmed as having glaucoma, a third were classified borderline and the final third were discharged as normal (Tuck and Crick, 1991). Bowling *et al.* reported that nearly half (45.8%) of all patients referred to glaucoma clinics were discharged at first visit (Bowling *et al.*, 2005). Although the high proportion of false positives is a reflection of the low prevalence of glaucoma (Rumney and Henson, 2009), it is clear that the sensitivity and specificity of optometrists' glaucoma case finding could be improved by combining test data (Harper and Reeves, 1999).

The principal aim of this paper is to identify the barriers, as perceived by UK optometrists, to adequate case finding for POAG. Data were collected as part of a wide-ranging, anonymous online survey of a sample of the UK profession.

Methods

A survey to investigate UK community optometrists' current practice in the detection of POAG was developed. The survey was entirely web-based and hosted by a US provider of online surveys (Survey Monkey; http://www.surveymonkey.com; OR, USA).

The survey was piloted on 100 optometrists selected using a convenience sampling technique. Based on their feedback, minor amendments were made and the final survey was open for 16 weeks between April and July 2008.

It should be noted that the survey was conducted prior to the publication in April 2009 of the National Institute for Health and Clinical Excellence (NICE) guideline on the diagnosis and management of chronic open angle glaucoma and ocular hypertension (OHT) (National Institute for Health and Clinical Excellence, 2009).

All optometrists on the Association of Optometrists (AOP) electronic database were invited to participate. The AOP represents the professional interests of UK optometrists. Seven thousand four hundred and thirty emails were sent to AOP members, but this total included non-practicing, retired optometrists and non-community practitioners. There were also some duplicate email addresses. The email invited members to participate in the survey online via a hyperlink to the website. Two reminders were sent and news features promoting the survey were included in AOP membership publications. The survey was closed following two consecutive days without responses.

The survey was anonymous and no incentives or feedback were offered. The survey consisted of five sections totaling 27 questions:

(1) Mode of practice (nine questions)

This section included multiple choice questions relating to type of practice and geographical location. Respondents had to decide on their choices from the options given.

(2) Strategies for glaucoma detection (two questions)

Section 2 consisted of two free-text boxes. Question 10 asked how the optometrist would investigate for suspect POAG. Question 11 formed the basis for this paper and read:

> In the box below (free-text entry) comment on any potential barriers that compromise effective detection for primary open angle glaucoma in community optometric practice. How do these barriers constrain implementation of practice and are there are any routine tests that sometimes have to be carried out selectively because of these barriers/constraints?

(3) Equipment used for glaucoma detection and practice organisation (nine questions)

(4) Strategies for glaucoma referral (five questions)

(5) Personal/Demographic information (two questions).

This research was approved by the City University London, Research and Ethical committee. The explanatory email sent to all potential optometrist participants, which included the hyperlink to the survey, contained full details of the research. Participation in the survey was completely voluntary and it was assumed that attempting the survey constituted informed consent.

The free-text responses were interpreted independently by two members of the research team and any disagreements or difficulties in interpreting particular responses were then reviewed by the principal investigator (JL).

Results

A total of 2044 optometrists entered the survey, a response rate of 27.5% which equated to 18.4% of UK registered optometrists (General Optical Council GOC

Table 1. The breakdown of optometrists by country according to the GOC 2007/8 Annual Report (2008), according to AOP[a] demographics, among survey respondents and among respondents to the perceived 'barriers' question

	GOC *n* (%)	AOP *n* (%)	Eligible survey respondents *n* (%)	'Barriers' question respondents *n* (%)
England	9052 (81.6)	8973 (82.5)	1400 (83.3)	1077 (83.3)
Scotland	1053 (9.5)	920 (8.5)	135 (8.0)	107 (8.3)
Wales	534 (4.8)	567 (5.2)	98 (5.8)	75 (5.8)
N. Ireland	455 (4.1)	415 (3.8)	47 (2.8)	34 (2.6)
Total	11094	10875	1680	1293

[a]AOP information via personal communication with AOP membership department at time of survey.

Annual Report, 2008). One thousand six hundred and eighty (82%) were community practitioners and therefore eligible to complete the survey. Of these, 1293 (77%) answered the question relating to barriers to glaucoma case-finding. A total of 56.5% were from independent practices, 23% worked in 'multiples' (familiar High Street optometrist premises) and the remainder were locums who did not hold a residency post. The majority of respondents (58.9%) stated that their principal practices were 'urban but not inner city', with 22.5% of practices described as inner city and the remainder classified as rural. The gender distribution of respondents was 46.9% male and 53.1% female, which reflects the 48.2% male and 51.8% female distribution of GOC registrants for the year 2007–2008. *Table 1* illustrates the breakdown of optometrists by country according to the GOC 2007/8 Annual Report (General Optical Council GOC Annual Report, 2008), AOP demographics (limited data are available), total survey respondents and respondents to the barriers question.

Analysis of the free-text boxes revealed eight main perceived barriers to POAG detection: time constraints, financial issues, equipment availability, optometry practice management, patient loyalty, patient information, training issues, and inter-disciplinary communication (*Table 2*).

Most respondents reported more than one barrier. The most commonly cited barrier was time constraints, closely followed by financial issues. A sub-analysis by area revealed that these two issues remained major barriers across the UK (*Table 3*). Of respondents in England who stated that financial issues were a barrier, 73% ($n = 350$) specifically referred to the General Ophthalmic Services (GOS) system.

Considering the results from the 948 respondents who reported at least one barrier, there was a statistically significant difference between the proportion of respondents in England (50%) and Scotland (34%) who reported financial issues as a barrier (chi squared test with Bonferroni correction for multiple comparisons, $p = 0.03$). The proportion of respondents from Scotland (23.4%) who reported no barriers was also statistically significantly different from those from England (12%) and Wales (4%) who reported no barriers (chi squared test with Bonferroni correction, $p < 0.001$). Other regional differences between those reporting barriers were not statistically significant, although it should be noted that only a small number of respondents from Northern Ireland reported barriers. The data were not collected in a way which allowed analysis of responses from different regions in England.

Table 2. Main perceived barriers reported by survey respondents

Barrier	Explanation
Time	Related mostly to the extra time required to either complete relevant tests or to repeat tests
Financial issues	Issues with loss of income and in turn the lack of finance to pay for equipment or staff
Equipment	Inadequate practice equipment to detect POAG
Patient education	Many of the barriers grouped together in this section related to public perception of the value of an eye test. These included: Glaucoma cases cannot be detected if the patients do not present. Lack of public awareness/ patient education regarding the serious nature of POAG. Failure to attend for follow-up. Other barriers in this section included communication problems and physical constraints affecting patients' abilities to access equipment
Practice management	Barriers relating to staffing or management issues
Clinical information	Two main issues; record keeping and the ability to detect change over time, closely linked with patient loyalty to the practice. Patients 'shopping around' leads to problems with access to previous records, and consequently with detection of change in the patient's clinical status
Training issues	Optometrists need for training to use newer technologies for glaucoma diagnosis e.g. HRT (Heidelberg Retina Tomograph), OCT (optical coherence tomography)

Table 3. Frequency of perceived barriers reported stratified by country

Barrier	England %	Scotland %	Wales %	Northern Ireland %
No barriers	12	23	4	6
Time	57	48	58	50
Financial	50	34	53	41
Equipment	23	27	21	13
Patient education	24	20	14	22
Practice management	7	7	7	9
Clinical information	4	9	7	3
Training issues	3	9	3	0
Interdisciplinary communication	3	2	1	0

Discussion

It is important when considering the results of a survey of this type to address the potential for response bias. The AOP provides professional indemnity insurance for approximately 90% of UK optometrists (AOP, personal communication) and therefore its membership database reflects the demographics of the GOC register. Since optometrists were invited to participate in the survey via email, only those AOP members who had provided a current email address were contacted, which may have biased the sample. However the demographics of those responding to the survey were consistent with the GOC register in terms of age and gender, with a similar stratification by geographic location (*Table 1*). Although we cannot exclude the possibility that the survey over-estimated barriers to case finding, because some respondents may not have responded to this question as they did not perceive any barriers, it is notable that the free-text question concerning barriers was one of 27 wider-ranging questions on glaucoma case finding and the question was answered by 77% of respondents, of which the vast majority (88%) documented one or more barriers.

Time and financial barriers

The most commonly stated barriers were financial issues and time constraints, which for many respondents were inextricably linked.

It should be noted that there are differences in the arrangement of ophthalmic services across the UK. The NHS provides some primary eyecare, namely 'sight tests', to the general public via the GOS (Association of Optometrists Sight Test Resource Pack, 2003). The GOS system includes 'free' NHS sight tests to eligible groups only (apart from Scotland, where GOS sight tests are free for everyone); the remainder pay a private eye examination fee, usually set by the practice owner. Patients eligible for 'free' examinations include those over 40 years of age with an immediate family history of glaucoma, and those over the age of 60. The GOS system differs across the UK. In England, the fee paid to optometrists for completing a GOS NHS sight test at the time of the survey was £19.80 (Federation of Dispensing Opticians, 2008). According to the Federation of Ophthalmic and Dispensing Opticians the average private examination fee in 2008 was £22.90 (Federation of Dispensing Opticians, 2008). It has been estimated that the actual cost is approximately £37, with NHS sight tests being heavily subsidised through spectacle sales (Bosanquet, 2006).

Of respondents in England who stated that financial issues were a barrier (50%), the majority specifically referred to the GOS system. Unlike Scotland, the GOS in England does not include any additional incentives to support optometrists in case finding for POAG. A patient recalled for repeat testing occupies an appointment slot and in some cases this could lead to an increase in the loss in revenue if an additional fee is not charged, which may lead to tensions between the clinical and retail sides of the optometric practice. Additionally, it is in the practice's business interests for practitioners to complete tests as quickly as possible, as the testing element generates little income per hour. The average optometrist has only 20–30 min to complete all the tests required to comply with their terms of service. As a result, optometrists may feel pressurised to refer patients for suspect glaucoma on the basis of a single test result (Stevenson, 1999; Salmon *et al.*, 2007). Some practices charge for supplementary procedures such as repeat fields, but it is the individual patient's decision whether they are willing to pay this additional fee.

On 1 April 2006, Scotland implemented a new GOS contract for community optometrists (Ang *et al.*, 2009), which introduced 'free' eye examinations for all. Under the new contract optometrists must pass an accreditation process to ensure a basic level of clinical competence. The new contract aimed to reduce inappropriate (including glaucoma) referrals to the HES and introduced supplementary examinations, which allowed for repetition of some or all of the triad of tests for glaucoma case finding. This change also included a new fee structure, where optometrists were paid a fee for the

primary eye examination and a separate fee for any supplementary eye examination. The primary eye examination fee, when this survey was conducted, was £36 for those under 60, £40 for those over 60, and £21 for a supplementary examination (http://www.assoc-optometrists.org/12711583863148.html). Ang *et al.* reported an improvement in the quality of glaucoma referrals from optometrists in Scotland, notably an increase in the percentage of true positive referrals from 18% to 31.7% and a reduction in false positives from 36.6% to 31.7%, since the introduction of the new contract (Ang *et al.*, 2009). Optometry Scotland, which represents the optical professions in Scotland, has also negotiated equipment and training grants.

Every referral to the HES incurs costs to the NHS. Traverso *et al.* (2005) noted that each ophthalmology outpatient appointment costs £380 (Traverso *et al.*, 2005), a heavy price for each false positive referral. Fewer respondents from Scotland (34%) cite financial implications as a barrier. In fact Scottish respondents were more likely to report 'no barriers' compared to their English counterparts, with this difference being statistically significant. The barriers most commonly reported by optometrists in England related to inadequate time available to perform tests, remuneration for NHS services, and adequacy of equipment for glaucoma screening. These were addressed by the GOS contract in Scotland, which, in addition to the introduction of the supplementary examination and the increases in the sight test fee, also provided equipment grants (Ang *et al.*, 2009).

In Wales, under the Welsh Eye Care Initiative (WECI) (Association of Optometrists, 2004), the Welsh Eye Health Examination (WEHE) is a scheme which caters for those who may be 'at risk of eye disease' and entitles them to a free eye examination from a WECI accredited optometrist. It should be noted that the provision of WEHE is outside the GOS provided by the NHS. All WEHE accredited optometrists undergo further postgraduate training and regular re-accreditation (Sheen *et al.*, 2008). They are also required to have a minimum standard of equipment, including an applanation tonometer. From a POAG perspective the criteria for eligibility for the WEHE include those 'at risk of eye disease by reason of race or family history', notably those of Black African and Black Caribbean descent. When performing a WEHE, it is mandatory to carry out the triad of tests recommended for POAG case-finding, however optometrists receive a higher fee (currently £40, per patient, which is double that in England). Despite the additional remuneration, the survey found that optometrists in Wales still perceived financial barriers similar to their English counterparts. One possible explanation is that the WEHE is only available to certain patient groups and there is no additional funding for repeat testing, unlike the situation in Scotland.

Equipment

Most UK optometrists do not own or share ownership of the practice in which they work. Practices may be owned or franchised by one of the well-known 'multiples'. Optometrists may be employed or self-employed (a locum) and may work in a number of practices. Hence the equipment available is not necessarily the choice of the optometrist. Furthermore, equipment issues are inextricably linked to financial issues. Some modern equipment for glaucoma case-finding is highly specialised and expensive. In some cases, specialised equipment does not generate further practice income and use of equipment may occupy valuable appointment slots at a cost to the practice.

The percentage of Scottish respondents (27%) who cited equipment as a barrier was higher than in England, Wales and Northern Ireland. This is perhaps a surprising finding since, at the time of the survey, each practice was eligible for an equipment grant of £10 000, a scheme unique to Scotland. However, it should be noted that Scottish optometrists cited barriers that related to more specialised items of equipment such as gonioscopes and pachymeters whereas in England the comments related more to equipment required for the more traditional 'triad' of tests.

Patient education

Many of the barriers grouped together in this section related to patient compliance and general public perception of the value of an eye test. Practitioners felt that there was lack of public awareness and poor patient education relating to POAG. This, in turn, could lead to patients either not presenting in the first instance for an eye examination or, if they do attend initially, subsequently failing to return for follow up appointments. Other perceived barriers cited included communication problems, such as language difficulties, and physical constraints affecting patients' abilities to access equipment.

Practice management

Practice related barriers were focused on staffing or management issues. Optometrists who reported barriers in this area felt that they were hindered by lack of support from either managers or ancillary staff. In some cases it was felt that support staff required more training to increase their knowledge and understanding of glaucoma.

Clinical information

Another commonly reported barrier was that patients no longer demonstrated loyalty to a practice. This highlights the commercial nature of the profession, with patients 'shopping around' for the best spectacle deal. Though freedom of choice should be encouraged, patients do not carry their clinical records and practices are not obliged to send them on to the next practice. As a fundamental factor in the accurate detection of glaucoma is to detect change in the patient's clinical status, difficulties accessing patient records can impair POAG case-finding.

Training

Optometrists' personal training was an infrequently cited barrier, suggesting that the majority of optometrists feel they are adequately trained to detect glaucoma.

Communication

Barriers less frequently mentioned included intra-optometrist, patient and inter-disciplinary communication issues.

The first raises the issue of record keeping. Whilst optometrists are legally required to keep adequate clinical records, the level and accuracy of information recorded differs greatly and poor record keeping hinders the detection of a change in the patient's clinical status. There is evidence that optometrists both under-record and to a lesser extent over-record the findings of eye examinations, including eye examinations on a patient at risk of POAG (Shah *et al.*, 2009a). Patient communication problems included poor compliance with follow-up visits, lack of patient understanding of the importance of family history, and language difficulties. When an optometrist suspects glaucoma, a referral to an ophthalmologist for investigation is initiated, normally via the patient's general practitioner. If the optometrist does not receive any correspondence following the referral, they will be unaware of the diagnosis. Some respondents felt that if optometrists received more feedback on referrals, this would have a training effect which could improve referral accuracy. However, among our respondents, this was not a major barrier to POAG detection.

In conclusion, UK optometrists perceive barriers that affect their case-finding of POAG suspects, primarily caused by financial and time constraints within a community-based optometric setting. It is important to address these issues and consider how the GOS can be adapted to encompass glaucoma diagnosis and management.

Acknowledgments

Miss Myint is funded through an unrestricted grant from Pfizer Ophthalmology. Dr Kotecha receives a proportion of her funding from the Department of Health's National Institute for Health Research Biomedical Research Centre for Ophthalmology at Moorfields Eye Hospital NHS Foundation Trust and the UCL Institute of Ophthalmology. The views expressed in this publication are those of the authors alone.

Conflict of interest

None to declare.

References

Ang, G. S., Ng, W. S. and Azuara-Blanco, A. (2009) The influence of the new general ophthalmic services (GOS) contract in optometrist referrals for glaucoma in Scotland. *Eye* **23,** 351–355.

Association of Optometrists (2004) http://www.aop.org.uk/uploaded_files/weci_info_for_optoms_onlyv4.pdf (last accessed 4 February 2010).

Association of Optometrists Sight Test Resource Pack (2003). http://www.assoc-optometrists.org/uploaded_files/pdf/sight_test_pack.pdf (last accessed 4 February 2010).

Bell, R. W. and O'Brien, C. (1997) Accuracy of referral to a glaucoma clinic. *Ophthalmic Physiol. Opt.* **17,** 7–11.

Bosanquet, N. (2006) Developing a new partnership contract for community eye care in England. Imperial College. http://www.aop.org.uk/uploaded_files/bosanquet_report.pdf (last accessed 4 February 2010).

Bowling, B., Chen, S. D. M. and Salmon, J. F. (2005) Outcomes of referrals by community optometrists to a hospital glaucoma service. *Br. J. Ophthalmol.* **89,** 1102–1104.

Bunce, C. and Wormald, R. (2006) Leading causes of certification for blindness and partial sight in England & Wales. *BMC Public Health* **6,** 1–7.

College of Optometrists (2009) *Members Handbook: Examining the Patient at Risk from Primary Open Angle Glaucoma.* http://www.college-optometrists.org/index.aspx/pcms/site.publication.Members_Handbook/ (last accessed 4 February 2010).

Federation of Dispensing Opticians (2008) Optics at a glance 2008. http://www.fodo.com/fckextras/File/OAAG%202008,%20FINAL%20FINAL.pdf (last accessed 4 February 2010).

Friedman, D. S., Wolfs, R. C., O' Colmain, B. J., Klein, B. E., Taylor, H. R., West, S., Leske, M. C., Mitchell, P., Congdon, N., Kempen, J. and the Eye Diseases Prevelance Research Group (2004) Prevalence of open-angle glaucoma among adults in the United States. *Arch. Ophthalmol.* **122,** 532–538.

General Optical Council GOC Annual Report (2008). http://www.optical.org/goc/filemanager/root/site_assets/publications/annual_reports/final_goc_ar.pdf (last accessed 4 February 2010).

Harper, R. A. and Reeves, B. C. (1999) Glaucoma screening: the importance of combining test data. *Optom. Vis. Sci.* **76,** 537–543.

National Institute for Health and Clinical Excellence (2009) Glaucoma: diagnosis and management of chronic open angle glaucoma and ocular hypertension. http://www.nice.org.uk/nicemedia/pdf/CG85FullGuideline.pdf (last accessed 4 February 2010).

Quigley, H. A. and Vitale, S. (1997) Models of open-angle glaucoma prevalence and incidence in the United States. *Invest. Ophthalmol. Vis. Sci.* **38,** 83–91.

Resnikoff, S., Pascolini, D., Etya'ale, D., Kocur, I., Pararajasegaram, R., Pokharel, G. P. and Mariotti, S. P. (2004) Global data on visual impairment in the year 2002. *Bull. World Health Organ.* **82,** 844–851.

Rumney, N. J. and Henson, D. B. (2009) Letter to the editor. *Optom Pract* **10,** iii–iv.

Salmon, N. J., Terry, H. P., Farmery, A. D. and Salmon, J. F. (2007) An analysis of patients discharged from a hospital-based glaucoma case-finding clinic over a 3-year period. *Ophthalmic Physiol. Opt.* **27,** 399–403.

Shah, R., Edgar, D. F., Spry, P. G., Harper, R. A., Kotecha, A., Rughani, S. and Evans, B. J. (2009a) Glaucoma detecton: the content of optometric eye examinations for a presbyopic patient of African racial descent. *Br. J. Ophthalmol.* **93,** 492–496.

Shah, R., Edgar, D. F., Harle, D. E., Weddell, L., Austen, D. P., Burghardt, D. and Evans, B. J. W. (2009b) The content of optometric eye examinations for a presbyopic patient presenting with symptoms of flashing lights. *Ophthalmic Physiol. Opt.* **29,** 105–126.

Shah, R., Edgar, D. F. and Evans, B. J. (2009c) How well does record abstraction quantify the content of optometric eye examinations in the UK? *Ophthalmic Physiol. Opt.* **29,** 383–396.

Sheen, N. J. L., Fone, D., Phillips, C. J., Sparrow, J. M., Pointer, J. S. and Wild, J. M. (2008) Novel optometrist led all Wales primary eye care services: evaluation of prospective case-series. *Br. J. Ophthalmol.* **93,** 435–438.

Stevenson, R. (1999) Automated perimetry by optometrists in patients at low risk of glaucoma. *Br. J. Ophthalmol.* **83,** 759–760.

Theodossiades, J. and Murdoch, I. (1999) Positive predictive value of optometrist-initiated referrals for glaucoma. *Ophthalmic Physiol. Opt.* **19,** 62–67.

Traverso, C. E., Walt, J. G., Kelly, S. P., Hommer, A. H., Bron, A. M., Denis, P., Nordmann, J-P., Renard, J-P., Bayer, A., Grehn, F., Pfeiffer, N., Cedrone, C., Gandolfi, S., Orzalesi, N., Nucci, C., Rossetti, L., Azuara-Blanco, A., Bagnis, A., Hitchings, R., Salmon, J. F., Bricola, G., Buchholz, P. M., Kotak, S. V., Katz, L. M., Siegarte, L. R. and Doyle, J. J. (2005) Direct costs of glaucoma and severity of the disease: a multinational long term study of resource utilisation in Europe. *Br. J. Ophthalmol.* **89,** 1245–1249.

Tuck, M. W. and Crick, R. P. (1991) Efficiency of referral for suspected glaucoma. *BMJ* **302,** 998–1000.

Tuck, M. W. and Crick, R. P. (1998) The age distribution of primary open angle glaucoma. *Ophthalmic Epidemiol.* **5,** 173–183.

OPO OPHTHALMIC & PHYSIOLOGICAL OPTICS
THE JOURNAL OF THE COLLEGE OF OPTOMETRISTS

Ophthalmic & Physiological Optics ISSN 0275-5408

A national survey of diagnostic tests reported by UK community optometrists for the detection of chronic open angle glaucoma

Joy Myint[1], David F Edgar[1], Aachal Kotecha[1,2], Ian E Murdoch[3] and John G Lawrenson[1]

[1]Henry Wellcome Laboratories for Vision Sciences, Department of Optometry and Visual Science, City University London, London, UK, [2]NIHR BMRC for Ophthalmology, Moorfields Eye Hospital NHS Foundation Trust and UCL Institute of Ophthalmology, London, UK, and [3]Glaucoma Unit, Moorfields Eye Hospital, London, UK

Citation information: Myint J, Edgar DF, Kotecha A, Murdoch IE & Lawrenson JG. A national survey of diagnostic tests reported by UK community optometrists for the detection of chronic open angle glaucoma. *Ophthalmic Physiol Opt* 2011, **31**, 353–359. doi: 10.1111/j.1475-1313.2011.00844.x

Keywords: diagnostic techniques, glaucoma, optometrist, screening

Correspondence: Joy Myint
E-mail address: joy.myint.1@city.ac.uk

Received: 12 November 2010; Accepted: 21 March 2011

Abstract

Purpose: In the UK, the majority of cases of chronic open angle glaucoma are detected by community optometrists following a routine sight test. However, there is potential for variability in case finding strategies used. The aim of this study was to carry out a national web-based survey to determine current diagnostic tests used by optometrists in glaucoma case finding.

Methods: Optometrists on the Association of Optometrists (AOP) electronic database were invited to participate. The survey was open for 16 weeks between April and July 2008.

Results: A total of 1875 optometrists were eligible to enter the survey, of which 1264 answered the questions relating to diagnostic equipment. Respondents were asked to indicate their usual method of examining the optic nerve head. Direct ophthalmoscopy only was used by 25% with the majority (62%) using a combination of direct and slit-lamp binocular indirect methods. The vast majority of optometrists (78%) used non-contact tonometry to measure intraocular pressure, with only 16% routinely using a Goldmann or Perkins applanation tonometer. The perimeter most frequently used was either one of the Henson range of instruments (39%) or the Humphrey Field Analyser (22%). A smaller number of optometrists (<5%) had access to more specialised imaging equipment, such as HRT, GDx or OCT.

Conclusions: The results of the survey demonstrate that UK optometrists are well equipped to carry out case finding for chronic open angle glaucoma, although there is a lack of standardisation with respect to equipment used.

Introduction

Chronic open angle glaucoma (COAG) is an insidious disease affecting 1–2% of the population aged 40–65 years, rising to 7% in those over 75. Sufferers are asymptomatic and may be unaware of glaucomatous visual field loss, which can lead to late presentation. In the UK, approximately 10% of blind and partially sighted registrations are attributed to glaucoma.[1]

In the absence of a formal screening programme for COAG, detection of the disease relies on case finding in individuals consulting community optometrists. In England, Wales and Northern Ireland, NHS-funded Sight Tests are available to everyone over 60 years and those over 40 with a family history of glaucoma through the General Ophthalmic Services (GOS). In Scotland NHS-funded Sight Tests are available to all. Guidance for all UK optometrists has been published by their professional body (College of Optometrists), regarding the 'examination of patients at risk from glaucoma',[2] recommending the usual triad of screening tests; assessment of the optic nerve head, tonometry and central visual field assessment.

However, the choice of equipment and the actual case finding protocol used is at the discretion of the individual optometrist. As a result, significant variation in glaucoma case finding practices has been reported.[3,4]

Twenty years ago a large survey was conducted on behalf of the International Glaucoma Association (IGA) to examine aspects of screening and referral for glaucoma by optometrists in England and Wales.[5–8] Since that time, there has not been an equivalent in-depth national survey of glaucoma case finding practices. The present study reports the results of a large online survey of members of the Association of Optometrists (AOP) conducted in 2008. The survey is particularly timely given the recent Health Technology Assessment (HTA) review considering the clinical and cost effectiveness of population-based screening for COAG.[9] The conclusion of the review was that population screening was not cost effective, and by implication that detection of the disease would continue to depend on opportunistic case finding. However there was an acknowledgement that glaucoma detection could be improved by increasing the uptake of sight tests and improving the standard of optometric assessment. The aim of this study was to carry out a national web-based survey to determine current diagnostic tests used by optometrists in glaucoma case finding.

Methods

A survey to investigate UK optometrists' current practice in the detection of COAG was developed. The survey was entirely web-based and hosted by a US provider of online surveys (Survey Monkey; http://www.surveymonkey.com). The survey was piloted on 100 optometrists selected using a convenience sampling technique. Based on their feedback, minor amendments were made and the final survey was opened in April 2008. There was no fixed closing date for the survey, which remained open until there were two consecutive days without any responses. This occurred in July 2008 after the survey had been open for 16 weeks.

All optometrists on the Association of Optometrists (AOP) electronic database were invited to participate. The AOP represents the professional interests of UK optometrists. Seven thousand four hundred and thirty emails were sent to AOP members, but this total included non-practicing and retired optometrists, and non-community practitioners (e.g. hospital-based optometrists). There were also some duplicate email addresses. The email invited members to participate in the survey online via a hyperlink to the website. Two reminders were sent and news features promoting the survey were included in AOP membership publications.

The survey was anonymous and no incentives or feedback were offered. It consisted of 27 forced choice or free-text questions covering different aspects of optometric practice.

Mode of practice (nine questions)

The survey was restricted to community-based optometrists and Question 1 established respondents' mode of practice. Those practicing outside primary care community optometry (e.g. hospital optometrists) and non-practicing optometrists were asked to proceed no further.

Strategies for glaucoma detection (two questions)

Section 2 consisted of two free-text boxes, with the former relating to optometrists' criteria for glaucoma case-finding and the latter to perceived barriers to effective detection.

Equipment used for glaucoma detection and practice organisation (nine questions)

Section 3 aimed to establish the extent of pre-screening testing equipment available in the practice, any involvement in local glaucoma schemes, and whether the individual had completed any further postgraduate training specifically related to glaucoma.

Strategies for glaucoma referral (five questions)

Section 4 asked for the total number of referrals made by the optometrist, how many of these were related to COAG, to whom referrals were made, and what information was included in the referral.

Personal/Demographic information (two questions)

Respondents were invited to give their gender and year of registration.

There were four questions relating to optometric instrumentation, which formed the basis for this paper. These questions asked respondents to indicate via forced choice options which equipment they used for glaucoma detection i.e. for field testing, for optic nerve head examination and for the measurement of intra-ocular pressures. An additional question inquired whether participants possessed any more 'specialist' equipment from a pre-determined list. The authors' initial selection of the options for equipment was based on their knowledge of UK optometric pre- and post-registration training and practice. These options were refined following feedback from the pilot study.

This research was approved by the City University London Research and Ethical committee. The explanatory email sent to all potential optometrist participants, which included the hyperlink to the survey, contained full details of the research. Participation in the survey was completely voluntary and it was assumed that entering the survey constituted informed consent.

Results

A total of 2044 optometrists entered the survey, equating to a response rate of 27.5% of those UK registered optometrists who received an email. One thousand eight hundred and seventy-five of these (92%) were currently working as community practitioners and therefore eligible to complete the survey. The online format allowed participants to exit at any time and 611 of those starting the survey dropped out before completing the section relating to diagnostic equipment, the majority exiting at an earlier unrelated free-text question. An analysis of the demographics of this group did not reveal any significant differences when compared to the 1264 (response rate of 17%) who completed the survey (Chi-square $p > 0.05$). These 1264 respondents represent 11% of the total number of optometrists on the General Optical Council (GOC) register at the time of the survey. Of the 1264 respondents who completed the equipment section (*Table 1*), 57% were from independent practices, 23% worked in 'multiples' (familiar High Street optometrists) and the remainder were mainly locum optometrists who did not hold a residency post. Of the respondents, 46.9% were male and 53.1% were female, similar to the 48.2% male and 51.8% female distribution of GOC registrants for the year 2007–2008.[10] Similarly the percentage of respondents from England (83%), Scotland (8.2%), Wales (5.9%) and Northern Ireland (2.6%) was similar to the distribution of GOC registrants (82%, 9.5%, 4.8%, and 4.1% respectively) in those countries.

The equipment questions were divided into; methods for examining visual fields, methods for examining the optic nerve head, methods for measuring intraocular pressure (IOP) and a final section on more specialised instrumentation.

The first question asked 'which field testing equipment is normally used routinely for primary open angle glaucoma detection in the principal practice?' The choices were 'Humphrey, Henson, Dicon, Frequency Doubling Technology Perimeter (FDT), Friedmann Visual Field Analyser (VFA), Oculus Easyfield and Other', the final option incorporating a free-text option to indicate the instrument used. The survey revealed that a wide range of perimeters were used, however the instruments most frequently used were either one of the Henson range of instruments (39%) or the Humphrey Field Analyser (22%) (*Table 2*).

Respondents were asked to indicate their usual method of examining the optic nerve head. Options were, 'Direct', 'Indirect', 'Direct and Indirect' or 'Other please specify' (*Table 3*). The majority (62%) used a combination of direct and indirect. In a supplementary question 43% of

Table 1. The breakdown of optometrists by country according to the GOC 2007/8 Annual Report,[10] according to AOP demographics, and among survey respondents

	GOC *n* (%)	AOP *n* (%)	Survey respondents *n* (%)
England	9052 (81.6)	8973 (82.5)	1053 (83.3)
Scotland	1053 (9.5)	920 (8.5)	104 (8.2)
Wales	534 (4.8)	567 (5.2)	74 (5.9)
Northern Ireland	455 (4.1)	415 (3.8)	33 (2.6)
Total	11 094	10 875	1264

Table 2. Relative frequency of perimeter use by community optometrists

	Frequency of respondents (%*) in 2008 survey *n* = 1264	Frequency of respondents (%) in 1989 IGA survey *n* = 101
Henson	39	34
Humphrey	22	4
Dicon	15	N/A
FDT	12	N/A
Oculus Easyfield	6	N/A
VFA	2	40
Other	4	23†

*Percentages have been rounded to the nearest whole number resulting in some percentage totals differing from 100.
†Tangent screens (Fincham Sutcliffe, Bjerrum). FDT, Frequency Doubling Technology Perimeter; VFA, Friedmann Visual Field Analyzer.

Table 3. Relative frequency of the different methods of optic nerve head examination by community optometrists

	Frequency of respondents (%*) in 2008 survey *n* = 1264
Direct and indirect	62
Direct only	25
Indirect only	11
Digital imaging	1

*Percentages have been rounded to the nearest whole number resulting in some percentage totals differing from 100.

respondents stated that they additionally used a fundus photographic imaging system for photodocumentation.

Respondents were asked to indicate which method they used routinely to measure intra-ocular pressures. The choices were 'Non-Contact Tonometer (NCT), Pulsair, Perkins, Goldmann, Tonopen, Schiotz, I-Care and Other (please specify)'. Non-contact methods were most popular (78%), with respondents mainly using a hand-held Keeler Pulsair (36%) or one of the table-mounted non-contact tonometers (NCT) (43%). Of those 16% using contact applanation tonometry, 11% used a Perkins and 5% a Goldmann applanation tonometer (*Table 4*).

The final question asked 'Does your principal practice possess any of the following specialist equipment?' and respondents were asked to indicate the availability of equipment from the following list 'Optical Coherence Tomography (OCT), Scanning Laser Polarimeter (GD_X), Pachymeter, Heidelberg Retina Tomograph (HRT), Goniolens, and Other (please specify)'. A breakdown of responses is given in *Table 5*.

Table 4. Relative frequency of the use of different tonometers by community optometrists

	Frequency of respondents (%) in 2008 survey *n* = 1264	Frequency of respondents (%) in 1989 IGA survery *n* = 186
Table-mounted NCT	43	55
Pulsair	36	19
Perkins	11	26[†]
Goldmann	5	
Tonopen	1	N/A
I-Care	4	N/A
Schiotz	0	N/A
Other	0	N/A

[†]Combined frequency for Goldmann and Perkins tonometers.

Table 5. Relative frequency of the availability of specialist equipment in community optometric practice

	Frequency of respondents (%) in 2008 survey
Goniolens	12
Pachymeter	7
GDx	3
HRT	2
OCT	2
Other	0

GDx, Scanning Laser Polarimeter; HRT, Heidelberg Retina Tomograph; OCT, Optical Coherence Tomography.

Discussion

In the UK, the current practice of glaucoma detection depends largely on community optometrists, who are responsible for over 90% of COAG referrals to secondary care.[11] However, the reliance on optometrists means that screening is opportunistic and only performed on a self-selected population. Although 5.8 million NHS sight tests were conducted on patients over 60 in England and Wales in the year ending March 2010,[12] significant numbers of the population 'at risk' of COAG do not consult optometrists. Moreover, higher rates of late presentation are associated with living in areas of high social deprivation where optometrists' premises are poorly represented.[13] Nonetheless, knowledge of the case-finding strategies used by community optometrists is of significant public health importance. The results of the present study suggest that optometrists are well-equipped to perform the usual triad of tests (IOP, optic nerve head assessment and visual fields) necessary to detect glaucoma and significant developments in clinical practice have occurred in the years since the last large-scale national survey of optometrists (the IGA survey) conducted 20 years ago.[5–8] These comparisons with the IGA study cannot take into account the different modes of delivery of the two surveys (paper-based in the IGA survey vs computer-based) nor the geographical variations in the scope of the surveys (targeting specific areas in the IGA survey vs national) which may lead to a different demographic distribution among respondents.

Visual field testing

At the time of the IGA survey (1990) only half of optometrists had access to an automated perimeter.[7] The routine use of visual field testing equipment in optometric practice increased throughout the 1990s and by 1998 it was reported that one-third of practitioners were performing routine visual fields in patients over 40 years of age.[14] Virtually all optometrists (>95%) in the present survey reported that they had access to an appropriate automated perimeter that was used for the detection of glaucoma. Although respondents had access to a range of instruments, the majority used either one of the Henson range of instruments (39%) or the Humphrey Field Analyser (22%). In routine practice, visual field testing is only performed if deemed clinically necessary; however College of Optometrists guidance[2] states that an assessment of the visual field should be performed on all patients at risk of COAG. Although published audits of referrals for COAG have shown that information on visual fields is provided in 67–82% of referrals,[15,16] a recent study, using a standardised patient methodology, found that visual fields were

assessed by only 36% of optometrists in a patient at risk of developing COAG.[4] Counterintuitively, it has been shown that the increased adoption of perimetry by optometrists has not necessarily led to an improvement in diagnostic accuracy.[16,17] A possible explanation is that the GOS contract in England and Wales does not remunerate optometrists for repeat testing and so optometrists may not ascertain that a defect is reproducible before referral. Furthermore the increased use of visual field screening may identify non-glaucomatous field defects.

Another question in the survey asked respondents to give details in free text form of their case-finding strategies for patients with suspect glaucoma. Full details of responses will be presented in another paper. However, of relevance to the current paper is whether optometrists surveyed used suprathreshold or threshold (full threshold or SITA) paradigms when assessing visual fields. Sixteen percent of our respondents referred to a specific testing strategy. Of these, 6.3% referred specifically to suprathreshold field testing strategies and 9.7% referred to threshold or full threshold strategies. This preference for threshold strategies (61%) over suprathreshold (39%) is encouraging as it indicates that optometrists recognise the value of a more in-depth field investigation in patients with suspect glaucoma.

IOP measurement

The current survey revealed that 79% of optometrists used a non-contact tonometer for IOP measurement, specifically a table-mounted NCT (43%) or a hand-held Keeler Pulsair (36%). This finding is consistent with previous clinical practice surveys.[8,18] Non-contact tonometry gained popularity in optometric practice during the 1980s. It had obvious advantages as a screening test for glaucoma: the test was quick and easy to perform, did not require anaesthetic eyedrops, was acceptable to patients and could be delegated to optical assistants. Non-contact tonometry is associated with high levels of sensitivity and specificity for detecting IOPs > 21 mmHg.[19] However, instruments require regular maintenance and accuracy is compromised when fewer than the recommended number of readings are performed.[20] Recently, the Colleges of Optometrists and Ophthalmologists have produced joint guidance on referral for glaucoma which provides advice on maximising the accuracy of non-contact tonometry.[21]

Surprisingly few optometrists (16%) reported using applanation tonometry, the accepted reference standard, for routine glaucoma detection, despite the findings of a recent College of Optometrists Clinical Practice Survey showing that approximately 53% of optometrists possessed an applanation tonometer within their practice.[22] Potential barriers to the widespread adoption of applanation tonometry may include; training issues, recurring costs of the procedure and patient acceptance. Evidence from Scotland suggests that these barriers can be overcome. In 2006, a new General Ophthalmic Services (GOS) contract for Scotland required that optometrists demonstrate competence in Goldmann applanation tonometry before they could be accredited. As part of the contract a supplementary fee was negotiated to perform the test. These measures led to an increase in the number of glaucoma referrals which included information on applanation tonometry from 11.8% prior to the new contract to 50% following its introduction.[23]

Optic nerve head assessment

Ophthalmoscopic examination of the fundus, including the optic nerve head, is mandatory in all optometric eye examinations performed by community optometrists. However, the choice of technique is at the discretion of the optometrist. Traditionally, optometrists have used direct ophthalmoscopy through undilated pupils to examine the fundus as part of a general evaluation of the posterior pole. However, the reference standard for the assessment of the optic nerve head in glaucoma is slit lamp binocular indirect ophthalmoscopy, which provides a stereoscopic view of the optic nerve head. The majority of respondents in the survey (62%) used a combination of direct and indirect, with 25% using direct only. Although increasingly optometric practices are incorporating fundus imaging into a general eye examination (43% in our sample), fewer than 2% were specifically using fundus imaging as their only method of assessing the optic nerve head for the purposes of glaucoma detection. This finding is consistent with the study of Shah *et al.* using a standardised patient considered to be at risk of glaucoma.[4]

The use of slit-lamp binocular indirect ophthalmoscopy has increased amongst optometrists in recent years. It is now a core competency for GOC registration and is formally assessed by the College of Optometrists in professional qualifying examinations.

Specialised equipment for the detection of COAG

The survey also obtained data on more specialist equipment used by optometrists for glaucoma detection. In this question respondents were invited to select as many or as few instruments as applied, with the result that some will have selected two or more items of equipment from the list supplied. Fewer than 7% of respondents possessed specialist imaging devices (e.g. GDx, or OCT) that quantify nerve fibre loss in glaucoma. Significantly, only 7% of optometrists had access to a pachymeter and 12% had access to a goniolens. The recently published NICE

guideline[24] on the diagnosis and management of glaucoma states that all patients with suspect COAG or ocular hypertension should have pachymetry and gonioscopy at diagnosis. Pachymetry and gonioscopy are not core competencies for optometrists although since publication of the guideline both techniques have been given prominence at optometry continuing professional development events.

Limitations of the study

It is important when considering the results of a survey of this type to address the potential for response bias. The AOP provides professional indemnity insurance for approximately 90% of UK optometrists (AOP, personal communication) and therefore its membership database reflects the demographics of the GOC register. Optometrists were invited to participate in the survey via email and, as a result, only those AOP members who had provided a current email address were contacted, which may have biased the sample. However the demographics of those responding to the survey were consistent with the GOC register in terms of age and gender, with a similar stratification by geographic location (*Table 1*).

A further potential source of bias may be introduced by the self-selection inherent in surveys of this nature. It is probable that those who elected to participate, even though all input was anonymous, are likely to include a higher proportion of better motivated practitioners who feel most confident about the equipment that they use for glaucoma detection. It is possible that this self-selection will lead to some overestimation of the quality of equipment found in practices.

Although the wording of questions in the survey asked about diagnostic equipment 'used routinely in COAG detection', it is possible that self-reported practices may not reflect actual practices, particularly with respect to discretionary tests.[4] A recent study has demonstrated that UK optometrists perceive barriers that affect their case finding in patients at risk of glaucoma, primarily caused by financial and time constraints imposed by the current GOS contract, which may compromise the quality of their clinical assessment.[25]

A total of 1264 respondents answered the questions on equipment discussed in this paper. This represents 17% of those AOP members who received emails and 11% of the total number of optometrists on the GOC register at the time of the survey. Not all those on the GOC register would have been eligible to complete the survey, for example hospital optometrists would have been excluded. Nevertheless, these 1264 optometrists represent <15% of the total number of optometrists on the GOC register who were eligible to complete the survey. It is also possible that there was some 'double-counting' where more than one respondent reported results from the same practice. Therefore, caution should be exercised when extrapolating the results and conclusions from this survey to UK primary care optometrists as a whole.

In April 2009 guidelines commissioned by the National Institute for Health and Clinical Excellence regarding 'diagnosis and management of chronic open angle glaucoma and ocular hypertension' were released. Though only 'guidelines' *per se*, advice from professional bodies to the optometric profession strongly suggests that the recommendations are likely to be regarded by optometrists as setting professional standards. The survey discussed in this paper was conducted prior to the introduction of the NICE guidelines, but the authors suggest the guideline would have minimal impact on the instrumentation present within optometric practice. There is a possibility that there may be an increase in the use of applanation tonometers, but research suggests that an increase in referral rates has been the reaction of the profession.[26]

Conclusion

The results of the present study demonstrate that UK optometrists are well equipped for COAG case finding. The study also provides evidence that optometrists' skills and scope of practice in the detection of glaucoma have evolved since the last national survey, which was commissioned by the IGA in the late 1980s. There is a lack of standardisation of the case-finding protocol and the tests performed are at the discretion of the optometrist, thereby compromising diagnostic accuracy. Attempts at standardisation using accredited community optometrists in a variety of referral refinement/shared care models appear to be safe and clinically effective alternatives.[27,28] However, it is too early to determine whether these models are cost effective.

Acknowledgements

Miss Myint is funded through an unrestricted grant from Pfizer Ophthalmology. Dr Kotecha receives a proportion of her funding from the Department of Health's National Institute for Health Research Biomedical Research Centre for Ophthalmology at Moorfields Eye Hospital NHS Foundation Trust and the UCL Institute of Ophthalmology. The views expressed in this publication are those of the authors alone.

References

1. Bunce C & Wormald R. Causes of blind certifications in England and Wales: April 1999–March 2000. *Eye* 2008; 22: 905–911.

2. College of Optometrists. Code of Ethics and Guidelines for Professional Conduct, Section D3 examining patients at risk from glaucoma. http://www.college-optometrists.org/en/utilities/document-summary.cfm/docid/D15DFBC3-5146-432D-BEFE9681ED555393, accessed 18/10/10.
3. Scully ND, Chu L, Siriwardena D, Wormald R & Kotecha A. The quality of optometrists' referral letters for glaucoma. *Ophthalmic Physiol Opt* 2009; 29: 26–31.
4. Shah R, Edgar DF, Spry PG *et al.* Glaucoma detection: the content of optometric eye examinations for a presbyopic patient of African racial descent. *Br J Ophthalmol* 2009; 93: 492–496.
5. Tuck MW & Crick RP. Screening for glaucoma: age and sex of referrals and confirmed cases in England and Wales. *Ophthalmic Physiol Opt* 1992; 12: 400–404.
6. Tuck MW & Crick RP. Relative effectiveness of different modes of glaucoma screening in optometrist practice. *Ophthalmic Physiol Opt* 1993; 13: 227–232.
7. Tuck MW & Crick RP. Use of visual field tests in glaucoma by optometrists in England and Wales. *Ophthalmic Physiol Opt* 1994; 14: 227–231.
8. Tuck MW & Crick RP. Non-contact tonometry: optometrists current practice in England and Wales. *Ophthalmic Physiol Opt* 1994; 14: 347–350.
9. Burr JM, Mowatt G, Hernandez R *et al.* The clinical effectiveness and cost-effectiveness of screening for open angle glaucoma: a systematic review and economic evaluation. *Health Technol Assess* 2007; 11: 1–190.
10. GOC Annual Report 2007–8. http://www.optical.org/en/news_publications/Publications/annual_reports_archive.cfm, accessed 18/10/10.
11. Bowling B, Chen SDM & Salmon JF. Outcomes of referrals by community optometrists to a hospital glaucoma service. *Br J Ophthalmol* 2005; 89: 1102–1104.
12. General Ophthalmic Services Activity Statistics for England and Wales, NHS Information Centre, Dental and Eye Care Team. 2010. http://www.ic.nhs.uk/webfiles/publications/Primary%20Care/Eye%20care/gosactivity0910/General_Ophthalmic_Services_Activity_Statistics_for_England_and_Wales_2009_10.pdf, accessed 18/10/10.
13. Day F, Buchan JC, Cassells-Brown A, Fear A, Dixon R & Wood F. A glaucoma equity profile: correlating disease distribution with service provision and uptake in a population in Northern England, UK. *Eye* 2010; 24: 1478–1485.
14. Tuck MW & Crick RP. Glaucoma screening by optometrists: ten years on. *Health Trends* 1999; 30: 130–134.
15. Lash SC. Assessment of information included on the GOS 18 referral form used by optometrists. *Ophthalmic Physiol Opt* 2003; 23: 21–23.
16. Lockwood AJ, Kirwan JF & Ashleigh Z. Optometrists referrals for glaucoma assessment: a prospective survey of clinical data and outcomes. *Eye* 2010; 24: 1515–1519.
17. Vernon SA. The changing pattern of glaucoma referrals by optometrists. *Eye* 1998; 12: 854–857.
18. Willis CE, Rankin SJ & Jackson AJ. Glaucoma in optometric practice: a survey of optometrists. *Ophthalmic Physiol Opt* 2000; 20: 70–75.
19. Atkinson PL, Wishart PK, James JN, Vernon SA & Reid F. Maximising the sensitivity and specificity of non-contact tonometry in glaucoma screening. *Eye* 1992; 6: 530–534.
20. Vernon SA, Jones SJ & Henry DJ. Deterioration in the accuracy of the pulsair non-contact tonometer with use: need for regular calibration. *Eye* 1991; 5: 491–493.
21. Guidance on the referral of Glaucoma suspects by community optometrists issued by The College of Optometrists and The Royal College of Ophthalmologists 17 December 2009. Available: http://www.rcophth.ac.uk/docs/profstands/Guidance_on_the_referral_of_Glaucoma_suspects_by_community_optometrists_Final.pdf, accessed 18/10/10.
22. Medix UK & The College of Optometrists. The College of Optometrists Clinical Practice Survey: Market Research Report. London: Medix UK, 2008.
23. Ang GS, Ng WS & Azuara-Blanco A. The influence of the new general ophthalmic services (GOS) contract in optometrist referrals for glaucoma in Scotland. *Eye* 2009; 23: 351–355. Epub 2007 Nov 30.
24. National Institute for Health and Clinical Excellence (2009). Glaucoma: diagnosis and management of chronic open angle glaucoma and ocular hypertension. http://www.nice.org.uk/nicemedia/pdf/CG85FullGuideline.pdf, accessed 18/10/10.
25. Myint J, Edgar DF, Kotecha A, Murdoch IE & Lawrenson JG. Barriers perceived by UK based community optometrists to the detection of primary open angle glaucoma. *Ophthalmic Physiol Opt* 2010; 30: 1–7.
26. Edgar D, Romanay T, Lawrenson J & Myint J. Referral behaviour among optometrists: increase in the number of referrals from optometrists following the publication of the April 2009 NICE guidelines for the diagnosis and management of COAG and OHT in England and Wales and its implications. *Optom Pract* 2010; 11: 31–34.
27. Bourne RRA, French KA, Chang L, Borman AD, Hingorani M & Newsom WD. Can a community optometrist-based referral refinement scheme reduce false-positive glaucoma hospital referrals without compromising quality of care? The community and hospital allied network glaucoma evaluation scheme (CHANGES). *Eye* 2010; 24: 881–887.
28. Syam P, Rughani K, Vardy SJ *et al.* The Peterborough scheme for community specialist optometrists in glaucoma: a feasibility study. *Eye* 2010; 24: 1156–1164.

Eye (2010) 24, 1509–1514

www.nature.com/eye

CLINICAL STUDY

Development of a competency framework for optometrists with a specialist interest in glaucoma

J Myint[1], DF Edgar[1], A Kotecha[1,2], DP Crabb[1] and JG Lawrenson[1]

Abstract

Purpose **To develop a competency framework, using a modified Delphi methodology, for optometrists with a specialist interest in glaucoma, which would provide a basis for training and accreditation.**

Methods **A modified iterative Delphi technique was used using a 16-member panel consisting almost exclusively of sub-specialist optometrists and ophthalmologists. The first round involved scoring the relevance of a draft series of competencies using a 9-point Likert scale with a free-text option to modify any competency or suggest additional competencies. The revised framework was subjected to a second round of scoring and free-text comment. The Delphi process was followed by a face-to-face structured workshop to debate and agree the final framework. The version of the framework agreed at the workshop was sent out for a 4-month period of external stakeholder validation.**

Results **There was a 100% response to round 1 and an 94% response to round 2. All panel members attended the workshop. The final version of the competency framework was validated by a subsequent stakeholder consultation and contained 19 competencies for the diagnosis of glaucoma and 7 further competencies for monitoring and treatment.**

Conclusions **Application of a consensus methodology consisting of a modified Delphi technique allowed the development of a competency framework for glaucoma specialisation by optometrists. This will help to shape the development of a speciality curriculum and potentially could be adapted for other healthcare professionals.**

Eye (2010) **24,** 1509–1514; doi:10.1038/eye.2010.62; published online 14 May 2010

Keywords: competency-based education; optometry; glaucoma; Delphi technique

Introduction

The majority of UK glaucoma cases are identified by community optometrists after routine eye examinations. Individuals detected in this way are usually referred into the hospital eye service for formal diagnosis and on-going management. Over the past decade, increasing demand for the care of patients with diagnosed glaucoma and glaucoma suspects has led to the involvement of non-medical healthcare professionals in hospital-based glaucoma services and in community-based settings.[1] The baseline competencies of optometrists and their existing function in glaucoma case finding makes them suitable healthcare professionals to undertake extended functions in the diagnosis and management of the disease.

The recently published National Institute for Health and Clinical Excellence (NICE) guideline[2] on the diagnosis and management of chronic open angle glaucoma (COAG) and ocular hypertension (OHT) made recommendations regarding the involvement of non-medical healthcare professionals in the diagnosis of OHT and suspected COAG and the formulation of a management plan. Although NICE recommends that all patients with suspected glaucomatous damage should be referred to a consultant ophthalmologist for consideration of a definitive

[1]Department of Optometry and Visual Science, Henry Wellcome Laboratories for Vision Sciences, City University, London, UK

[2]NIHR BMRC for Ophthalmology, Moorfields Eye Hospital NHS Foundation Trust and UCL Institute of Ophthalmology, London, UK

Correspondence:
J Lawrenson, Department of Optometry and Visual Science, Henry Wellcome Laboratories for Vision Sciences, City University, Northampton Square, London EC1V 0HB, UK
Tel: +44 0207 0404 310;
Fax: +44 0207 0040 8494.
E-mail: j.g.lawrenson@city.ac.uk

Received: 25 January 2010
Accepted in revised form: 26 March 2010
Published online: 14 May 2010

diagnosis and formulation of a management plan, there was recognition that appropriately trained non-medical healthcare professionals could diagnose OHT, suspect glaucoma and make a preliminary identification of cases of COAG. Furthermore, persons with a diagnosis of OHT, suspect COAG or COAG could also be monitored and treated under shared-care arrangements by trained non-medical healthcare professionals.

The NICE guideline stipulated that healthcare professionals involved in the diagnosis, monitoring and treatment of glaucoma should have relevant experience and a specialist qualification in glaucoma when not working under the direct supervision of a consultant ophthalmologist. An appropriate prescribing qualification would also be required for those involved in glaucoma treatment.

To develop curricula for specialist training and criteria for accreditation, the requisite diagnostic and management competencies need to be agreed. This study aimed to define a competency framework for optometrists with a specialist interest in glaucoma. Competencies build on those required by the General Optical Council (GOC) for registration as an optometrist.[3]

Materials and methods

A modified Delphi approach was used to seek views on the content of the competency framework. The Delphi technique is a well-established method that gathers a consensus of 'expert' opinion and has been applied to the development of competency frameworks and curricula for medical sub-specialities.[4–6] It involves a series of rounds to gather opinion anonymously, interspersed by controlled feedback. The advantage of the Delphi technique is that participants can express views without being influenced by others. The Delphi process was followed by a face-to-face workshop to facilitate consensus on borderline competencies and to agree the final framework.

The Delphi panel consisted of a multi-disciplinary group of five glaucoma sub-specialist ophthalmologists, ten glaucoma specialist optometrists and a researcher with extensive expertise in glaucoma. The panel was chosen using a convenience sampling technique to provide perspectives from ophthalmologists involved in glaucoma treatment, optometrists participating in hospital or community co-management of glaucoma and academics with experience in postgraduate education of optometrists.

To reduce the number of rounds, draft competency statements relating to the diagnosis, monitoring and treatment of glaucoma were generated by the project steering group. The expert panel members were invited to anonymously comment on and score these competencies using a 2-round Delphi process.

The questionnaire comprised two sections: Section A related to those competencies that should be shown by an optometrist involved in glaucoma diagnosis. NICE guidance describes this function as 'diagnosis of OHT and suspect COAG status and preliminary identification of COAG'. Section B related to those competencies possessed by an optometrist additionally involved in glaucoma monitoring and treatment. NICE defined this function as 'healthcare professionals involved in the monitoring and treatment of people with OHT, suspected COAG and established COAG'.

In round 1, panel members scored each statement on a 9-point Likert scale, ranging from 0 = 'not essential' to 9 = 'essential' for each specialist function (diagnosis or management). Respondents could also suggest modifications to the wording of each statement or suggest additional competencies. Written feedback on the round 1 result was given to panel members, along with a revised framework incorporating the suggestions from round 1 for rescoring and comment. For each statement, the mean rating was calculated together with the mean percentage of respondents scoring the competency above 5 (the neutral point).

As the literature on the Delphi technique does not stipulate the level at which consensus is judged to have been reached, this was chosen arbitrarily. Competencies with a mean score >5 with more than a 2/3 majority (66.6%) scoring the statement $\geqslant 6$ were included in the framework without further discussion at the workshop. Competencies were excluded if they had a mean score of <5 or if fewer than 66% of respondents scored the competency >5. All borderline competencies were considered at the workshop discussion and a consensus reached on the day (2/3 majority) regarding their inclusion in the framework. The version of the competency framework that was agreed after the workshop was circulated to relevant stakeholders (including national bodies representing optometrists, ophthalmologists, general practitioners, nurses and orthoptists) during a 4-month consultation period.

Results

Round 1

There was a 100% ($n = 16$) return for round 1 questionnaires. Twenty competency statements were initially presented and after analysis of the round 1 response, the wording of eight statements was modified

Table 1 Round 2 ratings for competencies required by optometrists involved in the diagnosis, and in monitoring and treatment of glaucoma

Competency	*Diagnosis*		*Monitoring/treatment*	
	Mean rating (9 = essential)	*% Scoring ⩾6*	*Mean rating (9 = essential)*	*% Scoring ⩾6*
1. The ability to take a comprehensive ophthalmic history in a patient with diagnosed or suspected glaucoma, including the identification of ocular and systemic risk factors for glaucoma.	7.4	87	8.6	93
2. The ability to maintain clear, accurate and contemporaneous clinical records of ophthalmic history, examination and results of clinical investigations in patients at risk of or with suspected glaucoma.	7.9	87	8.6	93
3. The ability to carry out an appropriate examination of the anterior segment of the eye in a patient at risk of, or with suspected glaucoma and to interpret relevant clinical signs.	8.3	93	8.7	100
4. The ability to perform the van Herick technique for the assessment of peripheral anterior chamber depth and to interpret the significance of the results.	8.1	93	7.6	87
5. The ability to perform a gonioscopic examination of the anterior chamber angle and to identify anatomical structures, accurately grade the angle width and interpret the significance of clinical findings.	7.1	80	7.8	87
6. The ability to perform an assessment of central corneal thickness using appropriate instrumentation and to interpret the significance of the results.	7.6	87	8.1	87
7. The ability to recognise the signs and symptoms of a patient suffering from angle-closure glaucoma (or at risk of angle closure) and to refer the patient accordingly (including the instigation of emergency treatment, if necessary).	8.5	93	7.9	100
8. The ability to assess the optic nerve head by binocular indirect ophthalmoscopy and to detect the characteristic features of glaucomatous optic neuropathy.	8.9	93	9.0	100
9. An understanding of supra-threshold perimetric techniques used in the assessment of a patient with suspected glaucoma, including test strategies used, sources of error, interpretation of results and the recognition of glaucomatous field loss.	8.4	93	7.9	87
10. An understanding of the use of threshold perimetric techniques used in the assessment of a patient with manifest glaucoma and the ability to detect the progression of disease.	6.7	67	9.0	100
11. An understanding of the imaging techniques used to assess the optic nerve head and retinal nerve fibre layer and the ability to interpret the results of such investigations.	6.5	73	8.1	86
12. The ability to differentially diagnose glaucoma through an interpretation and integration of the results of clinical examination and the results of any further investigative techniques.	8.3	93	8.6	100
13. The ability to detect and appreciate the significance of concurrent pathology in the management of glaucoma.	7.5	93	8.0	100
14. The ability to recognise the indications for treatment in glaucoma, the concept of target pressures and risk factors for disease progression.	7.2	60	8.6	100
15. The ability to detect a change in clinical status (e.g. visual field status, intra-ocular pressure, assessment of anterior or posterior segments).	6.5	67	9.0	100
16. The ability to monitor the response to treatment and modify the management plan or consult a more experienced colleague, if necessary.	4.1	33	9.0	100
17. An understanding of time frames for follow-up of patients taking into account local preferences, risk of progression and patient-related factors (age, concurrent disease, etc.).	4.9	53	8.9	100
18. Knowledge of the pharmacology, cautions, contraindications, interactions and side effects of anti-glaucoma medication.	4.9	53	8.6	100
19. Knowledge of the surgical management of the glaucomas, including indications for surgery, surgical techniques, complications and post-operative evaluation.	3.8	40	8.1	100
20. An awareness of one's own limitations and the ability to make clinical decisions based on the needs of the patient.	8.3	93	9.0	100
21. The ability to operate within local protocols for the detection and/or management of glaucoma.	8.1	93	8.9	100
22. The ability to help patients make informed choices about their management and to check their understanding of and commitment to their management and follow-up.	6.1	60	8.6	100
23. The ability to counsel patients regarding risks of blindness associated with glaucoma, risk to family members, potential impact of the disease on lifestyle (including driving) and provide information on available sources of help, counselling and support.	7.2	80	8.6	100

and three additional competencies added. Twenty-three statements were presented for scoring and comment in round 2.

Round 2

There was an 94% ($n=15$) return for round 2. Table 1 shows the competency statements and corresponding scores at the end of round 2. Panel consensus deemed that all 23 competencies were required for a function in glaucoma monitoring and treatment (Table 1).

For a diagnostic function, four competencies (Table 1, points 16, 17, 18 and 19) did not meet the criteria for consensus and were deemed not to be required for diagnosis. Four diagnostic competencies (Table 1, points 10, 14, 15 and 22) were considered 'borderline' and were discussed at the subsequent workshop.

Workshop

All Delphi panel members attended the workshop, at which borderline competencies were discussed and consensus reached regarding their inclusion. Competencies 9 and 10 were condensed into a single statement. Although applanation tonometry is a GOC entry level competency for registration as an optometrist, the panel felt that the specific competency statement relating to tonometry needed further precision and the revised statement *'The ability to accurately measure intraocular pressure using a slit-lamp mounted Goldmann applanation tonometer and the ability to analyse and interpret the results'* was added to the framework (competency statement 8, Appendix 1). The framework agreed after the workshop contained 19 competencies for glaucoma diagnosis and 7 further competencies for monitoring and treatment (Appendix 1).

Stakeholder consultation

After replies received during the consultation period, minor editorial changes were made to the wording of three competencies; however, the final competency framework (Appendix 1) did not differ significantly in content from that agreed at the workshop.

Discussion

The modified Delphi exercise has facilitated the development of a competency framework applicable to all optometrists with a specialist interest in glaucoma, whether they are hospital based or whether they provide primary-care optometry in community practice.

Vernon and Adair[1] recently determined the number and scope of shared-care schemes operating in England. In 2006, 58% of ophthalmic departments were operating schemes using a variety of non-medical healthcare professionals. These were predominantly in-house (80%), although approximately 14% were operating community-based schemes using optometrists.

Studies suggest that optometrists with additional training in glaucoma are able to make reliable and accurate diagnostic and management decisions.[7,8] However, training programmes differ widely across the United Kingdom. Although variations in training may reflect the experience and responsibilities of the optometrists involved, there is an urgent need for standardisation in training and accreditation.

The NICE guideline on the diagnosis and management of OHT and COAG[1] made recommendations on the organisation of care and began to define the competencies required for healthcare professionals involved in glaucoma service delivery. Competency frameworks, which define the core skills and knowledge for effective performance, provide a sound underpinning of curricula for core and specialist training, provide criteria for accreditation and inform the commissioning of continuing professional development. Such frameworks have been used extensively in the optometric profession for both pre-registration[3] and specialist post-registration education and training.[9]

Our study shows that the Delphi technique is a robust method for gaining autonomous expert opinion. Although the project steering group made the initial selection of competencies, the Delphi panel had opportunities to refine and add further competencies. We used a multi-disciplinary panel with wide experience in glaucoma detection and management. It is acknowledged that the use of a convenience sampling method for panel selection may have led to hidden bias. However, potential bias was largely offset by the subsequent wide stakeholder consultation to validate the framework.

Although the competency framework was developed specifically for optometrists, other non-medical healthcare professionals are also involved in glaucoma service delivery, for example nurses and orthoptists.[1] It is to be expected that the framework could be adapted for these professions. A shared competency-based approach could enable a coordinated training and development model for all professionals involved in glaucoma detection and management.

Summary

What was known before?

- Increasing demand for the care of patients with diagnosed glaucoma has led to the involvement of non-medical healthcare professionals (including optometrists) in hospital-based glaucoma services and in community-based settings.
- Training and accreditation for specified functions in diagnosis and management of the disease vary widely.

What this study adds

- The use of a modified Delphi exercise has facilitated the development of a competency framework for optometrists with a specialist interest in glaucoma.
- The framework is applicable to all optometrists with a special interest in glaucoma, whether they are hospital based or whether they provide primary care optometry in community practice.
- A competency-based approach will allow a co-ordinated training and development model to be developed for optometrists involved in the detection and management of glaucoma and could be adapted for other healthcare professionals.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

We thank all members of the Delphi panel who gave up their time for the development of the competency framework.

Appendix 1

Competency framework for optometrists with a specialist interest in glaucoma

Competencies required for optometrists involved in the diagnosis of glaucoma

1. The ability to take a comprehensive ophthalmic history in a patient with diagnosed or suspected glaucoma, including the identification of ocular and systemic risk factors for glaucoma.
2. The ability to maintain clear, accurate and contemporaneous clinical records of ophthalmic history, examination and results of clinical investigations in patients at risk of or with suspected glaucoma.
3. The ability to carry out an appropriate examination of the anterior segment of the eye in a patient at risk of, or with suspected glaucoma and to interpret relevant clinical signs.
4. The ability to perform the van Herick technique for the assessment of peripheral anterior chamber depth and to interpret the significance of the results.
5. The ability to perform a gonioscopic examination of the anterior chamber angle and to identify anatomical structures, accurately grade the angle width and interpret the significance of clinical findings.
6. The ability to perform an assessment of central corneal thickness using appropriate instrumentation and to interpret the significance of the results.
7. The ability to recognise the signs and symptoms of a patient suffering from angle-closure glaucoma (or at risk of angle closure) and to refer the patient accordingly (including the instigation of emergency treatment, if necessary).
8. The ability to accurately measure intraocular pressure using a slit-lamp mounted Goldmann applanation tonometer and the ability to analyse and interpret the results.
9. The ability to assess the optic nerve head by binocular indirect ophthalmoscopy and to detect the characteristic features of glaucomatous optic neuropathy.
10. An understanding of the use of perimetric techniques for the assessment of a patient with suspected

References

1 Vernon SA, Adair A. Shared care in glaucoma: a national study of secondary care lead schemes in England. *Eye* 2010; **24**: 265–269.
2 Glaucoma: diagnosis and management of chronic open angle glaucoma and ocular hypertension. National Collaborating Centre for Acute Care. April 2009. http://guidance.nice.org.uk/CG85.
3 The General Optical Council Stage 2 Core Competencies for Optometry. June 2005. http://www.optical.org/en/our_work/Standards/Standards_in_competence.cfm.
4 Stewart J, O'Halloran C, Harriagan P, Spencer JA, Barton JR, Singleton SJ. Identifying appropriate tasks for the preregistration year: modified Delphi technique. *BMJ* 1999; **319**: 224–229.
5 Hay EM, Campbell A, Linney S, Wise E. Development of a competency framework for general practitioners with a specialist interest in musculoskeletal/rheumatology practice. *Rheumatology* 2007; **46**: 360–362.
6 Clancy M, Kilroy D, Driscoll P. Content prioritisation of the College of Emergency Medicine speciality curriculum: an exploratory study using a modified Delphi approach. *Emerg Med J* 2009; **26**: 180–182.
7 Banes MJ, Culham LE, Bunce C, Xing W, Viswanathan A, Garway-Heath D. Agreement between optometrists and ophthalmologists on clinical management decisions for patients with glaucoma. *Br J Ophthalmol* 2006; **90**: 579–585.
8 Azuara-Blanco A, Burr J, Thomas R, Maclennan G, McPherson S. The accuracy of accredited glaucoma optometrists in the diagnosis and treatment recommendation for glaucoma. *Br J Ophthalmol* 2007; **91**: 1639–1643.
9 Competency framework for prescribing optometrists. National Prescribing Centre and General Optical Council. May 2004. http://www.npc.co.uk/prescribers/competency_frameworks.htm.

glaucoma, including test strategies used, limitations, sources of error, interpretation of results and the recognition of glaucomatous field loss.

11. An understanding of the imaging techniques used to assess the optic nerve head and retinal nerve fibre layer and the ability to interpret the results of such investigations.
12. The ability to differentially diagnose glaucoma from other ocular and central visual pathway anomalies through an interpretation and integration of the results of clinical examination and the results of any further investigative techniques.
13. The ability to understand treatment options and when they may be appropriate.
14. An understanding of the risk factors for conversion to glaucoma and the ability to detect change in optic nerve parameters.
15. The ability to make clinical decisions based on the needs of the patient.
16. Awareness of one's own limitations and the ability to consult a more experienced colleague, if necessary.
17. The ability to operate within local protocols for the detection and/or management of glaucoma.
18. The ability to help patients make informed choices within the limits of the patient's and practitioner's understanding after their diagnosis.
19. The ability to counsel patients regarding risks of blindness associated with glaucoma, risk to family members, and potential impact of the disease on lifestyle (including driving) and the ability to provide information on available sources of help, counselling and support.

Additional competencies required for optometrists involved in the monitoring and treatment of glaucoma.

20. The ability to monitor the response to treatment and modify the management plan, if necessary.
21. An understanding of the use of perimetric tests for the assessment of a patient with manifest glaucoma, including test strategies used, limitations, sources of error, interpretation of results and the recognition of glaucomatous field loss.
22. The ability to detect a change in clinical status (eg visual field status, intraocular pressure, assessment of anterior or posterior segments).
23. Knowledge of the pharmacology, cautions, contraindications, interactions and side effects of anti-glaucoma medication.
24. Knowledge of the indications for, techniques, expected outcomes and complications of laser therapies and surgical interventions used in the management of glaucoma and its related conditions.
25. An understanding of time frames for follow-up of patients taking into account local preferences, risk of progression, and patient-related factors (age, concurrent disease, etc.).
26. The ability to help patients make informed choices about their management and to check their understanding of and commitment to their management and follow-up.

Optometry in Practice 2010 Volume 11 33 – 38

Referral Behaviour Among Optometrists: Increase in the Number of Referrals from Optometrists Following the Publication of the April 2009 NICE Guidelines for the Diagnosis and Management of COAG and OHT in England and Wales and its Implications

Dave Edgar FCOptom, Tina Romanay MCOptom, John Lawrenson MCOptom and Joy Myint MCOptom

City University London

C-13098 1 CET point for optometrists

Background

The National Institute for Health and Clinical Excellence (NICE) guidelines for the diagnosis and management of chronic open-angle glaucoma (COAG) and ocular hypertension (OHT) in England and Wales were issued on 22 April 2009 (NICE 2009). In response to these guidelines, the Association of Optometrists (AOP), Association of British Dispensing Opticians (ABDO) and Federation of Ophthalmic and Dispensing Opticians (FODO) subsequently issued guidance (AOP: April 2009 and reiterated in June and October 2009) advising optometrists to refer intraocular pressures (IOPs) exceeding 21mmHg to an ophthalmologist, even if optic nerve heads and visual fields appeared normal. This advice related to IOPs recorded on any reliable and consistent tonometer and not just to Goldmann applanation tonometry.

When the NICE guidance was issued, the authors were in the final stages of preparation for the distribution of a web-based questionnaire which was soon to be distributed to the 9386 optometrists on the College of Optometrists' e-mail circulation list. The aims of the questionnaire were to collect data on the patterns of referrals made by optometrists to medical practitioners and to assess the nature and quality of interprofessional communication regarding these referrals. The survey was due to go 'live' soon after the publication of the NICE guidelines and this timing provided an opportunity to assess the effects of the guidance on referral numbers. To take advantage of this opportunity the survey was modified to include an extra question at the start of the questionnaire which asked each optometrist for the number of additional referrals, based on the NICE glaucoma guidelines only, made in the previous working month.

The new question was 'bolted on' to the top of the existing, already piloted questionnaire and this resulted in some constraints on how the question was phrased and on how the responses were categorised and analysed. These constraints introduce some limitations on the accuracy of the analysis of the responses to this question. Nevertheless, these data give the first nationwide and profession-wide snapshot of the immediate effect of the NICE guidance on the number of glaucoma referrals. The survey was conducted between 11 June and 23 July 2009.

Results

Question 1 of the survey read: 'Based on the recently published NICE guidelines only, approximately how many referrals have you made in the last working month? These are the referrals for suspected glaucoma/OHT that you would not have made prior to the introduction of the NICE guidelines.' There were 1124 responses to this question and these are summarised in Table 1.

Table 1. Estimate of the number of additional glaucoma referrals made in a month following publication of the NICE guidelines. The number of responses to this question totalled 1124.

Number of NICE referrals in the previous month	Response %	Response count
0	17.4	196
1–4	51.0	573
5–9	21.6	243
10–14	7.1	80
15–19	2.1	24
20–25	0.5	6
25+	0.2	2

Based on the data in Table 1 it is possible to calculate an approximate 'average number of additional referrals per optometrist per month'. To arrive at this average figure it is necessary to assume an 'average' number of referrals in each of the categories that respondents could select. These averages were as follows: for 1–4 referrals, the average taken was 2 referrals; for 5–9 referrals, average 7; for 10–14 referrals, average 12; for 15–19 referrals, average 17; for 20–24 referrals, average 22; and for 25+ referrals, average 25.

Multiplying the average number of referrals in each category by the number of respondents who selected that category and adding these products gives an approximate total number of referrals. For the 1124 optometrists who answered question 1 this gives an average of 3.9 additional referrals per optometrist per month. This is equivalent to approximately 540 000 additional referrals per year as a result of the NICE guidelines when extrapolated to reflect the 11 500 optometrists on the General Optical Council (GOC) register.

Date of acceptance: 22 December 2009. Address for correspondence: Dave Edgar, Henry Wellcome Laboratories for Vision Sciences, Department of Optometry and Visual Science, City University, Northampton Square, London EC1V 0HB.

Question 2 of the survey read: 'Apart from the additional NICE referrals listed above, approximately how many referrals have you made in the last working month to a medical practitioner (for example GP, ophthalmologist or other specialist)? These are all the referrals that were unaffected by the NICE guidelines, and you should include referrals for all conditions (not just suspected glaucoma).' The number of responses to this question totalled 1124 and these are summarised in Table 2.

Table 2. Estimate of the number of referrals made in a month, excluding those additional glaucoma referrals resulting from the publication of the NICE guidelines. The number of responses to this question totalled 1124.

Non-NICE referrals	Response %	Response count
0	1.2	14
1–4	13.9	156
5–9	35.4	398
10–14	26.9	302
15–19	13.3	150
20–25	6.5	73
25+	2.8	31

Using the same method of calculation described above, this gives an average of 10.4 referrals per optometrist per month, equivalent to approximately 1 435 000 non-NICE referrals per year when extrapolated to reflect the total number of optometrists on the GOC register. This total number of referrals is similar to the figure of 1 380 000 referrals obtained by calculation from data in a recent paper which also surveyed UK optometrists (Needle et al. 2008).

Discussion

In the period immediately following the issue of the NICE guidelines, the additional NICE referrals increased the total number of referrals made by these 1124 optometrists by 37.5%.

It is notable that 17.4% of respondents made zero NICE referrals. This figure may be attributable to a number of factors, including ignorance of the guidelines or variations in their interpretation, practitioners engaged in part-time or hospital practice, and optometrists in Scotland and Northern Ireland whose mode of practice was not affected by the NICE guidelines or by the AOP advice at the time of the survey. Although the survey response rate was only 12%, demographic data collected on each respondent suggest that the sample is broadly representative of the UK optometric profession.

Other sources give lower pre-NICE estimates of the total number of referrals per year than the 1 435 000 calculated from data from this survey, notably the figure of 780 000 which can be generated from the 2008 *Optics at a Glance* data (FODO 2008). Based on this figure of 780 000, applying the 37.5% additional NICE-based referrals found in our survey yields 292 500 additional NICE referrals for suspect glaucoma per annum.

If the number of additional referrals for suspect glaucoma immediately following the introduction of NICE guidance were replicated over 1 year, the additional 290 000–540 000 referrals would place a significant additional burden on the Hospital Eye Service.

Clearly these data should be interpreted with caution, since there were limitations to the study and optometrists may have modified their approach to the management of ocular hypertensives since the introduction of the guidelines. For example, practitioners may have been over-conservative in their management of ocular hypertensives in the period immediately following the introduction of the NICE guidelines, leading to more referrals during this period than subsequently. Alternatively, some of the 17.4% of practitioners who reported zero NICE referrals in this survey may now be referring ocular hypertensives as they became more aware of the NICE guidance and the AOP advice. Nevertheless, these data provide a useful insight into the short-term impact of the NICE guidance on referral patterns in the UK.

Acknowledgements

The authors thank the College of Optometrists for their support and co-operation with the distribution of the survey. We are also most grateful to the Optometric Collaborative Research Network (OCRN) for their invaluable assistance in piloting the survey. Miss Myint is funded through an unrestricted grant from Pfizer. The content of this paper presents the opinions of the authors alone and does not represent the views or opinions of any other organisation, business or institution.

Summary

The authors analyse and discuss the implementation of the April 2009 National Institute for Health and Clinical Excellence (NICE) guidelines for the diagnosis and management of chronic open-angle glaucoma (COAG) and ocular hypertension (OHT) in England and Wales. The discussion and commentary draw out implications for practitioners, including the possible consequences of non-compliance with professional guidance, and gives an overview of the fitness-to-practise procedure.

References

- Association of Optometrists (2009) Advice on NICE glaucoma guidelines. Available online at: http://www.aop.org.uk/uploaded_files/glaucoma_advice_and_faqs_01.06.09.pdf (accessed 23.11.09)
- Federation of Ophthalmic and Dispensing Opticians (2008) *Optics at a glance*. Available online at: http://www.fodo.com/fckextras/File/OAAG%202008,%20FINAL%20FINAL.pdf (accessed 23.11.09)
- National Institute for Health and Clinical Excellence (2009) Glaucoma: diagnosis and management of chronic open angle glaucoma and ocular hypertension. Available online at: http://www.nice.org.uk/nicemedia/pdf/CG85FullGuideline.pdf (accessed 23.11.09)
- Needle JJ, Petchey R, Lawrenson JG (2008) A survey of the scope of therapeutic practice by UK optometrists and their attitudes to an extended prescribing role. *Ophthalmol Physiol Opt* **28**, 193–203
- Steele C, Spry P (2009) The NICE guideline on diagnosis and management of chronic open-angle glaucoma and ocular hypertension: implications for optometry. *Optometry in Practice* **10**, 33–50

Commentary

Professor Stephen Parrish BSc PhD FCOptom MIET FHEA

From this survey it is surprising that 17.4% of practitioners did not change their referral criteria as a result of publication of the NICE guidance; this guidance was widely distributed throughout the professions and was published in a number of journals, including *Optometry in Practice*. As stated in the article, there may be reasons based around modality of practice which account for this figure but equally it may be that some practitioners do not appreciate the existence of the guidance or have chosen to ignore its advice. The increased burden on the Hospital Eye Service is also apparent from the survey results and this may well cause problems in areas where the ophthalmological services are already overburdened. This increased workload may put pressure on optometrists not to make 'low-risk' referrals and some practitioners may take the view that the existing arrangements have served them well for many years and so do not see any necessity for change.

Primary open-angle glaucoma is common, affecting around 2% of people older than 40 years and rising to 10% in white Europeans over the age of 75 years (Steele & Spry 2009). In a month, an average practitioner might see several cases warranting referral according to the NICE guideline.

Some will be ocular hypertensive, but a proportion will be genuine cases of glaucoma. There may be difficulty in defending accusations of impaired fitness to practise if cases of glaucoma are missed due to non-compliance with the guidelines.

It may be useful to reflect on the legal process which such an allegation would follow. When the GOC investigate an allegation, they need to put forward a case to the Fitness to Practise (FTP) committee. The FTP committee will hear the case and decide whether the registrant is guilty and whether the practitioner's fitness to practise is impaired.

In judging whether the practitioner's actions indicate impaired fitness to practise, the courts and professional bodies take into account any statutory legislation and professional guidance in force at the time, together with how a reasonable body of practitioners would act in similar circumstances. It would, therefore, be difficult to defend your action if you do not comply with guidance which has been accepted by the relevant professional bodies and implemented by your peers. Relying on being able to say you exercised your 'clinical judgement' to support your actions is only a credible line of defence if it is supported by an expert, or considerable body of, opinion.

It should further be noted that the General Optical Council (GOC) has changed the standard of proof in fitness to practise cases, which makes it easier for patients to prove their case.

The FTP committee applies the civil court standard of proof with a sliding scale. This means that the standard of proof applied to the facts in a case is on 'the balance of probabilities' (ie that the events described in an allegation are more probable than not). Applying this less rigorous test than the criminal court standard (ie 'beyond reasonable doubt') means that if the evidence suggests that something is more likely to have happened than not, then this is considered sufficient to judge that it has taken place.

It must be emphasised, therefore, that practitioners may compromise their defence in the event of a complaint if they fail to refer patients in accordance with the advice given by professional bodies, and they should consider carefully any external pressure to ignore this advice, however well intentioned it may be. All patients falling within the NICE guidelines for referral should be managed accordingly and, in doing so, the best interest of both patients and practitioners will undoubtedly be served.

And Finally

To Dave and John……..Thank you.