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Optometric Case Finding for Glaucoma in Ireland: An Investigation of Current Practice Patterns.

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Optometric case finding for glaucoma in Ireland: An investigation of current practice patterns.

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PhD Thesis

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Abstract

Optometrists play a vital role in the detection of glaucoma, a leading cause of irreversible blindness. As population screening for glaucoma is neither cost effective nor viable, glaucoma is primarily detected through opportunistic case-finding during routine eye examinations. The present study provides new insight into optometrists' practice patterns for glaucoma detection in Ireland. Chapters 3 and 4 report on a national survey. The results show that optometrists are well equipped to carry out the traditional glaucoma case finding triad. However, moving towards enhanced services such as monitoring glaucoma suspects or ocular hypertension cases would require some investment in equipment and training. Training, finance, and time restrictions were identified by optometrists as key barriers to detecting glaucoma during routine eye examinations. Optometrists showed strong interest in furthering optometric professional development and expanding the traditional role boundaries in Ireland. Chapters 5 and 6 describe our pilot collaborative care pathway, the Dublin glaucoma referral refinement and monitoring service. This pathway facilitated community refinement and monitoring of the majority (62%) of glaucoma suspect patients (n = 225) referred by optometrists, acting to bridge the gap between the sensitivity required when case finding for glaucoma and the specificity required when initiating treatment. Chapter 7 presents an analysis of optometrists' referral letters for suspect glaucoma, establishing an objective reference point for optometric case-finding strategies. The results highlight key areas for clinical practice reforms such as uptake of Goldmann applanation tonometry, pachymetry, and disc size measurement. Chapter 8 provides a summary and conclusions on the work, and contains recommendations for future research.

Declaration

I certify that this thesis which I now submit for examination for the award of PhD, is entirely my own work and has not been taken from the work of others, save and to the extent that such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the regulations for graduate study by research of the Dublin Institute of Technology (DIT) and has not been submitted in whole or in part for another award in any other third level institution.

The work reported on in this thesis conforms to the principles and requirements of the DIT's guidelines for ethics in research.

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Candidate: Catriona Barrett

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Abbreviations List

AMD	Age-related Macular Degeneration
AOI	Association of Optometrists Ireland
A/C	Anterior Chamber
ACG	Angle Closure Glaucoma
AOP	Association of Optometrists
BIO	Binocular Indirect Ophthalmoscopy
BSCGS	the Bristol Shared Care Glaucoma Study
CAT	Contact Applanation Tonometry
CCT	Central Corneal Thickness
CDR	Cup-Disc Ratio
COAG	Chronic Open Angle Glaucoma
CoO	College of Optometrists
COP	Community Ophthalmic Physician
CORU	Health & Social Care Professionals Council
COSMTS	Community Ophthalmic Services Medical Treatment Scheme
COSS	Community Ophthalmic Services Schemes
CPD	Continuing Professional Development
DIT	Dublin Institute of Technology
DR	Diabetic Retinopathy
EGPS	European Glaucoma Prevention Study
EU	European Union
FODO	Federation of Ophthalmic and Dispensing Opticians
GAT	Goldman Applanation Tonometry
GON	Glaucomatous Optic Neuropathy

GOS	General Ophthalmic Services
GP	General Practitioner
GRR	Glaucoma Referral Refinement
GRRMS	Glaucoma referral refinement and monitoring service
HES	Hospital Eye Service
HIQA	Health Standards and Quality Authority
HSCP	Health & Social Care Professionals
HSE	Health Service Executive
ICO	Irish College of Ophthalmologists
IMO	Irish Medical Organisation
IOP	Intraocular Pressure
MREH	Manchester Royal Eye Hospital
NCBI	National Council for the Blind of Ireland
NCP	National Clinical Programme
NCT	Non-Contact Tonometry
NES	NHS Education for Scotland
NHS	National Health Service
NICE	National Institute of Health and Clinical Excellence
NOC	National Optometry Centre
NRR	Neural Retinal Rim
NTG	Normal Tension Glaucoma
NTPF	National Treatment Purchase Fund
OCT	Optical Coherence Tomography
OHT	Ocular Hypertension
OHTS	Ocular Hypertension Treatment Study

OLGA	Optometric Led Glaucoma Assessment
ONH	Optic Nerve Head
PCET	Primary Care Eye Team
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
RVEEH	Royal Victoria Eye and Ear Hospital
SLBIO	Slit Lamp Binocular Indirect Ophthalmoscopy
SD	Standard Deviation
SOG	Specialist Optometrist in Glaucoma
SP	Standardised Patient
TD	Teachta Dála: member of the Irish parliament
UK	United Kingdom
vCDR	Vertical Cup-disc Ratio
VEGF	Vascular Endothelial Growth Factor
VF	Visual Fields

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1. OPHTHALMIC CARE IN IRELAND

1.1 Structure of eye care in Ireland

Ophthalmic care in Ireland is delivered by a range of health care professionals including ophthalmologists, optometrists, orthoptists, general practitioners (GPs), dispensing opticians and ophthalmic technicians, as well as various specialties within the nursing profession such as public health nurses, and clinical specialist eye nurses. Our eye care services are delivered in community and acute care settings, with different professional mixes operating in each environment.

Optometry is the largest body of professionals with 792 optometrists currently registered to practice in Ireland.[1] Ophthalmology is the second largest body with approximately 195 ophthalmologists registered with the Irish College of Ophthalmologists (ICO),[2] the recognised training and professional body for medical and surgical eye doctors in Ireland. These two groups provide the vast majority of eye care in Ireland.

Optometrists are at the front line of service, prescribing spectacles, contact lenses and screening for eye disease. They are often the first professional to be consulted by the general public when an eye problem presents and also detect disease through opportunistic case-finding during routine sight tests. Optometric training in Ireland consists of a four-year honours degree programme and a set of professional qualifying exams. During their undergraduate training, students must complete periods of supervised practice, attaining specific requirements for patient episodes and demonstrations of clinical competence. Graduation from the degree programme gives

eligibility to sit a set of clinical professional qualifying exams, which much be passed before graduates can practice unsupervised.

The Irish State is the largest single purchaser of optometry services,[3] subsidising eye examinations and optical appliances through a variety of schemes. Irish optometrists traditionally own, or are employed in, private optometry practices which are contracted by the state on a fee per service basis. Historically, the Health Service Executive (HSE), the publicly funded body responsible for the provision of health and personal social services for everyone living in Ireland, have not employed optometrists and HSE eye care teams usually consist of doctors, nurses, and orthoptists. This may be set to change: two full time optometrist positions at the Children's University Hospital, Temple Street, Dublin were recently created by the HSE[4] and two other HSE areas (Sligo and Dundalk) are currently piloting the employment of sessional optometrists as part of their ophthalmic teams.

There are two types of eye doctors registered in Ireland, medical eye doctors and surgical eye doctors. Both can be referred to as ophthalmologists and though their roles may overlap at times, there are some important differences in their training and subsequent clinical roles. Both types of eye doctor must complete a 5 year general medical degree and 1 year at intern grade before undertaking a 3 year basic specialist training programme. Medical ophthalmologists then complete 2 years at registrar grade after which they are eligible for registration as a medical ophthalmologist or community ophthalmic physician with the Irish Medical Council and to work independently. Ophthalmic surgeons follow their basic specialist training with a 5 year higher surgical

training programme, which is usually followed by a subspecialist training programme lasting another 1-2 years.

This 14-16 year surgical training programme is very similar to that undertaken by ophthalmologists in the UK,[5] where all eye doctors wishing to register as an independent ophthalmology subspecialist must undertake the full surgical training route and the lower training grade of the medical ophthalmology pathway does not exist in a formal capacity. Ireland's medical eye doctors are involved in the diagnosis and medical management of diseases of the eye and its related structures including systemic associations. They may also perform some minor surgical procedures such as excision of cysts, clearing tear ducts, and various laser procedures. Surgical eye doctors are trained to carry out all of these procedures in addition to major eye surgery such as cataract extractions, glaucoma surgeries such as trabeculectomy, and retinal detachment repair for example. Both medical and surgical eye doctors tend to have their own areas of subspecialisation and inter-referral between doctors is commonplace.

Ophthalmologists are employed by the HSE in both acute hospital settings, mainly staffed by consultant ophthalmic surgeons and non-consultant hospital doctors on ophthalmology trainee schemes, and local primary care clinics which are mostly staffed by medical ophthalmologists (also called community ophthalmic physicians). There are 24 hospital departments and 75 local primary care clinics offering public ophthalmology services around Ireland. The Irish State has placed a particular funding emphasis on community ophthalmology schemes such as the Community Ophthalmic Services Schemes (COSS) introduced in 1979, the Community Ophthalmic Physician (COP) services first formally contracted in 1991, and the more recent Community Ophthalmic

Services Medical Treatment Scheme (COSMTS), launched in 2004. Despite these investments, per capita ratios of ophthalmologists are still lower than other developed countries such as the UK or the United States.[6]

1.2 Poor access to ophthalmology services

Lack of access to public ophthalmology services in Ireland is a longstanding problem that is set to worsen in the face of demographic change. Ophthalmology departments are struggling to manage demand and long waiting lists can lead to delayed diagnosis and treatment of sight threatening conditions. Exact waiting times for public ophthalmology appointments could not be accurately determined for many years with just anecdotal evidence from frustrated healthcare professionals and patients bringing the issue to public consciousness.[7]

The situation became more transparent in 2013 when the National Treatment Purchase fund (NTPF), an independent statutory body tasked with the responsibility for 'collecting, collating and validating information on persons waiting for public hospital treatment' in Ireland, began publishing waiting list data. Figures for July 2017 show that 37,402 individuals in Ireland (total population 2016: 4.76 million[8]) were on a waiting list for a first appointment at a consultant-led ophthalmology outpatient clinic, with 11,275 individuals having already spent 12 months or more on the waiting list.[9]

This demonstrates that public hospitals are failing to reach their 12 month maximum wait time target for first visit outpatient appointments.[10] In fact, the Royal Victoria Eye and Ear Hospital (RVEEH), the largest ophthalmology service in the country, state a 12-15 month waiting time for outpatient appointments as standard.[11]

The National Council for the Blind of Ireland (NCBI) has condemned this situation, claiming that unmanageable waiting lists are leaving patients at real risk of avoidable sight loss.[12] Similarly, Mr. David Keegan, consultant ophthalmic vitreoretinal surgeon, described the waiting lists and subsequent potential for irreversible sight loss as a 'hidden scandal' and urged the Government to take immediate action.[12]

The Irish Medical Organisation (IMO), the professional association for doctors in Ireland and also the trade union representing all doctors in negotiations with the Irish Government, have cited high levels of false positive referrals as a major cause of long waiting lists in ophthalmology.[13] In their 2014 submission to the HSE Primary Eye Care Review Programme,[13] they suggest a refined screening service facilitated by improved training for nurses and orthoptists, and further expansion of our community ophthalmology service.[13] Within the IMO's proposed plan for eye care service reform there is very little mention of optometrists' roles in service provision. This is problematic, as it promotes an unhelpful segregation between medical and optometric professions and hints at a contentious relationship between optometrists and ophthalmologists in Ireland.

There is a reasonable argument for increased community ophthalmology posts, but it is doubtful that this alone would solve capacity issues. Mr. Michael O'Keefe, consultant ophthalmic surgeon, has pointed to systemic issues within the larger health service as the chief cause of the widespread waiting list crisis, claiming that our 'dysfunctional health system' needs complete restructuring rather than a simple supply of extra financing.[14]

1.3 'Reform fatigue' in our health service

A succession of governments have failed to solve the problem of health service reform in Ireland. In the last five years alone, we have seen three different ministers for health fail to achieve real change in the face of an escalating waiting list crisis.[14] In November 2012, the then Minister for Health, James Reilly, and Ministers of State Kathleen Lynch and Alex White published 'Future Health – A Strategic Framework for Reform of the Health Service 2012-2015'.[15] This framework claimed to represent the 'the most comprehensive reform of Irish healthcare since the establishment of the State' and set forth a number of time-bound actions that would support this objective. Many of the proposals in this document have not been implemented, most noticeably the highly publicised roll out of 'universal health insurance' (UHI).

UHI was promoted as a strategy to combat Ireland's two tier health service, a system that has been criticised for promoting and almost subsidising inequality in access to care as those with the ability to pay for private services not only skip long public waiting lists but actually receive their private care in publicly funded hospitals. A subsequent report from the Economic and Social Research Institute highlighted the potential high cost of a universal insurance model,[16] and enthusiasm for the UHI model has waned.

Since then, the Department of Health has published a new strategic health care reform document,[17] and a committee of TDs (Teachtaí Dála: members of the Irish parliament) have even weighed in on the issue with their own 'historic' policy document,[18] though little has really changed in the overarching structure of health care. Current Irish Minister for Health, Simon Harris, recently acknowledged that 'reform fatigue'[19] has

started to set in and advocated for a more consistent approach to reform, one that is not continually disrupted by changes in political leadership.

One positive outcome from this glut of strategic planning has been the establishment of 33 new national clinical programmes (NCP), including an NCP for eye care. The three main objectives of the NCPs are to improve the quality of care delivered to all users of HSE services, to improve access to all services, and to improve cost effectiveness.[20] After a thorough service review and stakeholder engagement process, the NCP for eye care just recently published the Primary Care Eye Services Review Group Report,[21] the first ever national review of public eye care services. The report presents a detailed description of the services in place across the country, highlighting the limitations of the current models of delivery and proposing new care models and pathways for the management of most eye conditions. A need to move from a system of overreliance on isolated community ophthalmic physicians is outlined and new multidisciplinary Primary Care Eye Teams (PCETs) are suggested. The need for better integration of optometrists into the public eye care service is also recognised in the report and the inclusion of optometrists as core team members in these new PCETs is recommended. These proposals seem positive, and will almost certainly be welcomed by optometrists who have pushed for inclusion within multidisciplinary ophthalmology teams.[22] What remains to be seen, is whether any of these proposals will actually be realised.

1.4 Catalysts for change

A number of aligning factors may make change within our health service inevitable. A recently completed report on health services in Northern Ireland described the choice in service reform as either 'planned change or change prompted by crisis'.[17]

Demographic changes in the Irish population will lead to increased demand on health care services. Significant population growth and ageing is occurring: between 2006 and 2014, the Irish population grew by 8%, and the number of people over 65 years of age increased by 14%,[23] a trend which is predicted to continue.[24] Figure 1.1 demonstrates this increase in the number and proportion of older people in Irish society with a concomitant decrease in the younger age groups.

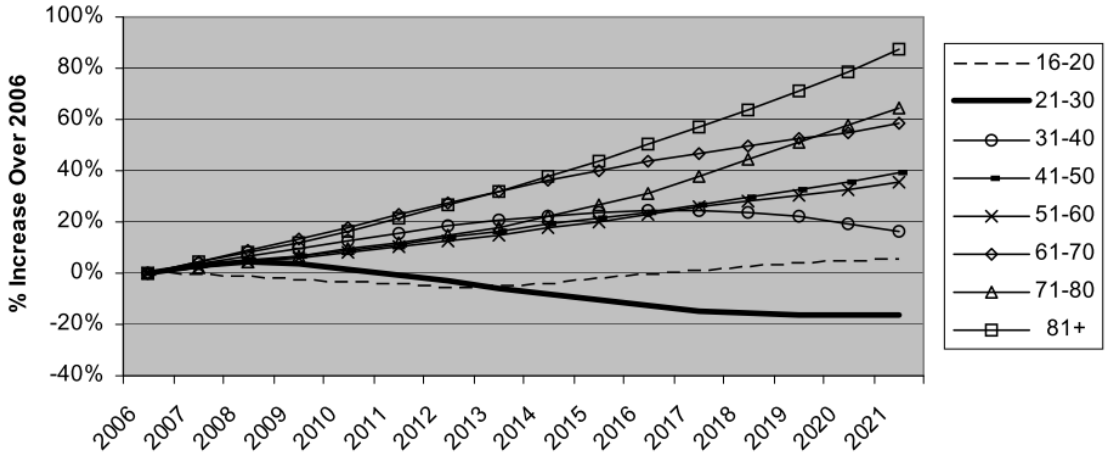


Figure 1.1: Proportionate change in the size of population age groups 2006-2021. Source Layte et al. 2009[24]

With older age comes an increase in the prevalence of age-related morbidities. This includes irreversible ophthalmic disease that can have a detrimental effect on health-

related quality of life, including the most common causes of blindness (Figure 1.2) such as age-related macular degeneration (AMD), diabetic retinopathy (DR), and glaucoma.[25]

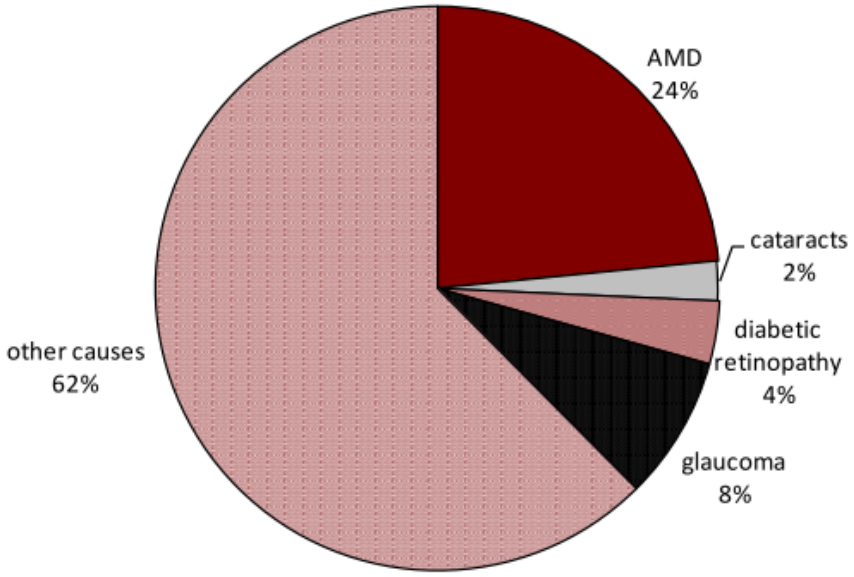


Figure 1.2: Registered blindness in Ireland - % breakdown by cause. Source: Deloitte Access Economics (2011)[26]

These same demographic patterns have been identified in many developed countries. The need for increased health care capacity in the face of greater longevity and subsequent increased demand for eye care services has been recognised in the UK,[27] Australia,[28] and the United States.[29]

New treatment and technology developments are also placing increased demand on services. Within ophthalmology services, new treatments such as anti-VEGF (vascular endothelial growth factor) intraocular injections for retinal vascular anomalies create increased workload due to higher numbers of patients now eligible for treatment. In

addition, aggressive conditions such as new onset exudative AMD require a 2-week diagnosis to treatment schedule necessitating careful workload management and planning within clinics.

The Foresight Report,[30] which assessed the potential impact of technology on the UK optical sector in the future, has shown that technological advances have the potential to take over some roles traditionally fulfilled by optometrists and dispensing opticians. This leaves potential for these professions to shift their role boundaries, perhaps supporting ophthalmology services through shared care disease management that is facilitated by improvements to e-referral and telehealth systems.

Recent changes in the legislation[31] governing optometric scope of practice in Ireland may give optometrists more freedom to adapt their clinical roles to new environments, serving as another tipping point for change.

1.5 Enabling reform through legislative change

Legislative changes have facilitated a decades long evolution in the role boundaries of optometrists practicing in the UK. In 2000, an amendment to the General Optical Council (GOC) 'Rules relating to injury or disease of the eye'[32] allowed optometrists in the UK, for the first time, to decide not to refer patients with a disease or abnormality of the eye to a medical practitioner if there was no justification to do so. In 2005, the rules in the UK were further changed to allow referral to a more specialist optometrist colleague with appropriate qualifications or expertise to manage the patient. In addition, amendments to medicines legislation[33] in the UK have facilitated access to therapeutic

agents, allowing optometrists with the appropriate qualifications to prescribe medications and treat some common eye conditions.

This sits in contrast with the situation in Ireland where optometric practice was tightly controlled by restrictive legislation right up until October 2015. Irish optometry was first regulated under the Opticians Act 1956, which established the Opticians Board, an authority that governed the profession and protected the titles of ophthalmic optician (later becoming optometrist) and dispensing optician. Since the enactment of the Opticians Act there was only one amendment, the Opticians (Amendment) Act 2003.[34] This amendment made small but important changes, allowing optometrists to used diagnostic drugs such as tropicamide and oxybuprocaine for the first time, but still confined optometric practice to a screening role, clearly stating that optometrists had a duty to refer to a medical practitioner if there was any suspicion of ocular pathology and it prohibited optometrists from diagnosing eye disease.

Section 48 of the Opticians (Amendment) Act[34] reiterated a clause from the Opticians Act, 1956, to state that '(a) registered optician who is not a registered medical practitioner shall not suggest by any written or oral statement or by any action that the registered optician has made or is capable of making a medical diagnosis of a disease of the eye or that, in relation to the treatment of the eyes, the registered optician has done or is capable of doing anything other than;

(a) in the case of a registered optometrist, the prescribing or provision of spectacles, or

(*b*) in the case of a registered dispensing optician, the provision of spectacles'.

This clause may have been an accurate reflection of optometrists' training and clinical skill at the time of its enactment in 1956, but over time it became unnecessarily restrictive. Irish optometrists are eligible to register with the GOC, and practice within the UK, with no adaptation period or further training required, demonstrating that their competence is considered on par with UK trained practitioners. Under the GOC, optometrists can participate in postgraduate training schemes which enable participation in a variety of enhanced service schemes, for example, direct cataract referral,[35] triage of acute eye disease,[36] and glaucoma referral refinement.[37] These schemes involve optometric diagnosis of ocular pathology and have been commissioned by the National Health Service (NHS) following guidelines from the National Institute for Clinical Excellence (NICE) in the UK. A systematic review was conducted of all UK-based research papers published between 1997 and 2011 regarding eye care services that incorporate the role of optometrists.[38] This report found that many optometrists are centrally engaged in hospital and community-based enhanced service delivery in the UK, and confirmed that optometric eye care schemes were providing safe and high quality services.

It is thought that the legislative changes which have loosened the boundaries of optometric practice in Ireland could pave the way for progressive development in scope of practice and the creation of new clinical roles similar to those seen in the UK. The process of drafting new legislation began in 2008 when the Irish Government's decision to subsume optometry's regulatory body, the Opticians Board, into the Health & Social Care Professionals Council (CORU) was announced.

Legislation for integrating the Opticians Board into CORU, transferring the Board's functions, establishing new registration board/s for optometrists and dispensing opticians, and transferring the Board's registers of optometrists and dispensing opticians was introduced into Dáil Éireann as the Health (Miscellaneous Provisions) Bill 2014 and eventually enacted the Health (Miscellaneous Provisions) Act 2015, on October 31st 2015. Under this new legislation, optometric scope of practice has been quite loosely defined, stating that professionals must 'act within the limits of (their) knowledge, skills, competence and experience' and 'practice only in areas in which (they) have relevant competence, education, training and experience'.[39]

Under this framework, there is scope for the development of new optometric clinical roles in Ireland, and there is hope that a broader scope of practice will better serve the public interest. The Optician's Act engendered false positive referrals, as optometrists had a duty to refer onwards once there was any suspicion of pathology, meaning that those with an acute sense of clinical awareness may have been generating very sensitive but non-specific referrals. There is the potential for better refinement of referrals when optometrists are enabled to monitor suspect findings.

There may also be scope, reliant on appropriate training and experience of course, for optometrists to monitor and manage conditions, such as atrophic AMD, that do not require prescribed medication or surgical treatment. In fact, there is anecdotal evidence to suggest that some optometrists already perform some of these functions, which would have been outside their legislated scope of practice prior to October 2015.

This research outlined in this paper aims to evaluate current practice norms within optometry in Ireland, serving as a benchmark for future reference, and to assess optometrists' level of interest in enhanced scope of practice (refer to Chapter 3 for an exploration of current practice norms within Irish optometry and an assessment of optometrists' interest in an enhanced scope of practice).

1.6 Resistance to change

Despite the potential benefits of enhanced optometry services, there has been concern expressed regarding the potential for unsafe practice by optometrists no longer bounded by Section 48 of the Opticians Act. In a 2010 submission to the Health Standards and Quality Authority (HIQA),[40] the Irish College of Ophthalmologists (ICO) stated that extending the scope of practice within optometry to allow 'medical diagnosis and treatment' of eye disease will result in 'lower standards' of practice similar to those 'accepted by the UK'. The ICO submission indicates a disregard towards the profession of optometry, warning that any increase in scope of practice is not in the public interest, arguing 'as a public health matter it is important that Section 48 of the Opticians Amendment Act 1956 should remain in force and be incorporated into the amended Health & Social Care Professionals (HSCP) Act 2005'.

It is unclear what 'lower standards' are being referred to, given that evaluations of enhanced optometric services in the UK[38] and also Australia[28] have found them to be safe and clinically effective,[41] and acceptable to both patients[42–44] and healthcare professionals themselves.[44]

When this recommendation was disregarded in the preparation of the Health (Miscellaneous Provisions) Bill, the ICO approached Senator John Crowne and requested he propose an amendment to the Health Bill during committee stage at Seanad Éireann (the Irish Senate) in November 2014. This amendment moved to insert the following into the Bill:

"Should any person registered by the Optical Registration Board, in the course of an examination, discover a medical condition that would require medical treatment, or arrive at the suspicion that there exists a medical condition that may require treatment, that person shall—

(a) inform the patient of the presence of that medical condition, or the suspicion of the existence of a medical condition,

and

(b) recommend that the patient consult with a registered medical practitioner."[45]

After discussion on the merits of the proposed amendment, it was put to the Seanad and declared lost.

This amendment may seem innocuous, describing a practice that is in fact commonplace. However, the legal requirement to refer to a medical practitioner on 'suspicion… (of) a medical condition that may require treatment' could again result in unnecessary referrals, an issue particularly relevant to suspect glaucoma for example, where borderline cases often require monitoring until the disease can be confirmed or ruled out. In an increasingly litigious society, optometrists may be inclined to err on the side of caution with regards to referral of suspect cases, perhaps being wary of

accusations of practicing outside their scope of authority should they decide to monitor any suspicions rather than immediately refer. False positive referrals may have little disadvantage to individual practitioners but can cause unnecessary psychological stress to patients,[46] as well as wasting time and resources in secondary care.[47] Allowing optometrists more freedom to use their clinical judgement seems a reasonable step in managing the delicate sensitivity-specificity balance.

The persistence of the ICO's effort to restrict optometric practice, and to enshrine the need for referral to a medical practitioner, indicates a mistrust in optometric clinical judgement. In order to address these fears, it is necessary to probe this issue further, to investigate optometrists' attitudes towards enhanced scope of practice, including their perceived training needs and practice limits. There may be a legitimate lack of expertise within optometry, or an unacceptable level of variability between practitioners such that some examples of bad practice have eroded trust in the entire professional body. Optometrists could be guilty of provoking contempt from ophthalmology by issuing reductive claims such as 'the optometrists network could end public eye care backlog',[48] an oversimplified ideology that is patently false and ignores the complexity of the issues we are facing. These issues may be unpalatable for optometrists to recognise, but identifying the root cause of ophthalmology's guarded stance will be the first step in opening the dialogue that can facilitate progress. The research outlined in this paper attempts to begin this process by putting forward a measured and realistic analysis of the optometric profession is Ireland.

It should also be acknowledged however, that the ophthalmology profession will also have to re-evaluate their stance in order to facilitate change. It could be argued that

ophthalmologists, in their persistent drive to limit the scope of optometric practice, have demonstrated an entrenched protectionism around eye care services that has, at times, been to the detriment of the patient.

1.7 Conclusion

The need for reform in our health care services is clear. Failing to meet the eye care needs of our population has direct prognostic implications and consequences for blindness prevalence in Ireland. Estimates suggest that there were 224,832 people suffering from visual impairment in 2010, which has been projected to rise to 271,996 by 2020 - a 21% increase.[26] The total economic cost of visual impairment and blindness in the Republic of Ireland was calculated as €2.14 billion in 2010, but is projected to rise to €2.7 billion by 2020.[26] From an economic and societal perspective, this increased level of avoidable visual impairment is unacceptable and contrary to the St Vincent's Declaration (1989), and the World Health Organisation's 'Vision 2020: Right to Sight' agreement.

Two previous reviews, in 2006[3] and 2017,[21] have identified a need for better integration of optometrists into the Irish health service, indicating their untapped potential to provide more clinical services. This research seeks to identify the barriers and enablers to enhanced optometric services in Ireland, and to pilot a shared care pathway to investigate the value and viability of this care model.

2. THE OPTOMETRIST'S ROLE IN GLAUCOMA CARE

2.1 Introduction to glaucoma

Glaucoma comprises a complex group of diseases with various aetiologies, which ultimately result in the same characteristic optic neuropathy and associated visual dysfunction (Figure 2.1).

Almost all glaucoma requires long-term treatment and monitoring in order to prevent significant visual loss over the course of an individual's lifetime (Figure 2.2).

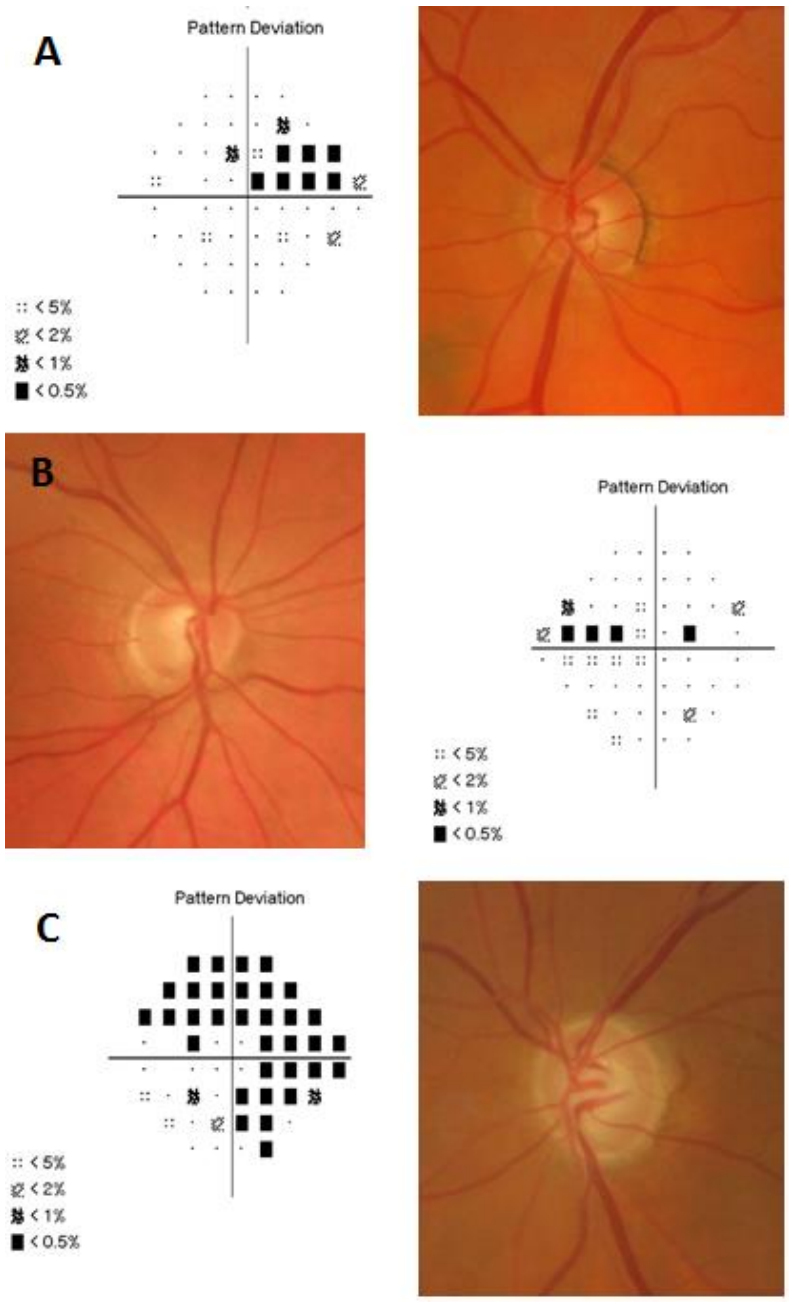


Figure 2.1: Optic neuropathy and associated visual field loss from three confirmed glaucoma cases seen within the Dublin glaucoma referral refinement and monitoring service. Image A shows atrophy of the inferior neuroretinal rim with corresponding superior nasal step defect. Image B shows atrophy of the inferior neuroretinal rim with corresponding superior nasal-paracentral defect. Image C shows advanced glaucomatous optic neuropathy. The corresponding field plot shows an advanced superior arcuate defect and an inferior nasal step that is starting to form an arcuate pattern.

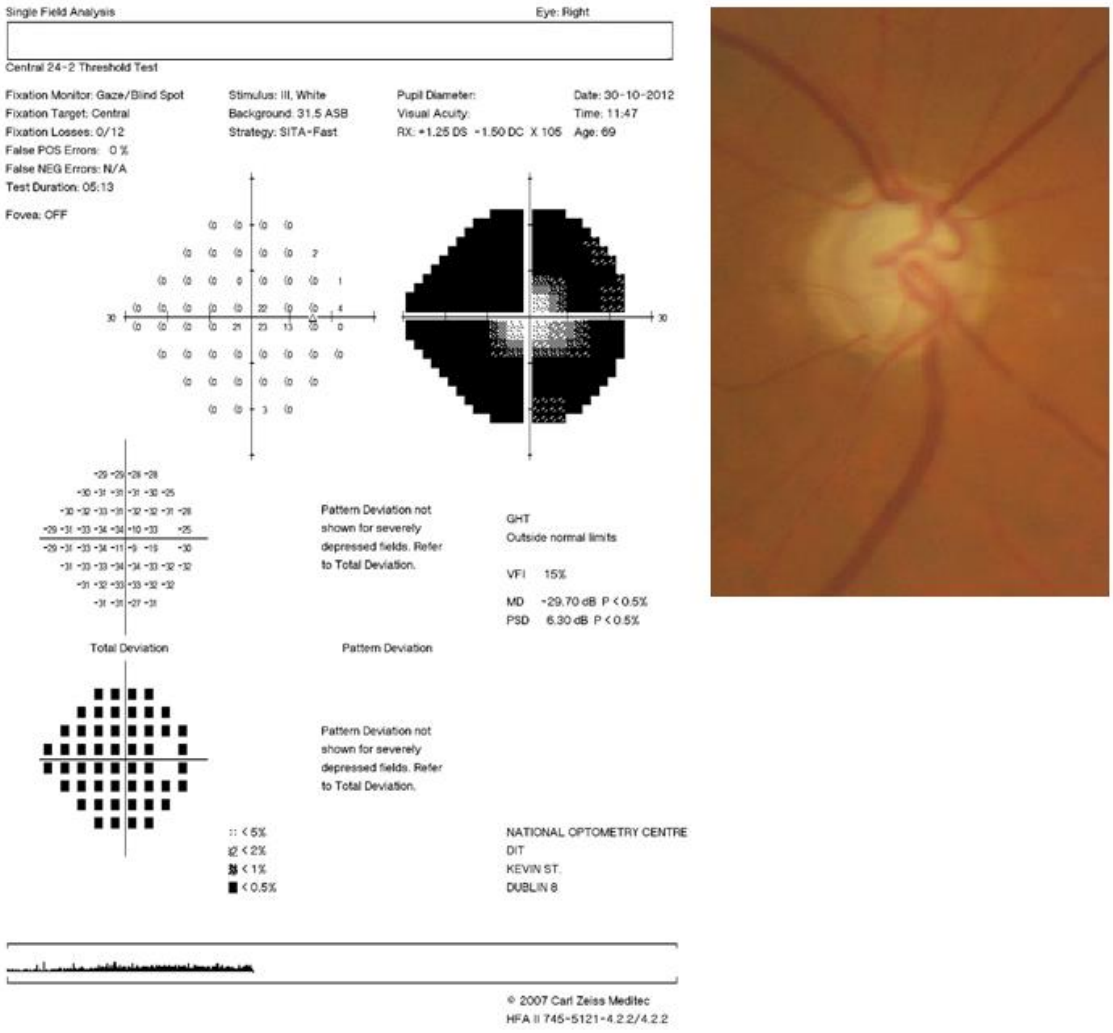


Figure 2.2: Advanced glaucoma in a 69 year old male seen in the Dublin glaucoma referral refinement and monitoring service. The images show advanced glaucomatous optic neuropathy with associated profound visual loss that is threatening fixation.

2.2 Classification and terminology

Glaucoma is commonly classified into two subdivisions on the basis of whether the glaucoma is related to a known underlying ocular or systemic co-morbidity.

- Primary glaucomas are unrelated to ocular or systemic disease. They are typically bilateral, though usually asymmetric, and probably have a genetic basis.
- Secondary glaucomas have a known contribution from ocular or systemic disease, they may be unilateral or bilateral, with some having a genetic basis, and others being acquired.[49]

These groups may be further subdivided into open or closed angle groups based on gonioscopic observation of the anterior chamber angle structures. Numerous further subdivisions and classifications exist, and accurate classification is essential in determining appropriate treatment regimens for the disease. When detecting glaucoma, such specific categorisations are not generally required. Therefore the terminology used in this thesis has been simplified as follows.

The publication of NICE clinical guidance for 'Glaucoma: Diagnosis and management of chronic open angle glaucoma and ocular hypertension'[50] has led to increased use of the term chronic open angle glaucoma (COAG). However, the terms COAG and POAG are both used within the literature to refer to the same condition. POAG appears to be used more widely in the publications referenced in this thesis. Therefore the author has adopted the term POAG, which is used consistently within this thesis and is intended to be synonymous with COAG.

POAG has previously been divided on the basis of statistical IOP elevation into 'high' and 'normal' pressure types, frequently referred to as POAG and normal tension glaucoma (NTG) respectively. It is now understood that the division of subtypes based on a statistical construct of mean IOP plus two standard deviations is arbitrary, and of little clinical value. Therefore, the term POAG, as used in this thesis, can be taken to include NTG.

Optometrists in Ireland are tasked with detecting pathology during routine eye examinations and this responsibility extends to glaucoma in all its forms. Therefore, the term 'glaucoma' is used within this thesis to represent optometrists' responsibility to detect all forms of the disease. However, epidemiological evidence indicates that POAG is, by far, the predominant form of glaucoma detected by community optometrists in Ireland

2.3 Epidemiology

Glaucoma is estimated to be accountable for 6.6% of blindness worldwide.[51] It is the second leading cause of blindness worldwide, second only to cataract,[52] and therefore, it is the world's leading cause of irreversible blindness.[53] Although glaucomatous damage is irreversible, sight loss is largely preventable. For these reasons, glaucoma is one of the priority eye diseases of the World Health Organisation's (WHO) Vision 2020 programme.[54]

In Western populations, primary open angle glaucoma (POAG) is the most common subtype.[53] In fact, primary glaucoma (includes both open and closed angle subtypes) accounts for 92%[52] of all presentations.

Coffey *et al.*[55] determined that POAG affects approximately 2% of the Irish population over 50 years of age, and that 50% of POAG cases remain undiagnosed[55] a figure consistent with other developed countries.[56] Prevalence of angle closure glaucoma was found to be just 0.01%.

According to most recent data, glaucoma is responsible for 8% of those registered blind in Ireland, ranking as the second leading single cause of visual impairment or blindness.[26] Our population is both growing and ageing, such that the very age groups who are the heaviest users of healthcare are increasing substantially in size.[24] This demographic change is leading to an increase in the absolute numbers of people with glaucoma. Providing sufficient care for people with, or at risk of glaucoma presents an ongoing challenge for all eye care professionals.

Of the approximately 37,000 people currently waiting for a first appointment in a consultant-led ophthalmology clinic in Ireland,[9] it is likely that between 10-15% have been referred for glaucoma diagnosis and management. This estimate is supported by an analysis of referrals and case notes in one UK hospital eye service (HES) which found that 13% of new referrals and 25% of follow up attendances were either glaucoma suspects or patients with glaucoma.[57] This demonstrates that the management of patients with ocular hypertension and glaucoma constitutes a large proportion of the workload in hospital ophthalmology. The reasons for this are manifold, including the ambiguity of diagnosis in early glaucoma, the need for repeat measures in findings that demonstrate short term fluctuation such as IOP and visual field sensitivity, and the long term monitoring and treatment regimens required.

2.4 Importance of early detection

Significant visual impairment results in a loss of quality of life, increased incidence of depression, and reduction in life expectancy.[26] However, early detection and treatment of glaucoma can minimise sight loss.[58] Therefore, early detection is of critical importance.

Glaucoma can also create a significant economic burden to society. A retrospective analysis of POAG cases in both the US and Europe, found that patients with more advanced glaucoma at presentation had higher treatment costs.[59] Thus, significant potential savings could be made if patients are diagnosed and treated at an earlier stage.

As population screening for glaucoma is neither cost effective[60] nor feasible,[61] and its insidious nature precludes self-detection, glaucoma identification is typically opportunistic. Evidence from the UK,[62] has shown that the vast majority of glaucoma cases are detected through opportunistic case-finding by community-based optometrists. Furthermore, higher rates of late presentation are associated with living in areas of high social deprivation where optometrists' premises are poorly represented.[63] This emphasises the importance of the optometrist's role in early detection.

2.5 Glaucoma detection in optometric practice.

The accuracy of optometric glaucoma referrals has been scrutinised over the past 25 years,[47,62,64–72] with much of the discourse focusing on false positive referrals. A recent multicentre review,[72] analysing data from five tertiary referral centres across Europe, found that only 10% of all newly referred glaucoma suspect patients actually had glaucoma. Even in the UK, with agreed examination guidelines and referral criteria, the

positive predictive value of referrals for suspected glaucoma is in the region of 40%.[67,73] It is known that glaucoma detection is particularly ambiguous due to the significant overlap in the clinical features of suspicious, but normal individuals and those with early glaucoma.[74,75] A number of other factors may also be contributing to the high proportion of false positives across Europe, including over caution on the part of the referrer,[69] the low prevalence of the disease in the populations typically attending primary care practices,[74] or the low diagnostic accuracy of the screening tests used.[76,77]

The type of equipment and clinical examination techniques used by optometrists may also affect the accuracy of their referrals. Traditionally, a triad of examinations is used for glaucoma detection. This triad includes optic nerve examination, visual field assessment, and IOP measurement.

Alteration of the structure of the optic nerve head is the defining feature of glacuoma.[78] Characteristic features of glaucomatous optic neuropathy (GON) include enlargement of the optic cup and corresponding loss of the neuroretinal rim particularly at the superior and inferior poles of the optic nerve head, retinal nerve fibre layer defects, increased pallor, vascular changes, and peripapillary atrophy.[49] *Figure 2.3* contrasts a healthy optic nerve head with advanced GON.

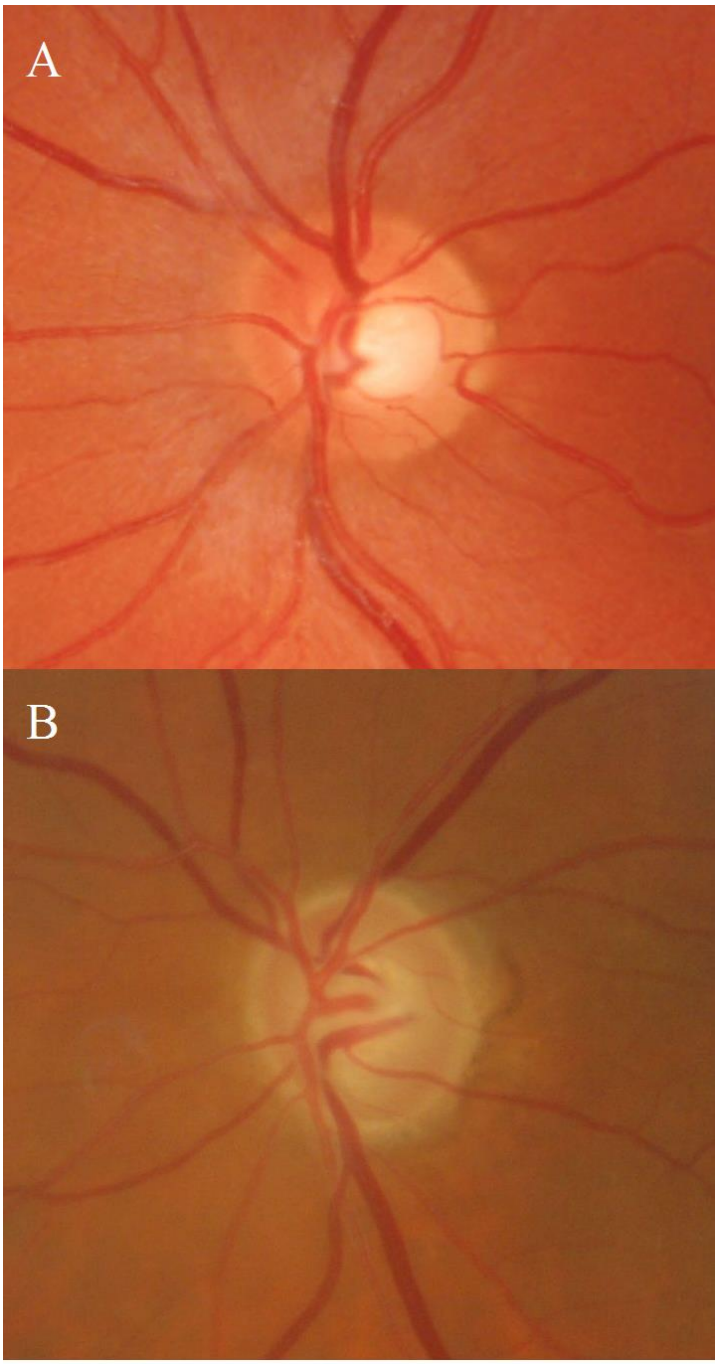


Figure 2.3: Image A shows a healthy optic nerve head. The neuroretinal rim appears intact and well perfused, having a pink colour. Healthy peripapillary retinal nerve fibre striations can be observed. Image B shows an optic nerve with advanced glaucomatous optic neuropathy. Although not obviously appreciable on a 2D image, the optic cup is enlarged, with marked thinning of the inferior neuroretinal rim and diffuse pallor. Both images are from patients seen in the Dublin glaucoma referral refinement and monitoring service.

Current best practice for comprehensive examination of the optic nerve head requires pupil dilation and use of binocular indirect ophthalmoscopy to provide a stereoscopic view of the disc features.[79] Optometrists using monocular direct ophthalmoscopy will be disadvantaged compared to those using binocular indirect ophthalmoscopy as they cannot appreciate stereopsis. Furthermore, the image produced in direct ophthalmoscopy is significantly affected by the eye's refractive error meaning the size of the optic disc cannot be measured. Given that the size of the cup and the size of the disc are interrelated (Figure 2.4) and the size of the cup-disc ratio (CDR) shows considerable overlap in normal individuals and glaucoma patients, an isolated CDR allows for little discrimination between early GON and normal cupping.

However, given the wide range of optic disc appearances within the normal population, and the subtlety of early glaucomatous optic neuropathy, even dilated, stereoscopic examination of the optic nerve head does not allow for perfect discrimination between early GON and physiological cupping. Practitioners are therefore advised to combine structural and functional assessments to maximize the accuracy of POAG assessment.[75]

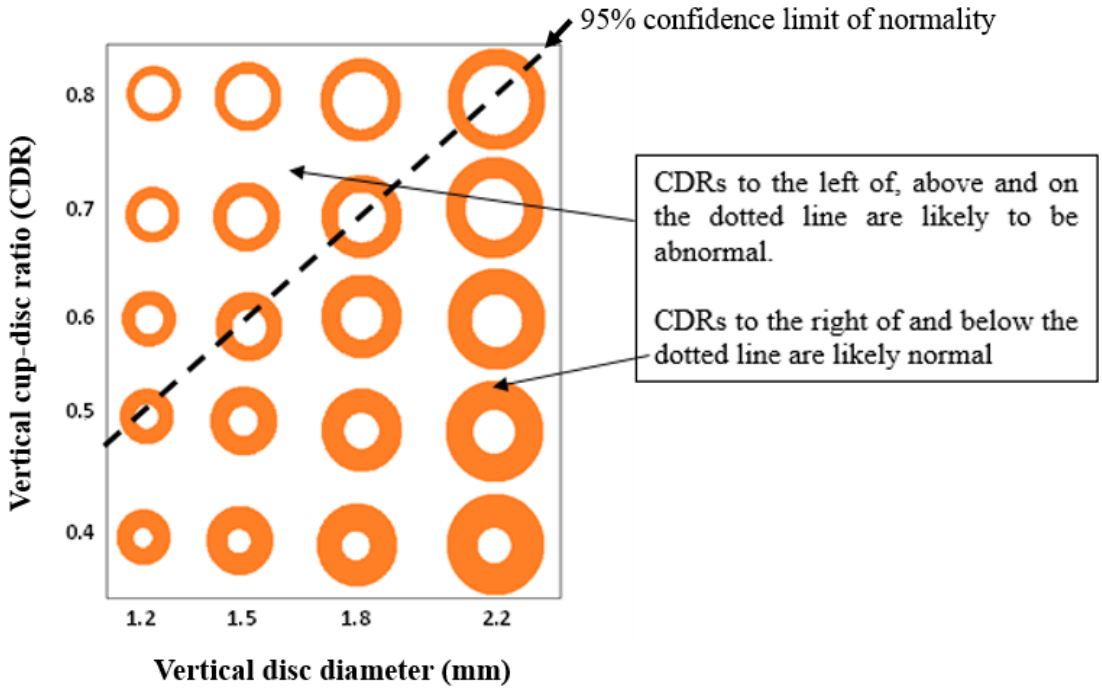


Figure 2.4: The estimated relationship between optic disc size (vertical disc diameter in mm) and the vertical cup-disc ratio (CDR). Note that a CDR of 0.6 falls outside the expected limit of normality for a small disc of height 1.2 mm, but is within the expected normal range for larger disc heights, e.g. 1.8 mm. Image reproduced from Harper and Spry's 'Essential Glaucoma Handbook: a guide to assessment and management for eye care professionals'.[49]

Axonal damage at the level of the optic nerve head results in visual field loss. Therefore, visual field testing is an essential component of POAG detection and in monitoring the progression of the disease. Automated static threshold perimetry is the clinically accepted gold standard for assessment of glaucomatous field loss.[80]

The specific patterns of field loss relate to nerve fibre bundle damage that occurs in POAG. Fibres from the superior and inferior retinas respect the horizontal raphe and therefore sensitivity differences across the horizontal meridian often are diagnostically useful. Damage characteristically occurs at the vertical poles of the disc. Therefore

losses characteristically affect the superotemporal or inferotemporal bundles first and typically present as paracentral scotomas, nasal steps and arcuate scotomas (refer to Figure 2.1 above for examples of established glaucomatous field loss and associated optic neuropathy).

Early glaucomatous field defects most often take the form of localised relative scotomas. Considerable test-retest variability is also a hallmark of the disease. Variable sensitivity reductions occurring in the same area, but not always at the same test point locations, typically precede clear-cut glaucomatous field defects[81] which may take years to become established. Figure 2.5 demonstrates that detection and confirmation of early glaucomatous field loss may require long term monitoring with full threshold testing strategies. Access to full threshold static automated perimetry and facilities to repeat suspect findings are therefore essential to successful glaucoma detection in optometric practice.

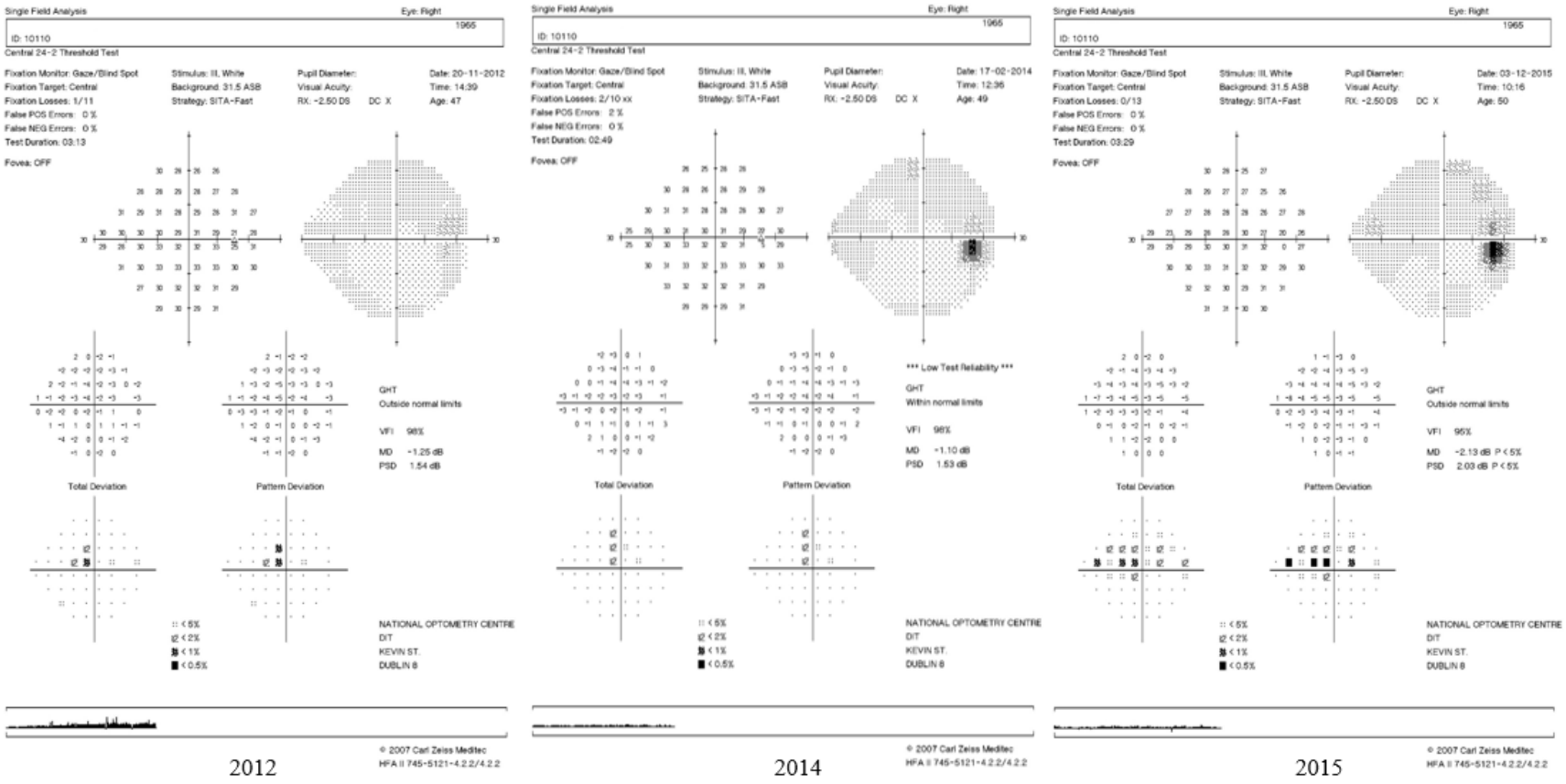


Figure 2.5: Repeated visual fields results for a glaucoma suspect patient seen in the Dublin referral refinement and monitoring service. In this example, the 2012 and 2014 field tests show just a small cluster of defects in the superior paracentral area of the pattern deviation (PD) probability plot and an 'outside normal limits' warning on the glaucoma hemifield test (GHT) test. In the 2012 and 2014 test results we see variable sensitivity reductions occurring in the same area. By 2015, the defect is more established. A more defined superior nasal/paracentral defect is present on the PD plot.

Raised IOP is the considered the most significant risk factor for glaucoma development.[82] However, evidence from the ocular hypertension treatment study (OHTS) has shown that many individuals with IOP values above the statistically normal range never develop POAG.[83,84] Furthermore, it is estimated that approximately 50% of all cases of POAG have statistically normal IOP at presentation.[55,85] This evidence demonstrates that IOP in isolation cannot discriminate between POAG and normals.

Accurate IOP measurement is however, essential in determining an individual's risk of glaucoma development and therefore is an essential component of glaucoma detection strategies. It is also essential to determining appropriate treatment regimens and risk of glaucoma progression. Currently, IOP is the only proven treatable risk factor in glaucoma.[86] Even in presentations where baseline IOP is within the statistically normal range, lowering of IOP by 30% from its baseline level has proven effective in reducing the rate of disease progression.[87]

Goldmann applanation tonometry (GAT) is widely accepted as the current clinical reference standard for IOP measurement. Survey results from the UK have shown that use of GAT among optometrists is poor, and that non-contact tonometry (NCT) techniques predominate in optometric practice.[88] It has been shown however, that there is an overestimation of IOP by NCT relative to GAT at higher IOP levels,[89] and that NCT is significantly more susceptible to the effects of central corneal thickness than GAT,[90] both factors that are particularly relevant in glaucoma detection, diagnosis, and management.

Even GAT is limited in its accuracy. It is commonly understood that tonometers are calibrated to average corneal thickness and therefore a thinner than average cornea can lead to underestimation of the IOP while a thicker than average cornea can lead to an overestimation.[91] This indicates that knowledge of the central corneal thickness (CCT) is essential to appropriate interpretation of IOP measurements. However, clinicians cannot completely rely on CCT correction formulas for GAT measurements, the interaction of IOP and CCT is complex and there are certainly other corneal factors, such as hysteresis or corneal curvature for example, that influence tonometry readings. Evidence suggests that CCT itself could be an independent biomarker for structural and physical factors involved in the pathogenesis of glaucoma[92] though there has been some debate on this topic.[93]

Although all of the examination strategies described above are limited in both their absolute accuracy and ability to detect glaucoma, there are clear benefits associated with gold standard techniques. Identifying the types of diagnostic tests routinely carried out within Irish optometry practices will allow us to establish recommendations for improving the accuracy of optometrists' case-finding strategies, and to identify potential training needs within the profession. Our investigations of current practice norms in optometry are detailed in Chapters 3 and 4, where optometrists have been surveyed to assess typical practice patterns in Ireland. In Chapter 7, we undertake a more objective assessment of optometrists' glaucoma case finding procedures in Ireland by analysing a sample of referral letters for suspect glaucoma.

2.6 Enhanced optometric services for glaucoma

A number of innovative care pathways, that increase optometrists' involvement in the diagnosis and co-management of glaucoma, have proven effective in addressing the challenge of glaucoma care.

2.6.1 Repeat measures schemes

The inherent variability of clinical features such as IOP and visual field sensitivity present a diagnostic challenge. As both features exhibit short-term fluctuation, the College of Optometrists (CoO) and the Royal College of Ophthalmologists (RCOphth) in the UK have issued joint guidelines recommending optometrists carry out repeat fields and IOP testing on any suspect results before referral.[94] Parkins & Edgar,[95] demonstrated the clinical and economic benefits of a repeat measures scheme for both tonometry and visual field testing. In this scheme, operating from Bexley, UK, optometrists were paid fees of £10 for repeating applanation tonometry and £14 for repeating fields testing on any individuals with abnormal results on first test. The results from this scheme were impressive: of 209 patients seen in the repeat measures scheme just 50 (24%) were referred on to hospital eye services. The scheme resulted in a net financial saving for the NHS of 62% when compared to the HES tariffs during 2007/2008 (net saving £17,067).

Repeat measures schemes are now commissioned by many Local Optical Committees across England.[96] In 2013, clinical commissioning guidance issued jointly by the CoO and the RCOphth recommended that 'repeat measurement schemes involving community optometrists should be established as a priority' as 'they can significantly

reduce false-positive referrals into the hospital eye service and are relatively easy to introduce'.[97]

Recent contract negotiations in Ireland, have led to changes in the contractual agreements between the Department of Social Protection and optometrists agreeing to provide State funded eye examinations, which may serve to facilitate repeat measures services in Ireland. On April 4th, 2017, a notification was issued declaring that the primary eye examination fee was to be increased from €22.42 to €30.00, and a further €20 (€30 if dilation is required) would be paid for a follow-up or repeat appointment. This represents an important change in the current funding of Irish optometry practices, as it is the first time supplementary examinations for follow up diagnostic investigations will be funded. There was previously no mechanism for a patient to be assessed by an optometrist unless a full eye examination (with refraction) was conducted. Therefore optometrists had just a single screening opportunity after which they were legislatively required to refer to a medical practitioner if pathology was suspected.

The new funding model could have a significant impact on optometric glaucoma case findings procedures, potentially facilitating more accurate diagnostic testing within community-based optometry practices, and it is hoped that this will result in net savings for the Irish State as well as multiple other benefits such as improved patient care and health outcomes.

Evidence from Scotland, where similar contract renegotiations and fee increases were implemented in 2006[98] and further increased in 2010,[99] demonstrates that increased State funding of optometry services did result in a net economic benefit[100] and a change

in case finding behaviour. In a retrospective study comparing referrals and hospital eye service notes for two six-month periods before and after the new general ophthalmic services (GOS) contract was implemented in Scotland,[101] there was a significant increase in true positive referrals and a decrease in false positive referrals. In addition, there was an increase in the number of referrals with information on GAT, dilated fundus examination, and repeat visual fields tests after the implementation of the new GOS contract. A recent review,[102] reflecting on ten years of the new General Ophthalmic Services contract in Scotland, found that the contract facilitated a 'significant shift in the balance of care from secondary into primary care' and delivered improved care to patients.

2.6.2 Glaucoma referral refinement

Glaucoma referral refinement (GRR) describes a two-tier assessment in which patients with initial suspicious findings are sent to a refinement clinic offering an enhanced assessment. GRR first emerged in Manchester, beginning in December 2000.[47] In this GRR scheme, patients with suspected glaucoma, instead of being referred to their GP and then on to the hospital eye service, were referred to specially trained community optometrists working to an agreed examination and referral protocol. Those patients who did not meet the referral criteria were returned to the referring optometrist, while those who met the referral criteria were referred directly to ophthalmology. Patients' GPs were informed of the outcomes. This care pathway is shown in Figure 2.6 below.

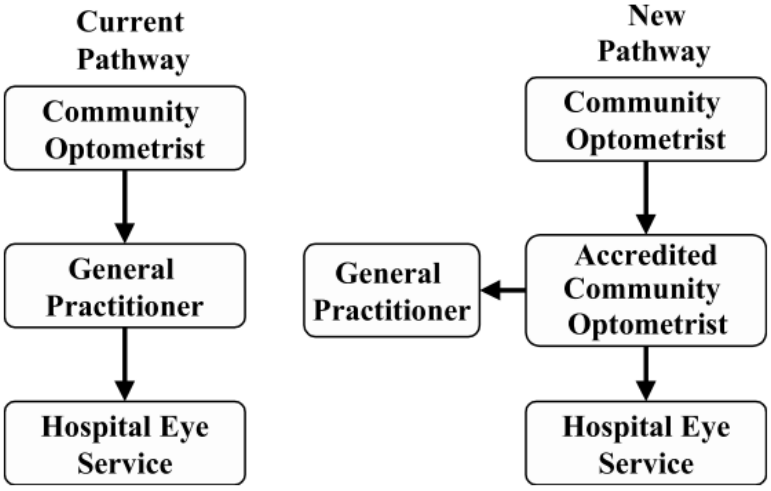


Figure 2.6: The current (traditional) and new (refinement scheme) referral pathways for suspect glaucoma cases in the Manchester GRR scheme. Image reproduced from Henson et al. 2003.[47]

Refinement aimed to send only those patients with the highest probability of glaucoma onwards to ophthalmology. The examination and referral criteria were established in partnership with the local ophthalmology team so that the refinement exam was closely aligned to the techniques used in the local hospital setting. After implementation of the Manchester GRR scheme the number of suspect glaucoma cases referred to the Manchester Royal Eye Hospital (MREH) was reduced by 40%, over a 3 year period. This figure was close to the percentage of false-positive referrals measured at MREH prior to the onset of the study. It was also reported that the referral information had been improved and that the scheme produced a financial cost saving to the NHS of approximately £17 per patient, as calculated in the three year period between 2000 and 2003.[47]

This landmark study paved the way for the development of glaucoma referral refinement schemes in many other parts of the UK. GRR proliferated after 2009,[37,103–105] largely in response to the rise in glaucoma referrals[71] following the publication of the of the NICE guidelines for 'Glaucoma: Diagnosis and management of chronic open angle glaucoma and ocular hypertension'.

Numerous peer reviewed papers published since have advocated for GRR schemes.[95,103–105] A recent multisite review of GRR schemes,[37] analysing data from 1086 patients, concluded that referral refinement schemes are effective in reducing first visit discharge rates of patients seen in secondary care and so are useful for 'demand management' in the hospital eye service.[37]

GRR schemes work in a number of ways. Firstly, they can address the low prevalence of glaucoma in traditional optometric practices. Harper *et al.*[74] demonstrated the difficulty faced by optometrists working in a primary care scenario where the proportion of non-glaucomatous individuals is high. It is known that the sensitivity and specificity of a given diagnostic test is dependent on the chosen study population, for glaucoma detection, a traditional triad of detection tests (visual-field testing, optic nerve examination, and IOP measurement) is used to maximise sensitivity and specificity. However, the relatively low glaucoma prevalence, estimated at 1.88% with prevalence rising to 3.2% in those over 70 years,[55] makes the resultant predictive power of positive testing low, even when the complete testing triad is used.[74,106] GRR schemes address this issue by offering enhanced diagnostic testing to a cohort of glaucoma suspect patients, a likely higher prevalence population than typically seen in

routine optometric practice. In this setting, the available diagnostic tests will have better positive predictive values.[74,106]

Another advantage of GRR schemes, is that refinement scheme optometrists see a greater concentration of glaucoma suspects than is typical in routine optometric practice and they tend to receive more feedback from their ophthalmology colleagues. Traditional optometry practices may not provide enough intensive experience with true glaucoma for optometrists to significantly develop their expertise and clinical decision-making skills.[107]

Feedback from ophthalmology services following referral has also been recognised as a vital support to the on-going management of patients within community optometry, and as an important method of improving the quality and appropriateness of referrals.[108] A lack of communication between community optometrists and ophthalmologists has previously been identified.[109,110] As GRR schemes tend to be locally commissioned in partnership with ophthalmology services and some operate through consultant supervision in a virtual clinic,[104,111] there are mechanisms for feedback which further develop the refinement optometrists' expertise. A qualitative study of stakeholder views regarding participation in a GRR scheme in Manchester found that optometrists cited improved communication and relationship building with other healthcare professionals as a benefit of participation. The learning opportunity created by feedback on referrals was cited as particularly valuable.[112] Both Myint *et al.* and Yoshioka *et al.* demonstrated that didactic teaching alone does not achieve real improvements in clinical skill.[75,113] The structures that surround GRR schemes, including the close support necessary from ophthalmology, can foster developments in

optometric clinical expertise over and above that seen in traditional optometric practice or even a repeat measures service.

In their 2013 joint clinical commissioning guidance, the CoO and the RCOphth stated that the enhanced assessment provided in GRR schemes 'add value' beyond that achieved through repeat measures alone.[97] More recent clinical commissioning guidance from the RCOphth[114] has included GRR in their 'high value care pathway'.

Our investigation of the clinical viability of GRR in Ireland is detailed in Chapters 5 and 6.

2.6.3 Monitoring of glaucoma suspects

The positive predictive value (PPV) of a screening test is the probability that subjects with a positive screening test truly have the disease. This metric has been used to assess the accuracy of optometric referrals for suspect glaucoma where the PPV is the probability that a patient referred to ophthalmology with suspect glaucoma actually has the disease. While the PPVs generated by GRR schemes, calculated at 0.78,[104] offer a marked improvement over unrefined glaucoma referrals (0.37),[115] they do not achieve perfect accuracy.

Absence of an ideal screening test for glaucoma not only results in false positive test results, but also identifies many individuals who do not have definite glaucoma, but have some clinical features leading to a suspicion of glaucoma. These individuals require ongoing observation until the disease can be either diagnosed or ruled out. Consequently, a significant proportion of the workload in glaucoma care involves monitoring suspect cases. In their evaluation of referrals for suspect glaucoma, Tuck

and Crick grouped these patients together in the category ‘uncertain, follow up required’, a suspect rate of 32%.[116] The Dublin based glaucoma referral refinement and monitoring service (GRRMS) incorporated a monitoring facility so that this workload (42% of referrals) could be managed (refer to Chapter 6), a strategy that has proven effective elsewhere.[117]

There is potential that new legislation[118] governing optometry in Ireland could shift some of this workload to traditional optometry practices. Monitoring of glaucoma suspect cases was considered outside Irish optometrists legislated scope of practice up until October 2015 when the legal definition of optometric scope of practice was broadened.[118] It is possible that optometrists will expand their scope of practice under this more liberal legislation, taking responsibility for monitoring of suspect features. However, the accompanying introduction of fitness to practice complaints procedures[119] could serve to exacerbate defensive practice patterns, whereby optometrists refer any suspect patients, due to fear of complaints or litigation.

Because glaucoma patients have a better visual prognosis when the disease is detected and treated in its initial stages,[58] detection strategies in optometry are best oriented to achieve high sensitivity in preference to specificity. A trade-off occurs that allows for early detection and minimises false negative rates. However, this can result in excess false positives. Missed cases of sight threatening diseases such as glaucoma could have serious ramifications for the responsible practitioner, whereas little personal disadvantage results from a false positive referral. In some cases, the optometrist may have a low level of suspicion but being limited by both legislation, available instrumentation, and their level of expertise perhaps, they refer the client to

ophthalmology. Consequently, a low risk patient, who might suitably undergo further investigations and monitoring within community optometry, is added to the long waiting list for public ophthalmology outpatient appointments.

This circumstance has been studied by Tuck, who found that 74% of the patients referred by an optometrist with 'almost definite' glaucoma were confirmed as having the condition, compared with only 21% of 'possible' glaucomas.[120] Community optometric monitoring of glaucoma suspects, ocular hypertension, and even stable glaucoma has been facilitated in the UK through collaborative care schemes sometimes referred to as 'shared care'.

2.6.4 Glaucoma Shared Care

The system of glaucoma care in the UK first changed in the 1990s when a process called 'shared care' allowed paramedical staff, including optometrists, to become more involved in clinical decision-making for their patients. The Bristol Shared Care Glaucoma Study (BSCGS) was designed to investigate the ways that optometrists might increase their role in the care of glaucoma patients, or glaucoma suspects, beyond their traditional detection responsibilities. The initiative involved specially trained community optometrists monitoring some stable POAG patients and glaucoma suspects, utilising direct referrals between the community and the HES.

A suite of papers emerged from this scheme, providing some of the first peer reviewed evidence to inform the debate around the viability of optometric care for established glaucoma in the UK. Initially the study group researched the validity of visual parameter measurements taken by community optometrists and found that community

optometrists could make measurements 'of comparable accuracy to those made in the hospital eye service'.[43] Patient satisfaction with the scheme was also assessed. Gray *et al*. found that patients were significantly more satisfied with a number of aspects of care provided by community optometrists, particularly those relating to waiting times, compared with those from the hospital eye service.[43] Spry *et al.* assessed the optometrists' monitoring compared to the 'gold standard' ophthalmologist assessment. The findings again suggested that community optometrists could provide equivalent services to that of the HES, in terms of using the key glaucoma case-finding methods of visual-field taking, cup to disc ratio and IOP.[121]

Follow-up studies two years into the scheme suggested no significant differences overall in outcome between patients followed up by the HES or community optometrists.[122] The economic outcomes were also similar between community optometrists and the HES, depending largely on the recommended follow up outcomes for the patients.[123] The authors found that their shared care model was unlikely to generate significant cost savings, but could provide a higher quality of service for patients living at some distance from the hospital, particularly in rural areas where there are difficulties with public transport.[122]

Since then, other schemes involving optometric monitoring of ocular hypertension and stable glaucoma have emerged in the UK, including those in Peterborough[124] and London.[125] A criticism that can be made of optometric community-based glaucoma clinics is that they can prove more costly to fund than similar hospital based services due to higher overhead costs in the community,[125] or a high rate of re-referral from community to hospital clinics.[123] A 2010 survey[126] of shared care schemes for

glaucoma in England found that approximately 50% of hospital ophthalmology departments were running a shared care scheme for glaucoma. The vast majority (80%) of these schemes were run 'in-house', perhaps due to the higher cost[125] of running community based clinics. Underutilisation of gonioscopy was identified as a key clinical governance issue with many of the schemes assessed.[126]

2.6.5 Hospital-based optometry

Hospital based optometrists are an important complement to community based referral refinement or glaucoma care schemes. Most patients presenting to optometry practices do not have significant ocular disease but rather seek glasses or contact lenses. Therefore the community optometrist's exposure to a broad spectrum of disease is limited. It is suggested that including optometrists in multidisciplinary hospital ophthalmology teams serves to enhance optometric training and develop expertise within the profession by providing a depth of experience that is not available in community optometry practice. Furthermore, the hospital team of ophthalmologists can offer more support and training for optometrists, compared to that available in community glaucoma schemes, where optometrists are often working in isolation.

One community care model[125] had optometrists alternate between running half day glaucoma clinics in their own high street community practices (with hospital patients attending), and assisting in one hospital-based glaucoma clinic session per week. This appears an ideal combination, providing community based care while offering optometrists contact with consultant level expertise and support, combating the issue of isolation.

Approximately 4% of the optometric professionals in the UK are employed in the HES.[127] While this may be a small proportion of the optometric profession, it represents approximately 740 optometrists in the UK.[128] In many eye hospitals the optometry department has become a major component of the out-patient department. The core optometry services typically include refraction (routine, diagnostic, paediatric), complex medical contact lens management and low vision rehabilitation. There may also be a dispensing service. Hospital optometrists are becoming increasingly involved in extended roles, particularly in glaucoma and medical retina.[128] A 2015 survey[128] of extended scope roles being provided by hospital optometrists in the UK found that glaucoma is the leading extended role service, with 92% of respondents providing extended role services for glaucoma (Figure 2.7).

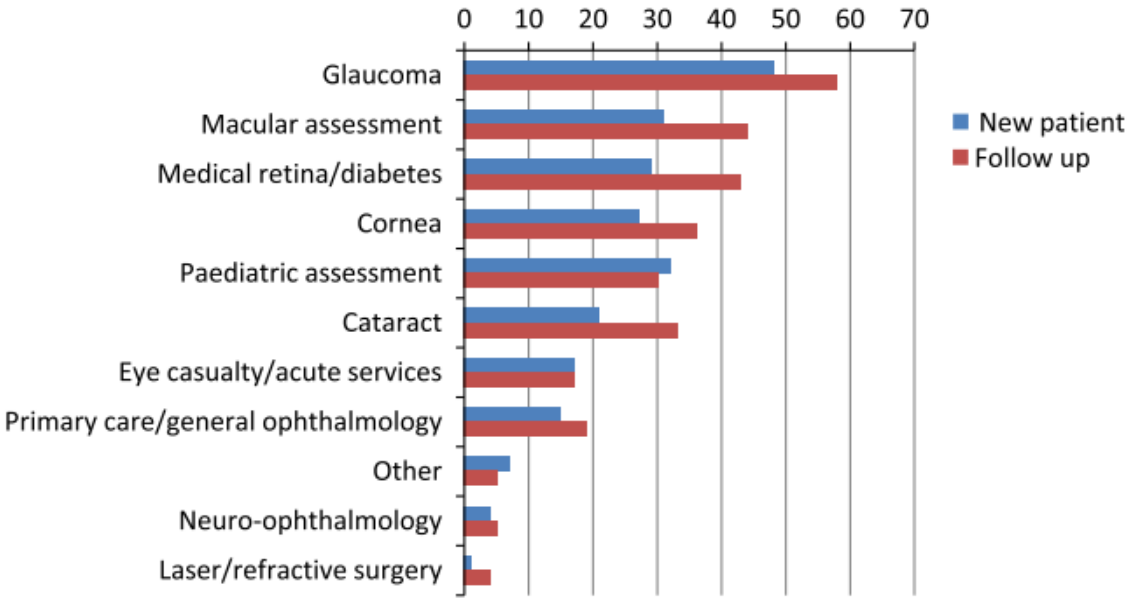


Figure 2.7: Frequency distribution of the number of optometrists providing each category of extended roles service for new and/or follow up patients. 'Other' category includes uveitis and vitreo-retinal clinics. This figure is reproduced from Harper et al. 2016.[128]

The Optometrist-led Glaucoma Assessment (OLGA) scheme has been running successfully at MREH for the past 14 years. The aim of OLGA is to manage glaucoma patients within the HES who are considered stable and low risk, therefore freeing up consultant-led outpatient appointments for new referrals and complex cases. A retrospective case note analysis of the OLGA clinic showed that the service compared favourably to non-specialist glaucoma care delivered by ophthalmologists.[129] This demonstrates that optometrists can successfully provide safe care and even improve the standard of care within ophthalmology outpatient clinics.

A recent review of eye care services in Ireland has proposed better integration of optometrists into the multidisciplinary primary eyecare team, suggesting 63 new posts for optometrists within the HSE's integrated eye service.[21] This new service development is a positive step for the optometry profession and the Irish health care service.

2.6.6 Training and accreditation

Methods of accreditation for optometrists in extended scope roles are varied. The evidence suggests[75,113] that a combination of apprenticeship style training and traditional didactic lectures is best suited to the development of clinical skill. It appears that apprenticeship training models predominate in the training of optometrists for extended scope roles with the UK's HES.[128] Even so, postgraduate training programmes have been an important facilitator of enhanced optometric glaucoma services in the UK, and the most recent (2016) clinical commissioning guidance[114] from the RCOphth recommends that optometrists involved in enhanced scope

glaucoma services undertake a Professional Certificate in Glaucoma, and progress to a Higher Professional Certificate in Glaucoma, or a Diploma in Glaucoma, depending on the level of clinical service being provided.

The UK CoO accredits Professional Certificates in Glaucoma from Cardiff University, City University London, University of Ulster, and the University of Bradford. Higher Professional Certificates and Diplomas in Glaucoma are accredited from Cardiff University and Moorfields Eye Hospital/University College London. These taught programmes have been designed to map directly to the NICE guideline (CG85)[130] requirements which provided specific recommendations clarifying permissible roles for healthcare professionals, with associated recommendations explicitly stating training and experience requirements.

Irish optometrists are eligible to complete these courses but there is no framework, as yet, in Ireland for them to practice beyond their traditional case finding role.

2.7 Conclusion

Glaucoma represents an important public health issue in Ireland and worldwide, and early detection is important if irreversible sight loss is to be avoided. The various systems of optometric glaucoma care that have been developed, from repeat measures, to GRR, to community monitoring schemes, to hospital based optometric clinics, serve to support and complement each other, each addressing different challenges in the glaucoma care pathway. What follows are our investigations into the current landscape of optometric practice in Ireland, with particular emphasis on POAG case finding strategies. Optometrists' attitudes towards enhanced scope of practice has also been

assessed, helping us to predict practice patterns in Ireland, and informing the development of optometric training so that it meets the current and future needs of the profession. A collaborative glaucoma referral refinement scheme was also piloted, the first of its kind to be conducted here. It is hoped that this work will serve as an important contribution to the future development of optometric practice in Ireland.

EXPERIMENTAL PROCEDURES, RESULTS & ANALYSIS

3. EXPANDING THE TRADITIONAL ROLE OF OPTOMETRY: CURRENT PRACTICE PATTERNS AND ATTITUDES TOWARDS ENHANCED GLAUCOMA SERVICES IN IRELAND

3.1 Abstract

Purpose

To investigate current diagnostic equipment availability and usage for glaucoma case-finding within community optometric practice, and to explore optometrists' attitudes towards an enhanced scope of clinical practice.

Methods

An anonymous survey was developed, validated, and distributed to all practicing optometrists in Ireland.

Results

199 optometrists (27% of registrants) responded to the survey. 87% had access to the traditional triad of tests necessary to conduct adequate glaucoma case finding. Standard automated perimetry was the most commonly absent (13%) of the three essential screening tests. 64% of respondents indicated that monocular direct ophthalmoscopy was their first choice technique for fundus examination. 47% of respondents had access to contact applanation tonometry, though just 14% used it as first choice during routine eye examinations. Among the 73 participants with access to both contact and NCT, 80.8%, used NCT preferentially.

The significant majority (98%) indicated an interest in enhanced glaucoma services with 57% agreeing that postgraduate training was an essential prerequisite to any increase in scope of practice.

Conclusion

Irish optometrists are well equipped to perform the traditional tests necessary to conduct adequate glaucoma case finding. Moving towards enhanced services such as monitoring glaucoma suspects or ocular hypertension cases would require some investment in equipment and training, particularly for gold standard techniques such as GAT and slit lamp binocular indirect ophthalmoscopy. There is strong interest in furthering optometric professional development and expanding the traditional role boundaries of optometrists, incorporating further education as an essential prerequisite to an enhanced scope of practice.

3.2 Introduction

Optometrists play a vital role in the detection of glaucoma, the world's leading cause of irreversible blindness.[131] The most common glaucoma sub-type, POAG, is insidious, progressive and irreversible, presenting a significant public health challenge. In Ireland, approximately 8% of blind and partially sighted registrations are attributed to glaucoma.[26] A study carried out in the west of Ireland showed an overall POAG prevalence of 1.88%, with prevalence rising to 3.2% in those over 70 years.[55] As our population grows, and as life expectancy continues to rise, the burden of glaucoma will increase. Between 2006 and 2014, the Irish population grew by 8%, and the number of people over 65 years of age increased by 14%,[23] a trend which is predicted to continue,[24] and which will lead to an inevitable increase in the demand for glaucoma-related care.

As population screening for POAG detection is neither cost effective[60] nor feasible,[61] detection is typically opportunistic. In countries where the optometry profession is well established, the responsibility for glaucoma detection largely falls to optometrists based in community practice. There is no available data for glaucoma referrals in Ireland, but figures from the UK, where undergraduate training and practice patterns are relatively similar, show that between 90%[65] and 96%[64] of referrals to ophthalmology for suspect glaucoma originate from optometrists.

In Ireland, as with many jurisdictions, there are no specific guidelines relating to glaucoma detection in optometric practice. In 2009, the Association of Optometrists Ireland (AOI), the largest professional representative body for optometrists in Ireland,

issued guidelines for optometrists outlining the procedures that might be carried out during a routine eye exam.[132] This guideline does refer to the examination of patients at risk of glaucoma, stating that intra ocular pressure measurement and visual field assessment should be carried out on all patients deemed to be at risk of glaucoma. The choice of equipment used for these tests and the protocol for determining those at risk from glaucoma are not defined, leaving considerable room for variation between practitioners.

Optometric practices wishing to provide state funded eye examinations in Ireland must sign an agreement that outlines the scope and content of the eye exam to be provided. This document states that the contracted optometrist agrees to '*provide eye examinations and advice to the best of his/her knowledge and ability for eligible persons...using suitable instruments and equipment in a suitable manner*' and to '*carry out all tests judged to be necessary to determine the patient's need for vision care as in both sight and health provided that the exact format and content will be determined by the optometrist's professional judgement*.'[133] It can be inferred, that the scope of the eye exam is quite broad and gives responsibility to Irish optometrists to determine the patients' refractive correction and to rule out any form of ocular pathology including glaucoma, though the accepted standards for examination strategies are not clearly defined.

Clinical practice norms in optometry have evolved significantly over the past few decades, with optometric training in Ireland moving from a once part-time, evening course diploma, to a now full-time, four-year honours degree programme.[134] The range of equipment and examinations in use within optometry practices has also grown, and

optometrists are expected to make pragmatic judgements as to which investigations can feasibly be carried out within an eye examination based on an individual's presenting complaints and risk factor profile. Anecdotal evidence suggests a large variation in equipment and practice boundaries between optometry practices and practitioners, though no accurate data exists as to Irish optometrists' typical glaucoma case-finding procedures.

The research outlined in this paper was designed to assess current practice patterns among optometrists in Ireland with a particular emphasis on the tests used in case-finding for glaucoma. This benchmark of current practice standards will be useful in determining equipment and training needs for future enhanced services schemes. Optometrists' level of interest in enhancing their scope of practice was also explored, as a means to provide an insight into the ways the profession might evolve in the coming years.

3.3 Methods

A survey to investigate community optometrists' current practice for glaucoma detection was developed. A review of similar international studies was conducted in order to inform the design and content of the survey.[88,135] Once developed, the survey went through a validation process: it was first reviewed by an expert on question construction, to ensure that it did not contain questions that were leading, confusing or double-barrelled, i.e. asking about more than one construct within a single question. A pilot survey was then sent to 20 community optometrists. The pilot group was selected at random from a group of 70 optometrists who had taken part in a Dublin GRRMS.

Feedback from the pilot was incorporated into the final survey design which consisted of four sections, covering different aspects of optometric practice (refer to Appendix 1 below for the online survey and Appendix 2 for the hard copy format).

Section A: Demographic information

This section sought information on the year that participants first qualified into the profession, their current mode of practice, their academic qualifications, and the time given for routine eye examinations in their practice.

Section B: Diagnostic examinations

The second section was designed to establish the range of equipment available within practices and to explore optometrists' level of confidence in performing a range of pertinent examination techniques.

Respondents were asked which tonometers were available to them in practice, whether they carried out tonometry themselves or if it was delegated to support staff. Respondents were also asked to indicate their first choice technique for intraocular pressure (IOP) measurement during routine eye examinations.

Respondents indicated their usual method of examining the fundus. Options were: 'direct ophthalmoscopy', 'binocular indirect ophthalmoscopy (BIO) using a slit lamp and condensing lens', 'BIO using a headset and condensing lens', or 'other please specify'. A supplementary question asked optometrists to indicate their level of competence at slit lamp BIO. They were asked to respond on a five-point scale, from 1 (unable to carry out slit lamp BIO) to 5 (expert).

Participants were also asked the identify the types of investigative equipment they had available within their workplace, specifically the exact model of perimeter if known, as well as other more specialist equipment such as optical coherence tomography (OCT), gonioscopy, and pachymetry.

Section C: Attitudes to enhanced scope practice

This section sought qualitative information on optometrists' attitudes towards enhanced scope optometry, exploring the level of interest in glaucoma shared care schemes as well as other forms of enhanced scope practice. Participant opinion on the need for postgraduate training as a pre-requisite for enhanced scope practice was also assessed.

Section D: Perceived barriers to glaucoma detection

The findings from this section are explored in detail in Chapter 4.

A multi-mode method of distribution was used to maximise survey responses and minimise sampling bias.[136] To capture responses from those who may be unlikely to volunteer to take part in an online or postal survey, the survey was launched in paper format at the AOI annual general meeting in November 2014. There was a 9-week run time ending in January 2015. All optometrists on the electronic databases of the Federation of Ophthalmic and Dispensing Opticians (FODO) and the AOI were sent a survey information leaflet, a link to the online survey in Google Forms, and a printable version for those who preferred to return the survey by post. The survey was anonymous. Practitioners were assured that all individual results would be kept strictly confidential. Participation in the survey was voluntary and completing the survey

constituted informed consent. The study was approved by the Research Ethics Committee at Dublin Institute of Technology (DIT).

The data collected was analysed on the statistical package for social sciences (IBM SPSS Statistics for Windows, Version 22.0 Armonk, NY: IBM Corp.). The results were analysed using descriptive and inferential statistics: a frequency analysis was carried out and logistic regression was used to further analyse the results.

3.4 Results

199 optometrists responded to the survey, equating to 27% of optometrists registered in Ireland. The study represents a large proportion of the optometrists registered to practice in Ireland, and has a margin of error of 6% at the 95% confidence level. This falls within an acceptable range for margin of error, allowing a reasonably high degree of confidence in the accuracy of the survey findings.

Demographic information

Respondents had varied levels of experience within optometry, the time since qualification into the profession ranged from 1-64 years (Mean 20.17 years, ±12.46). 14.9% of participants had acquired postgraduate qualifications within optometry, ranging from certificate level courses right through to PhD. The reported modes of practice are shown in Table 3.1

Table 3.1: Participating optometrists' modes of practice

Mode of practice	**n (%)**
Employee in an independent practice	37 (18.6%)
Owner of an independent practice	92 (46.2%)
Employee in a franchise or large multiple	34 (17.1%)
Franchise director or owner of a large multiple	3 (1.5%)
Locum optometrist	26 (13.1%)
Academic	3 (1.5%)
Employee in a private ophthalmology practice	1 (0.5%)
Not specified	3 (1.5%)

The median time per appointment was 30 minutes, range 20 mins - 60 mins (Figure 3.1).

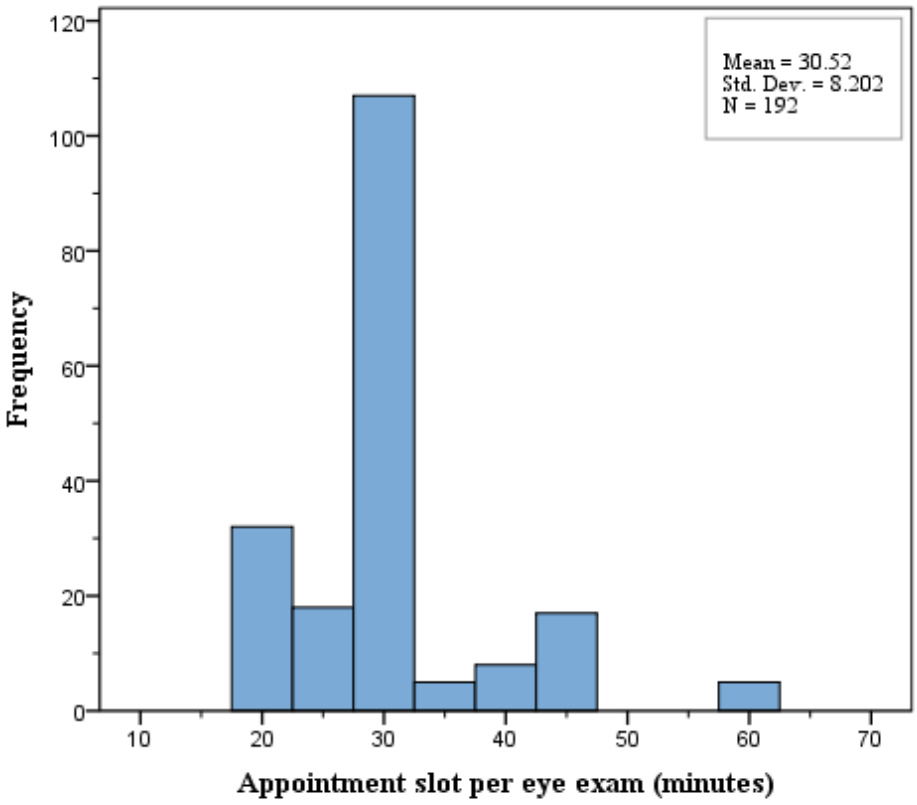


Figure 3.1: Reported times per appointment slot in community optometric practice

Diagnostic Equipment and Examinations

Tonometry

To measure intra-ocular pressure, 53% of respondents had access to non-contact tonometry (NCT) only, 8% had access to contact applanation tonometry (CAT) only, and 39% had both NCT and CAT available in their practice. Optometrists working in independent practices appeared more likely to have access to CAT (51.2%) relative to those working in franchises or large multiples (33.3%), though the difference did not quite reach statistical significance (Table 3.2).

Table 3.2: Tonometry availability according to optometrists' mode of practice. Non-contact tonometry (NCT). Contact applanation tonometry (CAT).

	NCT only	**CAT only**	**Both NCT and CAT available**	**NCT only vs CAT available**
	n (%)	n (%)	n (%)	χ^2 p
Independent practice (n = 129)	63 (48.8%)	14 (10.9%)	52 (40.3%)	p = 0.058
Franchised practice or large multiple (n = 36)	24 (66.7%)	0 (0%)	12 (33.3%)	

Respondents were asked to identify the tonometry technique they used as first choice during routine eye examinations, the responses are represented in Figure 3.2, which shows that NCT was by far the most popular technique.

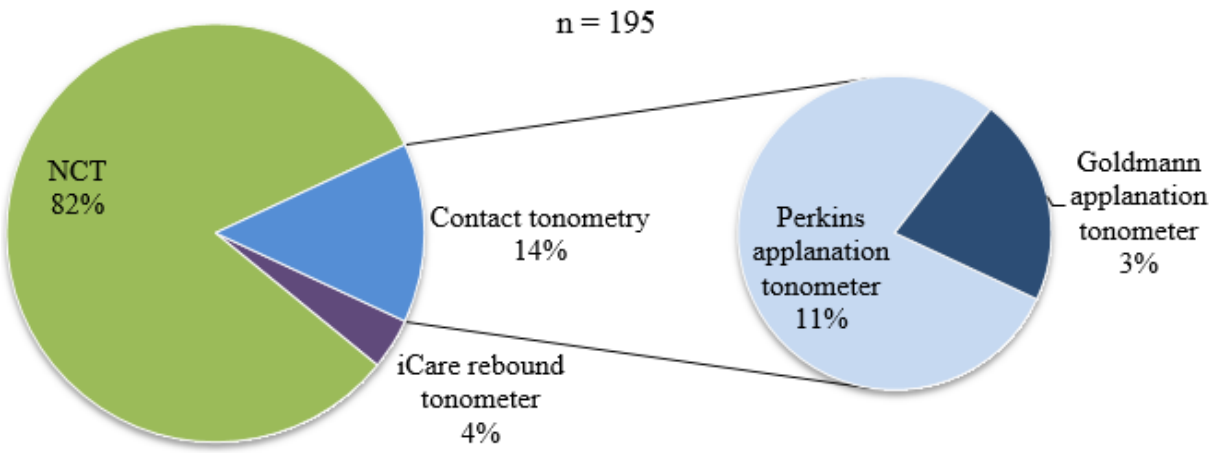


Figure 3.2: First choice tonometer for routine intraocular pressure screening in community optometry.

There were 73 study participants across all modes of practice who had access to both contact and non-contact tonometry techniques. Among this group, only 15% used contact techniques preferentially during routine eye exams. An additional 4% used an Icare rebound tonometer, while the remaining 81%, used NCTs preferentially despite having access to contact techniques. This finding was not related to the practice of delegating tonometry measures to ancillary staff, where NCT would be the expected technique of choice. Among practitioners with access to both techniques and who always carried out tonometry themselves (54 of 73 participants), the proportion using NCT routinely was even higher (83%).

Fundus examination

The majority of respondents (64%) indicated that monocular direct ophthalmoscopy was their first choice technique for fundus examination. Slit lamp binocular indirect ophthalmoscopy (SLBIO) was the second most popular technique (Figure 3.3). A small minority indicated that they used fundus photography in isolation as their method of choice for ocular examination. 79% had a fundus camera in practice which they used in addition to ophthalmoscopy.

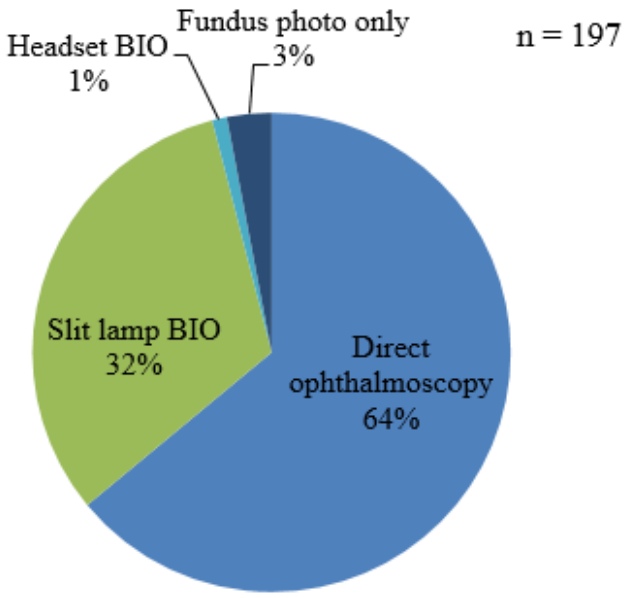


Figure 3.3: Relative frequency of the different methods of fundus examination by community optometrists

Of 197 responses to the Likert item relating to competence on SLBIO, 33% considered themselves 'expert' at the technique, representing the 33% of optometrists who reported using SLBIO as their first choice for fundus examination. 13% were unable to carry out SLBIO (Figure 3.4).

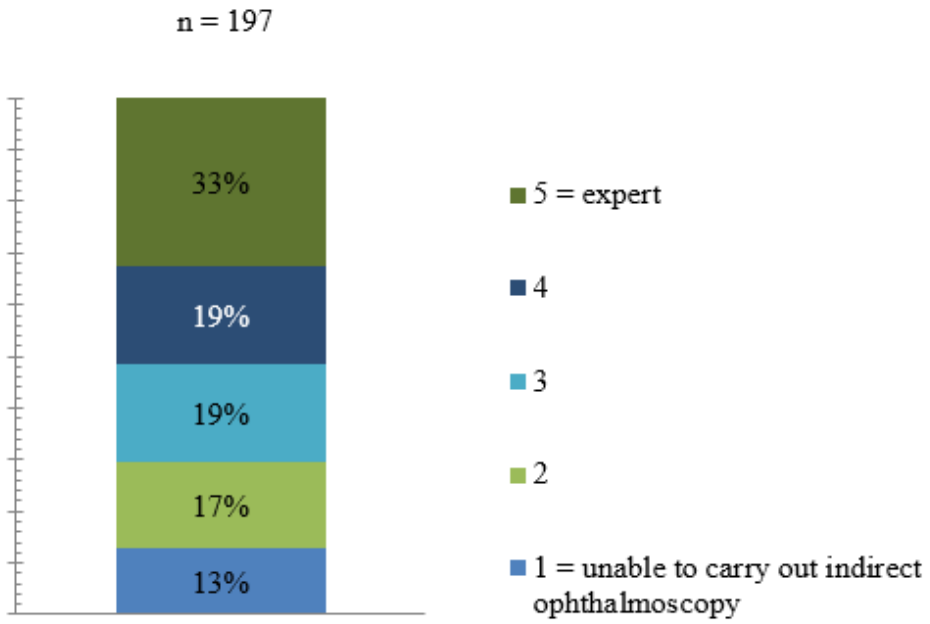


Figure 3.4: Optometrists' reported competence in slit lamp binocular indirect ophthalmoscopy ranked on a scale of 1-5.

While the majority of optometrists surveyed had some level of competence on SLBIO, direct ophthalmoscopy was the more popular technique for fundus examination. A binomial logistic regression was performed to explore potential determinant factors that might explain fundus examination technique preference. Specifically, the effects of years since registration, time per appointment, country of training [Ireland (n = 126) vs. UK (n = 27)], mode of practice [independent practice (n = 120) vs. franchise or large multiple (n = 33)], and postgraduate qualifications [yes (n = 19) vs. no (n = 134)], on the likelihood that participants use direct ophthalmoscopy or SLBIO.

The total n for this model was 153: in this analysis, those using headset BIO or fundus cameras only were excluded: in some of the variables, mode of practice especially, some data was excluded as roles such as locum optometry could not be accurately categorised into a specific practice type. Linearity of the continuous variables with respect to the

logit of the dependent variable was assessed via the Box-Tidwell (1962) procedure. A Bonferroni correction was applied using all eight terms in the model resulting in statistical significance being accepted when $p < .00625$.[137] Based on this assessment, both continuous independent variables were found to be linearly related to the logit of the dependent variable. There were three studentised residuals with values of 2.212, 4.628, and -2.965 standard deviations, which were kept in the analysis.[*]

The logistic regression model was statistically significant, $\chi^2(5) = 48.577$, $p < .0005$. The model explained 37.8% (Nagelkerke R^2) of the variance in ophthalmoscopy techniques and correctly classified 77.1% of cases. Of the five predictor variables, years since qualification and postgraduate education were statistically significant (Table 3.3)

More time since qualification was associated with an increased likelihood of using direct ophthalmoscopy. Notably, those with postgraduate qualifications were close to 12 times more likely to use indirect ophthalmoscopy relative to those without

[*] The regression also repeated after these three outliers were removed from the analysis. The same independent variables, years since registration and postgraduate qualifications, remained significant and there was no change to the significance of the other three variables in the model.

Table 3.3: Logistic regression predicting the likelihood of direct ophthalmoscopy use vs. indirect ophthalmoscopy use based on years since qualification as an optometrist (years), postgraduate qualifications within optometry, country of undergraduate training (Ireland compared to the UK), mode of practice (independent practice vs. franchise or large multiple), and appointment slot in minutes. Statistically significant variables are highlighted in grey.

							95% CI for Odds Ratio	
	B	***SE***	**Wald**	***df***	***p***	**Odds Ratio**	**Lower**	**Upper**
Years	-0.114	.025	20.742	1	**<0.0005**	1.12	1.07	1.18
Postgraduate qualification	-2.456	0.662	13.785	1	**<0.0005**	11.63	3.19	43.48
Country of training	-0.234	0.514	0.207	1	0.649	1.26	0.47	3.46
Mode of practice	0.512	0.593	0.746	1	0.388	1.67	0.52	5.34
Appointment slot	0.057	1.230	1.616	1	0.116	1.06	0.99	1.14
Constant	1.564	1.230	1.616	1	0.204	4.78		

In order to incorporate more cases into the regression model while also reducing the number of predictor variables, providing a model with less bias and more precise estimates, the 'mode of practice' category was excluded from a follow up regression analysis. Removing this variable, which was not a significant predictor of ophthalmoscopy technique choice, gave us 27 extra cases that could be included in the regression model bringing the total number of cases to n = 180.

The logistic regression was then repeated to see if the extra cases changed the significance level of any of the other independent variables: years since registration, time per appointment, country of training [Ireland (n = 150) vs. UK (n = 30)], and postgraduate qualifications [yes (n = 27) vs. no (n = 153)]. This showed that years since registration and postgraduate qualifications were both still significant at the $p < 0.0005$ level and the remaining variables were not significant predictors of ophthalmoscopy technique.

Investigative equipment

87% of respondents had an automated perimeter in practice. Various models of the Henson perimeter (ranging from the 2000 to 8000 model) were the most popular make (48%). 1.4% of those with perimeters used a Humphrey Visual Field Analyser. Most respondents listed just the brand name of the perimeter they had available in practice, omitting the exact model details so it is unclear exactly which instruments are most commonly used but it appears that the majority of the perimeters listed are capable of carrying out full threshold test strategies which are required for appropriate glaucoma diagnosis or monitoring.

The availability of other more specialist investigative equipment is given in Table 3.4

Table 3.4: Relative frequency of the availability of specialist equipment in community optometric practice

	n = 199
Fundus camera	79%
Digital slit lamp camera	12%
Optical coherence tomography	11%
Pachymeter	5%
Gonioscopy lens	7%

Attitudes to an enhanced scope of practice

Just 4 participants, (2.1%) indicated that they 'have no interest in changing the scope of the traditional eye examination', the remainder indicated varied levels of interest in expanding their scope of practice for glaucoma detection and/or monitoring ranging from a simple repeat measures service to independent medical management of glaucoma (Figure 3.5).

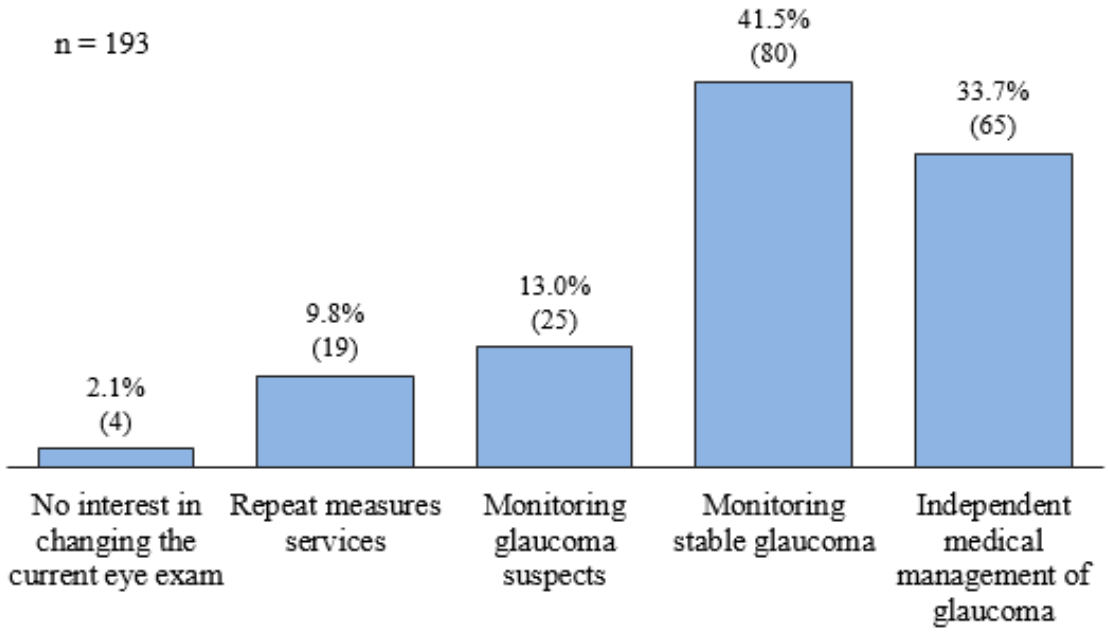


Figure 3.5: Optometrists' interest in enhanced scope practice for glaucoma, % (n).

A follow up question asked optometrists if they considered postgraduate education an essential pre-requisite to providing these enhanced scope services. Of the 196 respondents who completed this question, 57% considered postgraduate education an essential prerequisite to providing a repeat measures service or for monitoring glaucoma suspects, 60% deemed postgraduate education an essential prerequisite to optometric monitoring of stable glaucoma patients, and 92% considered postgraduate education an essential prerequisite to optometric management of the medical treatment for patients with glaucoma.

There was also a high level of interest in other forms of enhanced scope practice. This included 68% of respondents who indicated an interest in shared care schemes for diabetic retinopathy patients, while 67% were interested in providing pre/post-operative cataract services, 61% were willing to become involved in shared care schemes for age

related macular degeneration (AMD) patients, 47% indicated interest in expanding their role in paediatric services, 45% were interested in taking up hospital optometry positions, and 42% indicated an interest in independent prescribing by optometrists. Just 6% of respondents filled in a free text box allowing for other suggestions for enhanced optometry services. Suggestions included; low vision services, red eye triage and foreign body removal, sports vision assessment, keratoconus management, colorimetry, binocular vision therapy, hospital based advanced contact lens clinics, and clinical management of dry eye.

3.5 Discussion

The results show that Irish optometrists are well equipped to perform the traditional triad of tests necessary to detect glaucoma, with 87% of practitioners reporting access to all three clinical techniques (tonometry, optic nerve assessment, and standard automated perimetry), and a large proportion of optometrists reporting access to CAT (47%). This demonstrates that optometrists are well equipped for glaucoma case finding services but implementation of enhanced referral services, such as a repeat measures scheme, would require equipment upgrades and associated training in at least half of the surveyed practices.

Tonometry

NCT is, by far, the current first choice for IOP measurement during routine eye examinations, a finding consistent with previous clinical practice surveys carried out in Great Britain[88,120] and Northern Ireland.[138] There has been speculation that the ability to delegate non-contact tonometry to non-professional staff may contribute to its popularity

relative to contact techniques.[88] Our survey has found that NCT use is high even among those optometrists that do not delegate IOP measurement, and have ready access to CAT, the accepted reference standard. Other potential barriers to performing CAT, such as a need for training, the recurring cost of topical anaesthetic, a perception that CAT is more time consuming than NCT, or that NCT is a lower risk procedure, may be at play.

In 2006, a new GOS contract was introduced in Scotland. The new contract required optometrists to demonstrate competence in GAT before they could be accredited to practice in Scotland, and paid a supplementary fee to perform the test.[101] The inclusion of CAT results went from 11.8% to 50% following the introduction of the new contract and funding, demonstrating that training and finance barriers can be overcome, though it is notable that GAT was still the most common examination missing from optometric glaucoma referrals.[101]

Achieving a culture shift in IOP measurement in optometry practices might require a combination of strategies, including policy and funding changes, as seen in Scotland, as well as changes in education and training of optometrists. There might be a perception among optometrists that NCT is equivalent to GAT in terms of accuracy of IOP measurement. While NCTs have been shown to have high levels of agreement with GAT,[139] users should be aware that the calibration of most NCTs is not based on absolute (manometric) measures of IOP but against the established reference standard i.e. Goldmann applanation tonometry. Thus, NCTs calibrated in this way cannot exceed the accuracy attainable with the reference standard.

It has been shown in fact, that there is an overestimation of IOP by NCT relative to GAT at higher IOP levels,[89] and that NCT is significantly more susceptible to the effects of

central corneal thickness than GAT,[90] factors that are particularly relevant in glaucoma diagnosis and management. This evidence shows that contact techniques have clear advantages over NCTs, that optometrists should be encouraged to use contact techniques preferentially, especially when IOP or central corneal thickness are high. In addition, any practitioners wishing to progress from glaucoma case finding towards diagnostic services such as monitoring glaucoma suspects or patients with ocular hypertension, should be required to use CAT.

Fundus Examination

The majority of those surveyed reported some level of proficiency with SLBIO, though monocular direct ophthalmoscopy remains the most popular technique for fundus examination during routine eye exams. Indirect ophthalmoscopy has a number of advantages over direct techniques, two of which are particularly relevant to glaucoma detection. One, it provides a stereoscopic view of the optic nerve head, allowing for more accurate interpretation of cupping of the nerve, and two, the magnification of the image is not significantly affected by the patient's refractive error, allowing the size of the optic nerve head to be measured with a simple calculation.

In a separate review of Irish optometrists' referral letters for suspect glaucoma (refer to Chapter 7), there was an almost complete lack of disc size measurements, an essential factor in discerning the relevance of cup-disc ratio values, which may be due to reliance on direct ophthalmoscopy. Binomial logistic regression showed that those with postgraduate qualifications were much more likely to use indirect rather than direct ophthalmoscopy and that more recently qualified optometrists were also more likely to

use SLBIO as their first choice technique (Table 3.3). This shows that more recent participation in education is relevant in terms of likelihood of SLBIO use.

As indirect ophthalmoscopy is now a core competency required of undergraduate optometry students in Ireland, it is likely that the use of indirect ophthalmoscopy will become more commonplace over time. There may be scope for continuing professional development events that could promote the more widespread use of SLBIO among less recently qualified optometrists.

Perimetry

Automated perimeters were shown to be widely available (87%) though this still lagged behind UK estimates which have shown that virtually all optometrists (>95%)[88] have access to automated perimetry. The reasons for this difference are unclear. The AOI recommend a visual field examination is conducted on any patient deemed to be at risk of glaucoma,[132] but some Irish optometrists might consider automated perimetry to be beyond their traditional screening role, preferring to refer any glaucoma suspect findings rather than investigating for visual field loss.

One could argue that referring patients on the basis of inadequate screening tests such as isolated tonometry or ophthalmoscopy findings represents poor professional performance, potentially causing unnecessary psychological stress to patients[46] as well as wasting time and resources in secondary care. Development of a standardised approach to visual field testing could become important in relation to the new fitness to practice complaints procedures[119] being implemented by optometry's regulatory body in Ireland. Professional performance is now assessed in relation to the perceived practice

norms, and failure to conduct a visual field examination in a glaucoma suspect could be considered substandard practice.

Advanced diagnostics

The availability of specialist equipment broadly follows trends which have been reported in the UK.[88,140] It is notable that some Irish optometry practices are willing to invest in advanced diagnostic equipment despite the lack of state funding for enhanced services, and restrictive legislation which, until recently, tightly controlled optometrists' scope of practice, requiring that any patient found suspect for pathology be informed and referred to a medical practitioner.[34] This legislation was abolished in October 2015 and replaced with a broader definition of scope of practice, indicating that optometrists can 'act within the limits of (their) knowledge, skills, competence and experience' and 'practice only in areas in which (they) have relevant competence, education, training and experience'.[31]

Within this framework, there is clear scope for optometrists, with the appropriate skills and equipment, to become more involved in the diagnosis, monitoring and management of ocular pathology. It appears that enhanced case-finding could be easily implemented in those few practices with ready access to CAT, pachymetry and gonioscopy for example, but the majority of optometrists in Ireland would require equipment upgrades and corresponding training to carry out more detailed diagnostic testing for glaucoma.

Enhanced scope of practice

The overwhelming majority of participants indicated some interest in broadening their scope of practice in glaucoma care. With an established base of practices dispersed across the country, optometrists are well placed to redirect some eye care services away from acute hospitals, though there was also a high level of interest in hospital optometry positions.

Under the UK's NHS, a number of innovative care pathways have emerged such as repeat measures,[95] referral refinement,[37] and optometry-led hospital-based glaucoma assessment clinics[129] for example, which involve optometrists in the co-management of glaucoma and have proven an effective strategy in dealing with increasing patient numbers.

The majority of respondents in our study considered postgraduate education an essential prerequisite to enhanced scope of practice. Current professional development opportunities in Ireland are mainly in the form of short lectures or workshops, often sponsored by companies or private ophthalmology clinics as a means to generate business rather than target specific training needs within the profession. The DIT, the only optometry programme in Ireland, offer various postgraduate research opportunities for optometrists. However, there is just one level 9 clinical module which was launched in January 2017. It is clear that new, more targeted training opportunities will be an important facilitator of enhanced optometric services in Ireland.

Irish optometrists can partake in distance learning opportunities offered in many universities across the UK, but clinical experience in these modules is necessarily

limited. A number of studies have shown that didactic teaching alone is unlikely to lead to significant improvements in clinical competence[113] and that longer term training, including ophthalmology feedback on referred patients, may be essential to improving the PPV of optometric glaucoma referrals.[117] Involving ophthalmologists in training and appraising optometrists in enhanced scope roles would provide expert feedback on performance and referrals which would serve to better align practice patterns between hospital and community.

In order to provide this form of training, optometrists could be included in multidisciplinary ophthalmology teams, where apprenticeship style training can be integrated into work practices and optometrists will be exposed to a range and volume of pathology that is not seen in most traditional optometric practices, further developing the depth of expertise within the optometry profession.

3.6 Limitations

The results reflect the current trends in Irish optometry practices, so the findings may not be applicable to other jurisdictions. However, information on the development of Irish optometry is of interest in a European context where demographic change owing to an ageing population is prompting a re-evaluation of primary eye care delivery models.[141] Optometric practice patterns across Europe vary widely, though it appears that a decline in the numbers of ophthalmologists[142] is resulting in a transfer of many primary care responsibilities to optometrists and opticians.[143]

This survey may have underestimated optometrists' use of CAT techniques as the questions regarding tonometry use related to first choice screening technique during

routine eye exams. It is possible that some optometrists use CAT to repeat IOP measurements when individuals are found suspect for glaucoma or NCT readings are high. Although evidence from a further analysis of optometric referrals for suspect glaucoma (refer to Chapter 7) found a very low rate of CAT use: just 5% of the IOP measures recorded on the referral letters (n = 215) were taken using CAT.

It is also possible that survey bias impacted the results, particularly in relation to attitudes towards enhanced scope of practice as those with most interest in glaucoma detection were most likely to respond to a survey titled 'detecting glaucoma in optometric practice'. Nonetheless, it is notable that at least a quarter of all optometrists in Ireland are expressing interest in enhanced optometric services for glaucoma detection and management.

3.7 Conclusion

Irish optometrists are well equipped to perform the traditional tests necessary to conduct adequate glaucoma case finding. Moving towards enhanced services such as monitoring glaucoma suspects or ocular hypertension cases would require some investment in equipment and training. There is strong interest in furthering optometric professional development and expanding the traditional role boundaries of optometrists in Ireland, incorporating further education as an essential prerequisite to an enhanced scope of practice.

4. BARRIERS TO GLAUCOMA CASE FINDING AS PERCIEVED BY OPTOMETRISTS IN IRELAND

4.1 Abstract

Purpose

This research was designed to provide an in-depth exploration of optometrists' perceptions of the challenges of glaucoma case finding in the Irish health care system.

Methods

A survey was developed, piloted and distributed for anonymous completion by optometrists registered to practice in Ireland. The survey included ten five-level Likert items exploring potential barriers to glaucoma detection, and a free-text box for participants to comment more broadly.

Results

199 optometrists (27% of registrants) responded to the survey. Among the barriers identified, there was notable agreement (71%) with the need for extra training on glaucoma detection. Logistic regression showed that optometrists without postgraduate qualifications were more likely to agree with the need for extra training (OR 3.2 (95% CI 1.3 - 8.1)). Respondents largely agreed (61%) that patient unwillingness to pay additional fees for supplementary glaucoma specific tests was also a barrier. Appointment times of less than 30 minutes were significantly associated with six of the ten proposed barriers to glaucoma detection. A logistic regression analysis (n = 179) confirmed that the time allotted per appointment was a significant predictor of

optometrist's agreement time as a barrier, χ^2 (1) = 13.52, p<0.001. Multiple linear regression showed that optometrists with less experience, charging lower fees, and working in large multiples or franchised practices have the shortest appointment times.

Conclusion

The strong link found between postgraduate education and optometrist's confidence in detecting glaucoma indicates that optometrists wishing to increase their scope of practice in Ireland's new legislative environment may more actively seek out training in areas of interest. The responses also indicate a lack of funding for the level of diagnostic testing required for accurate glaucoma diagnosis. Recent increases in the State's eye examination fees have the potential to address the identified time and financial barriers to glaucoma detection in Ireland. Future work should look to analyse the effects of increased funding on optometric case finding for glaucoma.

4.2 Introduction

The difficulty of the optometrist's role in the ophthalmic care pathway often goes unrecognised. It has been documented that optometrists are seen differently than other healthcare professionals, as patients perceive the profession as having a commercial rather than a healthcare role.[144] The responsibilities of an optometric eye examination are, in fact, quite broad, as optometrists are tasked with investigating and managing refractive and binocular vision anomalies, while also evaluating ocular health to detect ocular pathology including glaucoma.

Public perception of optometry practices as retail businesses with little to no health care role[144] affects credibility, which has impact on patient education in relation to perceived utility of optometrist recommended supplementary tests and recall visits, potentially affecting healthcare outcomes. Additionally, optometric glaucoma referrals have been scrutinised over the past 25 years,[62,64–69] with a strong, arguably disproportionate, focus placed on false positive referrals.[47,70,71] Optometrists' responsibility to detect disease, inherently leads to false positive referrals in a population where the relative prevalence of glaucoma is low,[74] and this effect is likely being compounded by a tendency for optometrists to preference sensitivity over specificity in their diagnostic testing.[145]

This practice pattern could be considered pragmatic, given that optometrists are required to detect pathology and are at risk of litigation[146,147] if they fail in this duty of care. It is understood that no medical test has perfect sensitivity and perfect specificity, and glaucoma detection is a particularly ambiguous area given the significant overlaps in the

clinical features of suspicious, but normal individuals and those with early glaucoma.[74,75] While decreasing false positive referrals for glaucoma would improve efficiency in a hospital eye care service that is struggling to cope with demand,[148] a myopic focus on false positive referrals could be detrimental. Repeated reports of false positive referrals could create a culture of diminishing sensitivity, where referrals are very specific but glaucoma diagnoses are missed because of reticence to refer or inability to carry out follow up investigations.

This research aims to provide an in-depth exploration of optometrists' perceptions of the challenges for glaucoma detection within the Irish health care system. In case finding for glaucoma, optometrists face the challenge of detecting an insidious disease of relatively low prevalence,[74] using tests with limited diagnostic accuracy.[74,75] Identifying additional barriers to glaucoma detection in optometric practice can help inform and underpin the future service reform required to cater to the increasing demand for ophthalmic care. Consultation with the profession and investigation of any barriers to clinical practice for glaucoma, represent important precursors to the development of any new glaucoma care schemes.

4.3 Methods

A survey to investigate community optometrists' current practice in the detection of POAG was developed. The design of the survey is described in detail in Chapter 3. This analysis utilises results from sections A, B, and D of the survey described in Chapter 3, the relevant detail on these sections is described here for clarity.

The survey comprised three sections. The first section was designed to establish optometrists' demographic information such as mode of practice, academic qualifications, and to explore appointment times available for routine eye examination. The second section aimed to establish the range of equipment available within practices and to explore optometrists' level of confidence in performing a range of pertinent examination techniques. The final section addressed optometrists' perceived barriers to glaucoma detection during routine eye examinations. It contained ten five-level Likert items that presented possible barriers that might be perceived by optometrists in relation to glaucoma detection.

The Likert items were based on themes identified in a 2010 survey of UK based community optometrists that presented seven main barriers to optometric detection of glaucoma.[135] These barriers were expanded for our survey, to include 10 potential barriers (Table 4.2). Participants were asked to indicate their level of agreement or disagreement with each. A final free-text box was provided for participants to expand upon the themes already suggested, or to express their own opinions on the barriers faced by optometrists.

The data collected was analysed on the statistical package for social sciences (IBM SPSS Statistics for Windows, Version 22.0 Armonk, NY: IBM Corp.) and RStudio (RStudio Team (2015). RStudio: Integrated Development for R. RStudio, Inc., Boston, MA). The results were analysed using descriptive statistics and inferential statistics: chi-square test of independence, multivariate ordinal regression, logistic regression and linear regression.

4.4 Results

199 optometrists responded to the survey, equating to 27% of optometrists registered in Ireland.

Demographic information

Analysis of the demographic data showed a broad geographic range including respondents practicing in 25 of the 26 counties in the Republic of Ireland. County Dublin, had the highest response (n = 47, 24% of the total response), followed by County Cork (n = 15, 8%), reflecting the population distribution in Ireland.[149] Practice summary information is represented in Table 4.1 and Figure 4.1.

Table 4.1: Practice summary information. Part 1.

Variable	**n**	**Range**	**Mean**	***SD***	**Mode**
Time since qualification (years)	199	1-64	20.17	12.46	21
Fee per private eye examination (€)	189	0-98	33.15	9.98	30
Time per appointment (mins)	192	20-60	30.52	8.20	30
Number of optometrists employed within a practice	180	1-19	2.65	2.41	1

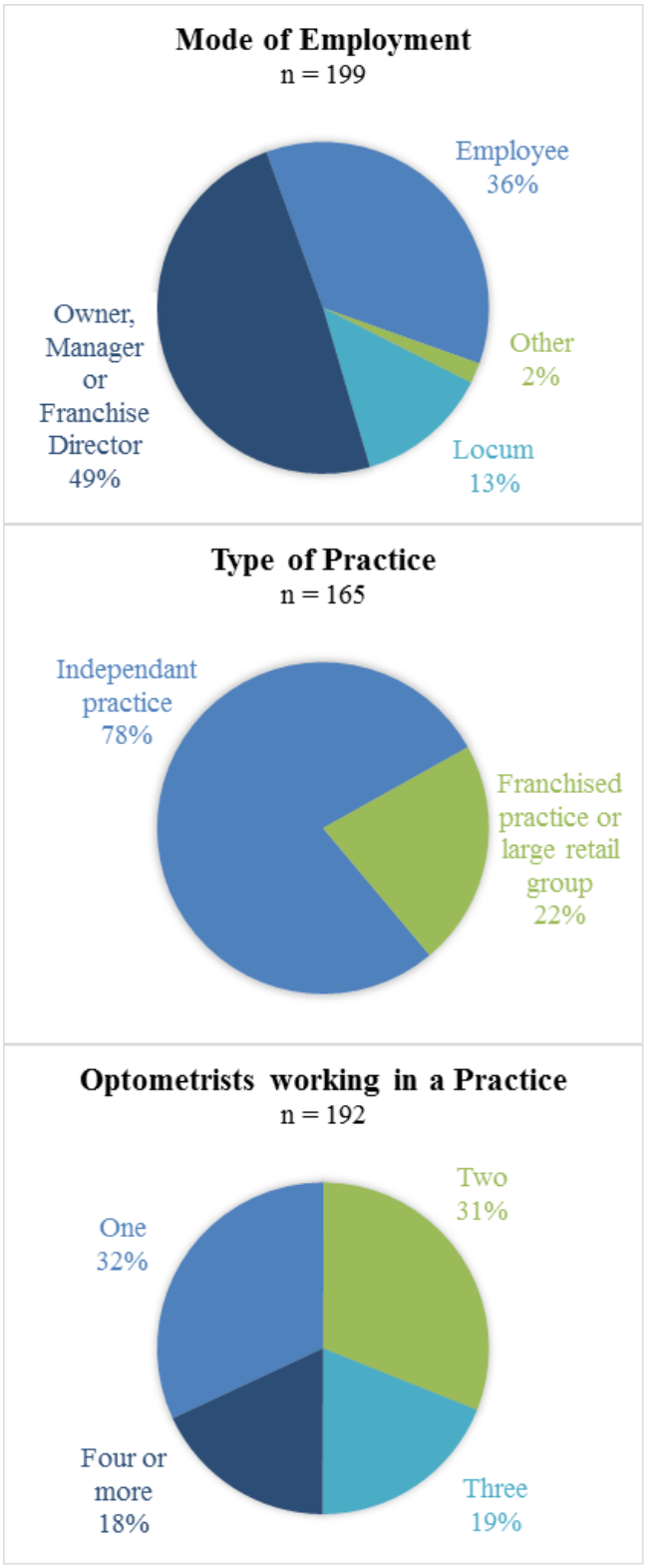


Figure 4.1: Practice Summary Information. Part 2.

Perceived barriers to glaucoma detection

97% of participants responded to the Likert items proposing barriers to glaucoma detection in optometric practice and 94% agreed with one or more of the suggested barriers. The most frequently cited barriers included:

- the need for extra training (71% agreement);
- patient unwillingness to pay for supplementary tests, defined as any diagnostic investigations that cannot feasibly be offered during a routine eye exam (examples might include repeat IOP measurements or full threshold automated perimetry) (61% agreement); and
- poor continuity, caused by patients moving between practices (55% agreement).

The Likert items presented in the survey and the frequency of agreement with the proposed barriers are represented in Table 4.2.

Table 4.2: Frequency of optometrists' agreement with proposed barriers to glaucoma detection during routine eye examinations.

	Barriers presented	Agree Freq. (%)	Neutral Freq. (%)	Disagree Freq. (%)
1	**Training needed:** 'I feel I need extra training on some examination techniques and/or interpretation of some tests results. E.g. new technologies such as OCT.'	137 (71%)	33 (17%)	23 (12%)
2	**Unwilling to pay:** 'Some patients are unwilling to pay an extra fee for supplementary tests that may aid detection of glaucoma. These tests cannot feasibly be offered during the routine exam.'	118 (61%)	45 (23%)	30 (16%)
3	**Continuity:** 'Patients shopping around between practices leads to problems with access to previous clinical records and hampers my ability to detect change over time.'	104 (55%)	43 (23%)	43 (23%)
4	**Finance:** 'It's not financially viable to purchase specialist equipment and/or schedule repeat testing appointments.'	85 (45%)	56 (30%)	49 (26%)
5	**Fail to attend:** 'Patients do not consider the eye exam an important health check and so may fail to attend for recommended follow up tests.'	69 (36%)	59 (31%)	61 (32%)
6	**Time:** 'Time constraints limit my ability to carry out some tests and/or repeat tests.'	54 (29%)	44 (24%)	89 (48%)
7	**Equipment:** 'The equipment available where I work is inadequate; this limits the accuracy of my glaucoma exam.'	45 (24%)	34 (18%)	107 (58%)
8	**Practice Management:** 'Practice staffing and management issues affect my ability to perform necessary tests and/or schedule repeat testing appointments.'	36 (19%)	31 (16%)	124 (65%)
9	**Training not accessible:** 'Training on glaucoma detection is not available or accessible to me.'	28 (15%)	53 (29%)	104 (56%)
10	**Record keeping:** 'Record keeping within the practice is inadequate and hampers my ability to detect change over time.'	15 (8%)	15 (8%)	161 (84%)

**Percentages have been rounded to the nearest whole number resulting in some percentage totals differing from 100.*

To examine the relationship between the group demographics and agreement with the proposed barriers, a chi-square test for association was conducted. Agreement with the need for extra training was significantly associated with postgraduate education. Optometrists without postgraduate qualifications were more likely to agree with the need for extra training in glaucoma detection, OR 4.3 (95% CI 1.7 – 11.6) $\chi 2$ p=0.003. Agreement with a lack of continuity of care as a barrier to glaucoma detection was associated with both employment status and time allowance per appointment. Employees were statistically significantly more likely to agree with a lack of continuity, OR 2.2 (95% CI 1.1 – 4.6) $\chi 2$ p=0.029, than self-employed persons or those in managerial roles, as were optometrists with shorter appointment times (<30 mins), who were more likely to agree with lack of continuity, OR 3.0 (95% CI 1.2 – 7.4) $\chi 2$ p=0.015, than those with more time.

Time allowance per appointment emerged as the variable that was significantly associated with the most barriers. Those optometrists with an appointment slot shorter than 30 minutes (26%) were statistically significantly more likely to agree that time constraints, equipment levels, staffing and management issues, inadequate record keeping, financial constraints, and a lack of continuity of care all limit their ability to detect glaucoma in routine practice (OR 2.9 to 6.6, $\chi 2$ p<0.025 for all).

The results of the full chi-square analysis are shown in Table 4.3.

Table 4.3: Chi square test for association. Statistically significant differences (P<0.05) are highlighted in bold and grey

		Fail to attend	**Finance issues**	**Record keeping**	**Training needed**	**Training not accessible**
Appointment slot <30 mins	Freq. <30 mins (%) Freq. ≥30 mins (%) χ^2 p OR (95% CI)	20 (50%) 47 (53%) 0.825 0.9 (0.4 – 2.0)	28 (80%) 55 (57%) **0.017** **3.0 (1.2 – 7.5)**	7 (16%) 6 (5%) **0.020** **3.7 (1.2 – 11.6)**	38 (88%) 95 (86%) 0.740 1.2 (0.4 – 3.5)	9 (28%) 18 (19%) 0.272 1.7 (0.7 – 4.2)
Employment status	Freq. employed (%) Freq. self-employed/director (%) χ^2 p OR (95% CI)	41 (59%) 28 (47%) 0.175 1.6 (0.8 – 3.3)	43 (64%) 41 (63%) 0.895 1.1 (0.5 – 2.1)	12 (13%) 3 (4%) **0.021** **4.2 (1.1 – 15.5)**	72 (86%) 65 (88%) 0.695 0.8 (0.3 – 2.1)	16 (25%) 11 (17%) 0.260 1.6 (0.7 – 3.9)
Time since qualification	Freq. ≤10 years Freq. >10 years χ^2 p OR (95% CI)	21 (58%) 48 (51%) 0.457 1.3 (0.6 – 2.9)	23 (70%) 62 (61%) 0.389 1.4 (0.6 – 3.4)	9 (20%) 6 (5%) **<0.001** **5.2 (1.7 – 15.6)**	31 (80%) 106 (88%) 0.165 0.5 (0.2 – 1.3)	9 (26%) 19 (20%) 0.464 1.4 (0.6 – 3.5)
Fee for private eye exam	Freq. <€30 (%) Freq. ≥€30 (%) χ^2 p OR (95% CI)	11 (58%) 54 (51%) 0.551 1.4 (0.5 – 3.6)	14 (67%) 68 (64%) 0.052 1.2 (0.4 – 3.1)	2 (10%) 10 (6%) 0.651 1.442 (0.3 – 7.1)	17 (85%) 114 (87%) 0.804 0.9 (0.2 – 3.2)	6 (30%) 20 (19%) 0.269 1.8 (0.6 – 5.3)
Tonometers available	Freq. NCT only Freq. GAT or combination χ^2 p OR (95% CI)	39 (55%) 29 (51%) 0.648 1.2 (0.6 – 2.4)	52 (71%) 33 (56%) 0.068 2.0 (1.0 – 4.0)	13 (14%) 1 (1%) **0.002** **13.0 (1.7 – 101.8)**	77 (89%) 57 (82%) 0.210 1.8 (0.7 – 4.6)	15 (24%) 13 (19%) 0.510 1.7 (0.4 – 5.9)
Perimeter available	Freq. Yes Freq. No χ^2 p OR (95% CI)	59 (56%) 9 (47%) 0.504 1.4 (0.5 – 3.7)	71 (62%) 13 (87%) 0.062 0.3 (0.1 – 1.2)	11 (7.4%) 3 (15%) 0.250 0.5 (0.1 – 1.6)	114 (87%) 17 (81%) 0.454 1.6 (0.5 – 5.3)	25 (22%) 2 (14%) 0.499 1.3 (0.6 – 3.1)
CPD support from employer	Freq. Yes Freq. No χ^2 p OR (95% CI)	30 (57%) 31 (55%) 0.896 1.1 (0.5 – 2.2)	43 (62%) 31 (67%) 0.578 0.8 (0.4 – 1.8)	5 (6%) 7 (11%) 0.304 0.5 (0.2 – 1.8)	58 (85%) 57 (89%) 0.518 0.7 (0.3 – 2.0)	9 (15%) 16 (30%) 0.058 0.4 (0.2 – 1.1)
Postgraduate qualification	Freq. No Freq. Yes χ^2 p OR (95% CI)	58 (53%) 11 (55%) 0.851 0.9 (0.4 – 2.4)	77 (67%) 8 (42%) **0.037** **2.7 (1.0 – 7.5)**	2 (7%) 13 (8.8%) ***** 	121 (90%) 16 (67%) **0.003** **4.3 (1.7 – 11.9)**	28 (26%) 0 (0%) **0.005** **1.4 (1.2 – 1.5)**

		Time	Equipment	Management	Fail to pay	Continuity
Appointment slot <30 mins	Freq. <30 mins (%) Freq. ≥30 mins (%) χ^2 p OR (95% CI)	21 (57%) 31 (31%) **0.006** **2.9 (1.3-6.3)**	20 (53%) 23 (21%) **<0.001** **4.2 (1.9 – 9.1)**	23 (53%) 13 (13%) **<0.001** **6.6 (2.8 – 15.1)**	33 (85%) 80 (77%) 0.314 1.7 (0.6 – 4.4)	37 (84%) 64 (64%) **0.015** **3.0 (1.2 – 7.4)**
Employment status	Freq. employed (%) Freq. self-employed/director (%) χ^2 p OR (95% CI)	34 (45%) 20 (31%) 0.077 1.9 (0.9 – 3.7)	35 (44%) 10 (14%) **<0.001** **5.0 (2.3 – 11.2)**	31 (37%) 5 (7%) **<0.001** **8.5 (3.1 – 23.3)**	60 (78%) 57 (81%) 0.598 0.8 (0.4 – 1.8)	64 (78%) 40 (62%) **0.029** **2.2 (1.1 – 4.6)**
Time since qualification	Freq. ≤10 years Freq. >10 years χ^2 p OR (95% CI)	21 (54%) 33 (32%) **0.017** **2.5 (1.2 – 5.3)**	18 (42%) 27 (25%) **0.038** **2.2 (1.0 – 4.6)**	14 (33%) 22 (19%) 0.050 2.1 (0.1 – 4.8)	29 (78%) 89 (80%) 0.813 0.9 (0.4 – 2.2)	36 (82%) 68 (66%) 0.054 2.3 (1.0 – 5.5)
Fee for private eye exam	Freq. <€30 (%) Freq. ≥€30 (%) χ^2 p OR (95% CI)	7 (43%) 43 (36%) 0.554 1.4 (0.5 - 4.0)	10 (52%) 31 (25%) **0.012** **3.4 (1.3 – 9.1)**	8 (36%) 23 (18%) **0.044** **2.6 (1.0 – 7.1)**	13 (76%) 99 (80%) 0.796 0.9 (0.3 – 2.8)	16 (70%) 82 (70%) 0.994 1.0 (0.4 – 2.7)
Tonometers available	Freq. NCT only Freq. GAT or combination χ^2 p OR (95% CI)	30 (37%) 22 (37%) 0.934 1.0 (0.5 – 2.1)	37 (48%) 7 (10%) **<0.001** **8.1 (3.3 – 19.8)**	21 (25%) 14 (19%) 0.360 1.4 (0.7 – 3.1)	55 (75%) 59 (84%) 0.153 0.6 (0.2 – 1.3)	59 (74%) 44 (68%) 0.424 1.3 (0.7 – 2.8)
Perimeter available	Freq. Yes Freq. No χ^2 p OR (95% CI)	48 (40%) 4 (27%) 0.317 1.8 (0.6 – 6.1)	33 (26%) 10 (59%) **0.005** **0.2 (0.1 – 0.7)**	26 (20%) 9 (45%) **0.012** **0.3 (0.1 – 0.8)**	99 (80%) 15 (83%) 0.774 0.8 (0.2 – 3.1)	78 (71%) 13 (68%) 0.796 1.2 (0.4 – 3.3)
CPD support from employer	Freq. Yes Freq. No χ^2 p OR (95% CI)	29 (43%) 17 (35%) 0.385 1.4 (0.7 – 3.0)	13 (18%) 25 (45%) **<0.001** **0.3 (0.1 – 0.6)**	11 (15%) 20 (35%) **0.006** **0.3 (0.1 – 0.7)**	63 (88%) 40 (76%) 0.081 2.3 (0.9 – 5.8)	44 (70%) 45 (73%) 0.735 0.9 (0.4 – 1.9)
Postgraduate qualification	Freq. No Freq. Yes χ^2 p OR (95% CI)	43 (36%) 11 (50%) 0.198 0.6 (0.2 – 1.4)	38 (31%) 7 (25%) 0.555 1.3 (0.5 – 3.4)	31 (23%) 5 (21%) 0.832 1.1 (0.4 – 3.2)	101 (79%) 17 (85%) 0.528 0.7 (0.2 – 2.4)	91 (73%) 13 (59%) 1.8 0.5 (0.7 – 4.7)

** Expected cell count below five, therefore invalid and removed from the table.*

Regression Analysis

Logistic and linear regression analyses were conducted to allow continuous variables to be incorporated into the analysis, to maintain the Likert scale ratings of the proposed barriers, and to incorporate the effects of confounding factors.

Perceived need for extra training

To explore the impact of potential confounders on the perceived need for extra training, a cumulative odds ordinal logistic regression with proportional odds was run to establish the adjusted odds ratios for completed postgraduate education, subjective competence on binocular indirect ophthalmoscopy (BIO), tonometry equipment available, years since qualification, number of optometrists working within one practice, and access to financial support for continuing professional development (CPD) on the dependent variable, the perceived need for extra training. The final model statistically significantly predicted the dependent variable over and above the intercept-only model, $\chi^2(7) = 14.656$, $p=0.041$. The adjusted odds of optometrists without postgraduate education agreeing with the statement that they needed extra training for glaucoma detection was 3.2 (95% CI 1.3 - 8.1) times that for optometrists with postgraduate education, $\chi^2(1) = 6.204$, $p=0.013$. Postgraduate education, therefore, remained as a significant predictor of agreement with the need for extra training, even when potential confounding factors were included in the analysis.

The remaining predictor variables used in the regression model were not significant. The model is shown in Table 4.4.

Table 4.4: Ordinal regression: dependant 'the perceived need for extra training'.

Variable	Training Needed OR (95% CI)	Sig.
Tonometry equipment available: NCT only	2.2 (1.0– 4.9)	0.062
GAT only	3.5 (0.6 – 20.0)	0.16
Competence on BIO	1.0 (0.7 – 1.3)	0.88
Support for CPD	0.7 (0.3 – 1.4)	0.30
Years since qualification	1.0 (1.0 – 1.0)	1.0
Postgraduate education	**3.2 (1.3 to 8.1)**	**0.013**
Number of optometrists working within the practice	1.0 (0.9 – 1.2)	0.86

Short appointment times

A logistic regression was conducted, incorporating the full time range of appointment slots (removing outliers) to further analyse the effects of appointment duration as a barrier. The analysis was conducted for 179 optometrists, and found that the test of the full model against a constant only model was statistically significant. Time slot allotted per appointment reliably distinguished between agree and disagree (or neutral) responses relating to whether optometrists have enough time to conduct a "full" test, χ^2 (1) = 13.52, p<0.001. For estimate values, see Table 4.5. Figure 4.2 shows the probability of disagreeing with time constraints as a barrier (probability of no barrier) versus the appointment slot time, and shows that an appointment time of ~45 minutes would result in a 75% probability of no barrier to diagnosis.

Table 4.5: Time slot logistic regression analysis

	Estimate	Std. Error	z value	Odds Ratio	Confidence Interval	p
Intercept	-2.29	0.67	-3.43	0.10	(0.026 - 0.35)	<0.001
Time slot	0.072	0.022	3.35	1.08	(1.033 - 1.13)	<0.001

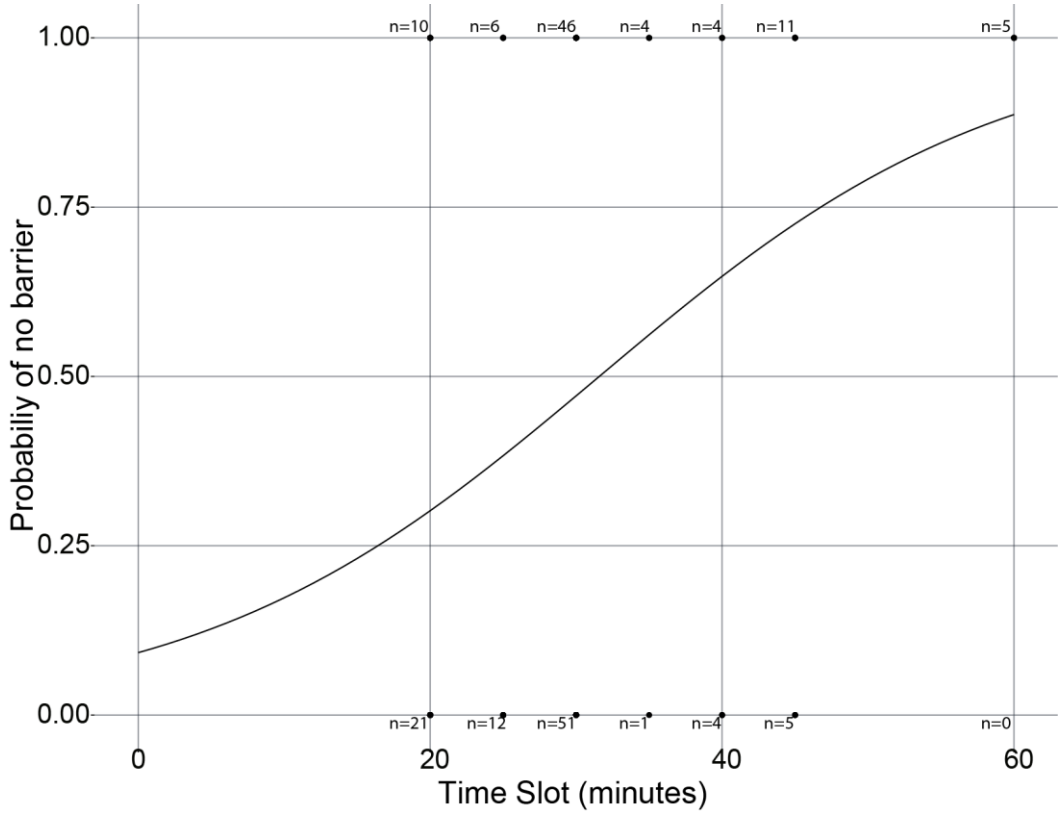


Figure 4.2: Time slot logistic regression analysis graph, the dots and n depicts the number of optometrists who indicated no barrier (1) or that there is a time barrier (0) as a function of time slot (minutes)

A multiple linear regression was conducted to identify those optometrists most likely to be affected by short appointment times. Fees charged per eye examination, years since qualification and mode of practice (independent private practice versus large multiples or franchises) all proved to be significant predictors of the amount of time available to

optometrists per eye examination. R^2 for the overall model was 42.2% with an adjusted R^2 of 41.1%, a large size effect. The multiple regression model statistically significantly predicted the time per appointment slot, F (3, 158) = 38.412, $p < 0.0001$. All three variables added statistically significantly to the prediction, $p < 0.05$. Regression coefficients, standard errors, and exact p values are shown in Table 4.6

The model shows that optometrists with less experience, charging lower fees, and working in large multiples or franchised practices have the shortest appointment times. Using the regression model to predict appointment times illustrates the effects of each independent variable, showing that years of experience had a small, though statistically significant, effect on the appointment time, whereas mode of practice had a large effect: optometrists working in independent practice, charging 30 euro for a sight test with ten, twenty and thirty years' experience are predicted to have an appointment slot of 30.80 (95% CI 29.30 – 26.30), 31.97 (95% CI 30.75 – 33.19) and 33.1 (95% CI 31.63 – 34.65) minutes respectively. For optometrists working in a franchise or multiple, charging 30 euro for a sight test with ten, twenty and thirty years' experience, the predicted test time is substantially shorter, at 22.92 (95% CI 20.73 – 25.11), 24.09 (95% CI 21.84 – 26.33) and 25.26 (95% CI 22.64 – 27.87) minutes respectively.

Table 4.6: Multiple linear regression analysis summary
B = standardized regression coefficient; SE_B = standard error of coefficient; β = standardised coefficient; t = t-value.

Variable	**B**	**SE_B**	**β**	**t**	**p**
Intercept	30.26	2.88		10.49	*< 0.001*
Fee per eye exam	0.24	0.055	0.29	4.39	*< 0.001*
Years since qualification	0.12	0.045	0.17	2.63	*0.010*
Mode of practice	-7.88	1.33	-0.39	-5.92	*< 0.001*

The final element in the survey was a free text box, where respondents could elaborate on their responses, or suggest other barriers to glaucoma detection. 9% of respondents completed the free text box. The most commonly cited barrier was a lack of finance or time for diagnostic tests (41%). Specific mentions included shortfalls of state funding and patients' unwillingness to pay supplementary fees as a restriction to buying equipment and giving extra chair time for enhanced or repeated diagnostic tests. 31% of respondents cited poor care pathways including lack of structured referral pathways and absence of multidisciplinary cooperation as a barrier.

4.5 Discussion

The key findings to emerge from our study include:

(i) the perceived need for extra training in glaucoma detection and the clear link between a perceived need for training and a lack of postgraduate education;

(ii) a lack of funding for supplementary diagnostic tests, where optometrists agreed that patients were unwilling to pay an extra fee for diagnostic investigations that could not reasonably be provided for a standard eye examination fee and;

(iii) a strong link between shorter appointment times and increasing barriers to glaucoma detection.

Training needs

The high frequency of agreement (71%) with the need for extra training in examination techniques relating to glaucoma detection contrasts with UK data where optometrists' level of training was an infrequently cited barrier.[135] This difference might be partly explained by the difference in survey methodologies used in the two studies. Myint *et al.* assessed barriers to glaucoma detection through qualitative analysis of a free-text question and found that time and financial constraints were the most commonly stated barriers.[135] The use of Likert items in our survey may have influenced responses, where conscientious practitioners were inclined to agree that further training would improve their ability to detect glaucoma. It is possible they would have been less likely to raise this issue independently. The response to our free-text question regarding barriers to glaucoma detection was low (9%), though it is notable that lack of finance and time

were the key barriers raised, showing very close alignment with the barriers identified by optometrists in the UK.[135]

While this methodological influence should be acknowledged, the high level of agreement with the need for extra training, and differences identified between optometrists' perceived need for training in the UK and Ireland, cannot be completely ignored. Higher uptake of postgraduate education among optometrists practicing in the UK could have generated higher levels of confidence. 15% of respondents to our survey indicated that they have already obtained postgraduate qualifications, whereas uptake of postgraduate education among optometrists working the UK is higher at 24%.[150]

Only 15% of our participants agreed that access to training was a barrier (Table 4.2), implying that training is perceived as available, but is not being availed of, so the difference in uptake of postgraduate education is unlikely to be accounted for by lack of access alone. In the UK, optometrists can participate in a variety of enhanced service schemes,[151] examples of which include; glaucoma repeat measures,[152] referral refinement,[37] and co-management,[153] many of which require postgraduate training. It is possible that the lack of extended scope roles in Ireland has resulted in a relatively lower level of uptake of postgraduate training. Within our free text response spaces, two optometrists noted that they would only consider structured postgraduate training if shared care, or enhanced scope schemes became a reality in Ireland.

At the time of the survey, optometrists in Ireland were constrained in their scope of practice by a restrictive and arguably archaic legislation, which obliged optometrists to refer patients to a medical practitioner once the minimum index of suspicion for

pathology was met (described in detail in Chapter 1). Optometrists practicing within this context may have felt discouraged from expanding their clinical skill and expertise, and may have considered themselves 'over-trained' for the role defined by the 1956 legislation.

Recent changes in the legalisation governing Irish optometry, framing scope of practice more broadly (refer to Chapter 1, section 1.5, for a thorough description) could enable development in scope of practice. In this new environment, Irish optometrists might feel more motivated to engage in further education and training, as any new skills can now be put to use in areas of sub-specialist interest. A UK survey found that 43% of optometrists identified a special interest in a particular area of optometry, and 69% of these respondents wished to undertake further training in the field of interest.[150] The top area of special interest was glaucoma.[150]

Even those optometrists who may not feel inclined to partake in structured postgraduate education will need to meet a new statutory requirement for CPD. Optometry's new regulatory body CORU, require 30 hours of CPD in a 12 month period, with the first cycle beginning on April 1st, 2017. This could lead to extra demand for structured CPD in Ireland. Future work could conduct further analyses into the types of training that optometrists require. Training strategies that have been shown to develop real improvements in clinical competence[73,75,113] should be prioritised. Any new educational opportunities should be developed in consultation with the profession, to ensure that the identified need for extra training is appropriately addressed. Consideration should also be given to design and content of the undergraduate degree programme, to ensure that newly qualified optometrists are appropriately trained in glaucoma detection and also

equipped the with the skills to engage in, and take responsibility for, their own continuing professional development.

Very few of the surveyed optometrists had glaucoma specific qualifications, just 6 of the 30 respondents with postgraduate education had completed a glaucoma related programme though only 14 of the 30 gave enough detail in their answer that the exact type of postgraduate qualification could be could be discerned. Respondents were considered to have completed postgraduate education if they had completed a level 9 or 10 postgraduate course in any area relating to optometric practice, including modules, certificates, diplomas, clinical masters, or PhDs. Interestingly, any form of postgraduate education (as defined above) appeared to increase optometrists' confidence in their ability to detect glaucoma (they were less likely to agree with the Likert item 'I need extra training'). Perhaps this indicates that those optometrists who have sought out postgraduate education are more independent, life-long learners, and even if they have not completed a course specifically relating to glaucoma detection, they are confident in their own ability to keep their training up to date.

Financial constraints

Patient unwillingness to self-fund supplementary diagnostic tests within optometry practices was the second most frequently perceived limitation to optometrists' case finding for glaucoma. A similar theme emerged in free text responses, where shortfalls of state funding as well as patients' unwillingness to pay supplementary fees, were identified as barriers to buying equipment and giving extra 'chair time' for enhanced diagnostic tests. Optometrists could potentially improve patient uptake of supplementary

testing by improving patient education, putting emphasis on the importance of detecting insidious disease and emphasising the clinical rather than the commercial aspects of their service.

Shah *et al.* found that only a minority of optometrists discussed glaucoma risk factors with a patient of African racial decent, even when the standardised patient asked the optometrist if she was at greater risk of any eye conditions,[154] showing that patient education by optometrists is likely underutilised and inconsistent. Even if patient education was significantly improved however, the funding structures within the healthcare system may incentivise patients to seek referral to secondary care, where appointments are free, rather than self-fund diagnostic testing within an optometry practice.

In Ireland, the State is the largest single purchaser of optometry services, subsidising eye examinations and optical appliances through a variety of schemes.[3] When the survey was carried out, the contracts did not allow or pay for repeat appointments to refine clinical decision making. As a result, patients found suspect for glaucoma had to pay for follow up appointments (for example repeated visual fields or tonometry measurements), or the practice provided these services with no additional remuneration.

Public hospital services, including ophthalmology outpatient departments, are free to all (subject to small co-payments). This financial incentive, coupled with the considerable pressure optometrists are under to detect every case of sight threatening disease, naturally leads to false positive referrals to secondary care. Low risk patients, who might suitably undergo further investigations and monitoring within community optometry,

may be added to the long waiting list for public ophthalmology outpatient appointments. This circumstance has been studied by Tuck,[120] who found that 74% of the patients referred by an optometrist with 'almost definite' glaucoma were confirmed as having the condition, compared with only 21% of those with 'possible' glaucoma.

Recent contract negotiations have led to increases in the fees paid to optometrists providing State funded eye examinations and a facility to recall patients for follow up diagnostic appointments (refer to section 2.3.1 for a full description). This may have impact on both the time and equipment available to optometrists in community practice. Our chi square analysis (Table 4.3) shows that optometrists charging less than €30 for a private eye examination were significantly more likely to agree with the Likert item 'the equipment available where I work is inadequate; this limits the accuracy of my glaucoma exam'. The new fee structures demonstrate a recognition of the primary eye care services provided by optometrists, and they may represent a watershed moment in clinical practice patterns. Future work should look to map the changes in practice norms that emerge from the increased funding of optometry services in Ireland.

It stands to reason that optometrists with shorter appointment times would feel that time constraints limit their ability to detect glaucoma and the logistic regression (Table 4.5, Figure 4.2) confirmed that time per appointment was a significant predictor of agreement with this barrier. It is also important to note that this same group identified many more barriers, which highlights the importance of time as a facilitator of comprehensive and effective clinical practice.

Time since registration was found to be a significant predictor of sight test time, where optometrists with less experience are more likely to have a shorter appointment times. It is possible that younger or more junior optometrists are more susceptible to pressure from management to deliver faster eye examinations. Senior or more experienced clinicians may have more confidence in dictating suitable appointment times, or may be in the position of setting their own appointment diaries. Although there was a much higher proportion of less experienced optometrists working in large retail groups or franchises, which tended to have shorter appointment times compared to independent private practices, the regression shows that time since registration is a significant predictor of test time even when this confounding factor is adjusted for (Table 4.6).

Davey *et al.*[69] examined the factors influencing false positive referrals from optometrists, and found that clinician experience had the greatest effect on referral accuracy, where inexperienced optometrists were more likely to generate false positive referrals to ophthalmology. Shorter appointment times for inexperienced optometrists might contribute to this effect, where less experienced optometrists, who might be more uncertain of a diagnosis, also have less time to refine their clinical decision-making, making them more likely to make unnecessary referrals.

The factor which had most effect on the time per appointment was mode of practice, where optometrists working in large multiples or franchises were predicted to have significantly shorter test times than those in independent private practice. The assumption one could draw from this, is that franchised practices and large retail groups have a higher volume of patients and optometrists are under pressure to produce faster eye exams, but other factors might also be at play.

Multiples often have more ancillary staff who can carry out preliminary testing prior to the patient's eye exam. This can shorten examination times significantly, and is arguably a better use of optometrists' time. There may also be a significant difference in the patient populations of the different types of practices, representing a type of causality dilemma. It is possible that more 'straightforward' patients tend to present to multiples or franchises, whereas patients who perceive their issues as more complex, tend to present to independent optometry practices. This may be because independent practices are perceived as more competent or clinically experienced given that there is a much higher proportion of more experienced optometrists working in independently owned businesses. Therefore, the shorter appointment times reported by those in multiples or franchised practices may result from their less complex patient base, or vice versa.

The fact remains, however, that shorter appointment slots appear to influence optometrists' perceptions of the barriers that exist to glaucoma detection. Though the AOI advise that eye examinations should not take less than 20 minutes,[132] our findings suggest that a minimum sight test time of 30 minutes is more appropriate, which falls in line with recommendations from the Scottish General Ophthalmic Services.[155]

State financing of extra time for diagnostic testing within community optometry could facilitate more accuracy in referrals to secondary care, which would likely result in a net saving for the State[37] while also relieving the significant psychological burden[46] created by unnecessary referrals. The recent renegotiation of the State's eye examination fees may serve to address the time and finance issues identified; similar repeat measures schemes have proven to be a cost effective[95] intervention in the glaucoma care pathway. It will be interesting to observe how the increased funds are implemented across various

practice settings, whether increased fees will result in improved equipment levels, increased appointment times, or perhaps just become assimilated into the business without any discernible change to service provision.

4.6 Limitations

Surveys are vulnerable to both sampling and response bias, and a healthy degree of scepticism toward survey data is often appropriate. The methodology used within our survey aimed to minimise bias, and the demographics of the respondents do appear representative in terms of geographic location and time since qualification. Being aware of the potential for bias, particularly voluntary response bias where the survey can over represent individuals with strong opinions, we have conducted a conscientious and judicious analysis of the survey responses.

4.7 Conclusion

This study is the first in depth exploration of optometrists' perceptions of the barriers to glaucoma detection in community practice in Ireland. The research took place at a critical time for Irish optometry, taking stock of practice norms prior to the enactment of landmark legislation, which may usher in significant developments in the scope of practice over the coming years.

Any change in scope of practice, will need to be underpinned by appropriate training, education and experience, and optometrists' responses to the survey show a clear acknowledgement of the link between further education and improving clinical practice. To deliver real improvements in clinical competence, the type of training made available should be carefully considered by educators and legislators in Ireland.

The responses also identified financial constraints on clinical practice that may be addressed by the recent renegotiation of the State's eye examination fees. Increased fees and repeat measures allowances, may serve to provide more equitable access to refined clinical decision making. Increases in the standard eye examination fee might be best used to facilitate longer appointment times, so that optometrists, including younger graduates and those working in multiples, are not burdened with examination times that limit their perceived ability to detect glaucoma. Future research should build on the findings presented in this paper, to analyse the impact of funding increases and legislative changes on optometric clinical practice patterns in Ireland.

5. ESTABLISHING IRELAND'S FIRST OPTOMETRIC GLAUCOMA REFERRAL REFINEMENT AND MONITORING SERVICE

5.1 The genesis of the scheme

The establishment of the Dublin glaucoma referral refinement and monitoring service (GRRMS) began in 2011, through consultation between Prof. James Loughman at DIT and Prof. Colm O'Brien at the Mater Misericordiae University Hospital (MMUH). Both were aware of the multitude of research on optometrists' roles in the glaucoma care pathway that was being produced in the UK. Evidence on the benefits of referral refinement schemes had piqued particular interest.

In early 2011, the research student inquired about research opportunities within the optometry department at DIT. A meeting with Prof. James Loughman confirmed that their research interests overlapped, and the idea of researching expanded scope roles for Irish optometrists, particularly in relation to glaucoma care, was further examined.

At that time in Ireland, collaboration between optometry and ophthalmology was rare. There were some optometrists working alongside ophthalmologists in private settings, but public ophthalmology services did not employ optometrists, and therefore, the professions were quite segregated.

Optometric scope of practice was still tightly controlled by the Opticians Act of 1956, which precluded the development of extended scope optometry roles. Though optometrists were aware of the 2008 Government decision to subsume optometry's regulatory body, the Opticians Board, into the Health & Social Care Professionals

Council (CORU) it was unclear what affect this might have on the legislation governing optometric practice.

This system of ophthalmic care had created frustration among many optometrists, who were obliged to refer suspect patients into an ophthalmology service that was unable to cope with demand. In 2011, there was no publicly available data on waiting lists for ophthalmology services, but optometrists were seeing public patients languish on long waiting lists while those with the capacity to privately fund services skipped these queues. This despite the fact that the Government funds over 70% of all health expenditure in Ireland, spending approximately €18.4 billion in 2013.[156] Ireland reportedly spends the largest share of government expenditure on health of any country in the European Union (EU).[157] It was felt that better collaboration between optometry and ophthalmology on improved models of patient care could go some way to ameliorate the situation.

The group applied to the AOI for research funding, who agreed to support the scheme by providing funds to cover academic fees. The National Optometry Centre (NOC) at DIT agreed to host the scheme.

From there, the literature relating to glaucoma detection by optometrists in the UK and Australia was scrutinised, and plans for a glaucoma shared care scheme in Ireland were formalised.

5.2 Pre-scheme training

The research student, being an optometrist herself, planned to become the scheme's specialist optometrist in glaucoma (SOG). Having only practiced in high street

optometry prior to commencing the postgraduate research, there was a significant training requirement prior to the launch of the GRRMS.

This training began with self-directed study, using textbooks such as Harper and Spry's 'Essential Glaucoma Handbook: a guide to assessment and management for eye care professionals'[49] and specific texts on visual fields interpretation including 'Essential perimetry: The field analyser primer' by Heijl and Patella,[81] as well as more in depth texts on the medical and surgical management of the various forms of glaucoma such as 'Shields' Textbook of Glaucoma'.[158] As the SOG was expected to have clinical expertise in both early glaucoma diagnosis and the management of a wide spectrum of glaucoma typically seen within the hospital glaucoma clinic, the background study needed to be extensive, examining glaucoma treatment paradigms, ongoing management and detection of progression, as well as becoming familiar with rare glaucoma subtypes such as iridocorneal endothelial syndrome glaucoma for example.

We tried to supplement this reading with appropriate taught courses. Within Ireland, the only clinical professional development opportunities available were in the form of one off lectures or workshops. The only relevant event that ran (on October 26th 2011) within the months preceding the scheme launch, consisted of three hours of lectures on various aspects of glaucoma, including a one hour lecture by Prof. David Henson on using visual fields to detect glaucoma in optometric practice.

A meeting on the 'The Future of Glaucoma Management' hosted at the Royal College of Ophthalmologists, London was also attended (on 6th Sept 2011) by both the SOG and the supervising glaucoma specialist consultant ophthalmic surgeon. This conference

consolidated our interpretation of the literature surrounding glaucoma care pathways in the UK.

It might have been appropriate to take part in a distance learning certificate in glaucoma,[159] available from a number of universities within the UK, though there were no available funds to cover the cost implications of both fees and travel as the research optometrist completed the PhD research without a stipend to cover such expenses.

The central element of the pre-scheme training was certainly the apprenticeship style training undertaken in the hospital outpatient glaucoma clinic at the MMUH. The research optometrist completed 24 hours of clinical training across six hospital clinic sessions before the launch of the scheme, starting off with observation of medical staff and progressing to more independent assessment of patients within the clinic. This falls in line with UK norms, a recent survey of hospital optometry roles in the UK,[128] found that the primary format of training across extended roles within the hospital eye services was apprenticeship style training, incorporating sessions worked under supervision in ophthalmology clinics.

There was no formal evaluation or assessment of the SOG's performance before they began examining patients under the GRRMS, the scheme began when the supervising ophthalmologist considered the SOG was ready, which was agreed after 24 hours of training. It is recognised that this training and accreditation process would need to become more standardised if the scheme was to be expanded, but this arrangement was deemed appropriate for this process given that the detailed one to one supervision

allowed the consultant to closely monitor and assess the SOG's ongoing performance. Such close cooperation would not likely be achievable under an expanded scheme.

Participation in weekly hospital clinic sessions continued over a period of over two years, from October 2011 to January 2014 which facilitated the running of 'virtual clinic' reviews of the suspects seen within the GRRMS (see section 5.4 below), and ensured that there was ongoing communication between the optometrist and the ophthalmology team, as recommended by Lockwood[115] and Trikha.[104]

For the final 18 months of the scheme, (between January 2014 and August 2015) where monitoring visits were conducted, the SOG made less frequent visits to the MMUH to present the virtual clinic information.

5.3 Recruitment

Some community optometric glaucoma schemes divert all new glaucoma suspect referrals to the hospital eye service to SOGs in their own practices to carry out refinement exams,[124] while others stratify referrals for risk, sending only 'low risk' referrals to community based SOGs.[105] In establishing our scheme, we did not have the cooperation of a full hospital ophthalmology department, and so we could not access this broad base of referrals. It was decided that the scheme would operate on voluntary participation from optometrists and patients within the greater Dublin area.

To launch the recruitment drive, both PhD supervisors presented the aims and background to the research at the AOI AGM in November 2011. Information leaflets, detailing the running and aims of the scheme (refer to Appendix 3), were also emailed to

all optometrists on the AOI register, and a more detailed description of the rationale for the scheme was published in the periodical journal of the AOI (refer to Appendix 4).

The research optometrist also presented the research at a national Specsavers directors meeting on the 23rd January 2012.

Throughout the early months of the scheme, the research optometrist continued to disseminate information on the scheme more informally, making an effort to attend almost all CPD events running in the Dublin area so that she could informally recruit optometrists.

5.4 Ongoing management

Patient safety was a key clinical governance issue in the scheme. In order to ensure patient safety, it was decided that every patient seen in the GRRMS would be reviewed by the glaucoma specialist consultant ophthalmic surgeon in a 'virtual clinic' format.

This also ensured that the SOG was not operating outside optometrists' legislated scope of practice, as defined by the Opticians Act 1956, by monitoring suspect patients independently.

A barrier to the operation of a virtual clinic review model was the lack of suitable electronic patient records within the hospital eye service. It was decided that the SOG would manually create a virtual clinic of patient records for the supervising ophthalmologist to review each week. This consisted of visual field plots and fundus photos presented on a laptop slide show, with an accompanying written report detailing the case history, anterior chamber examination, GAT IOP values, pachymetry, optic disc

drawings and disc size, an interpretation of the visual field plots, and an overall impression of the case (Figure 5.1).

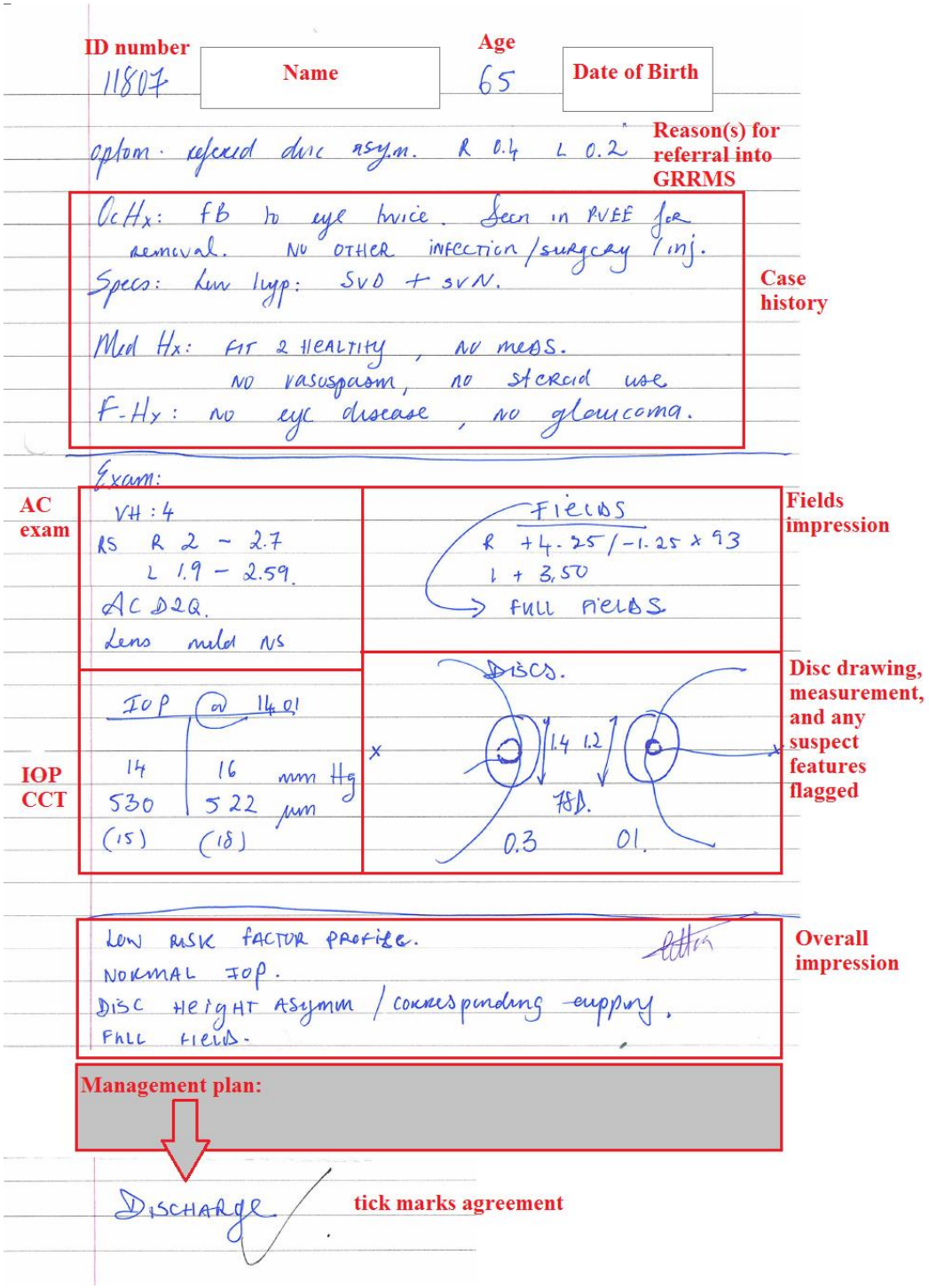
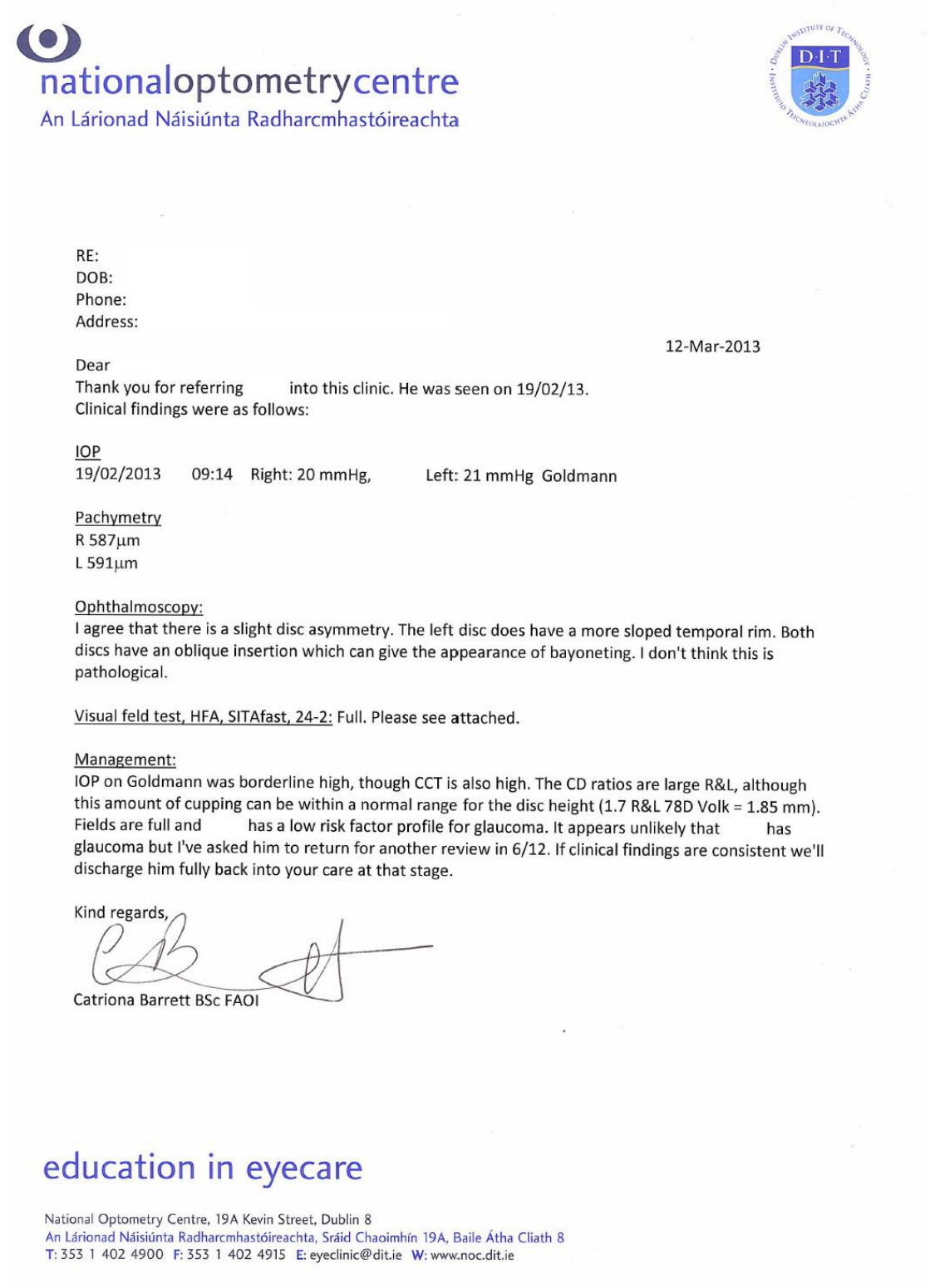


Figure 5.1: A sample 'virtual clinic' record form the GRRMS

There were times when this ‘virtual clinic’ was used as a teaching aid for the entire ophthalmology team. Junior staff would discuss management options though the final decision was always made by the supervising consultant ophthalmologist. This final management decision was noted on the paper record as well as the agreement between the SOG and the ophthalmologist.

Patients were informed of their final management decision through phone calls from the SOG.

Every optometrist that referred into the scheme received a detailed letter back explaining the GRRMS management and the exams performed (Figure 5.2). It was felt that this encouraged participation in the scheme, and was particularly useful for those patients who were discharged back to their referring practitioners. An evaluation of stakeholder views on participation in a Manchester based GRR scheme, showed that optometrists particularly valued the feedback given by GRR SOGs on the outcome or diagnosis and quality of their referral.[112]



nationaloptometrycentre
An Lárionad Náisiúnta Radharcmhastóireachta

RE:
DOB:
Phone:
Address:

12-Mar-2013

Dear
Thank you for referring into this clinic. He was seen on 19/02/13.
Clinical findings were as follows:

IOP
19/02/2013 09:14 Right: 20 mmHg, Left: 21 mmHg Goldmann

Pachymetry
R 587µm
L 591µm

Ophthalmoscopy:
I agree that there is a slight disc asymmetry. The left disc does have a more sloped temporal rim. Both discs have an oblique insertion which can give the appearance of bayoneting. I don't think this is pathological.

Visual feld test, HFA, SITAfast, 24-2: Full. Please see attached.

Management:
IOP on Goldmann was borderline high, though CCT is also high. The CD ratios are large R&L, although this amount of cupping can be within a normal range for the disc height (1.7 R&L 78D Volk = 1.85 mm). Fields are full and has a low risk factor profile for glaucoma. It appears unlikely that has glaucoma but I've asked him to return for another review in 6/12. If clinical findings are consistent we'll discharge him fully back into your care at that stage.

Kind regards,

Catriona Barrett BSc FAOI

education in eyecare

National Optometry Centre, 19A Kevin Street, Dublin 8
An Lárionad Náisiúnta Radharcmhastóireachta, Sráid Chaoimhín 19A, Baile Átha Cliath 8
T: 353 1 402 4900 F: 353 1 402 4915 E: eyeclinic@dit.ie W: www.noc.dit.ie

Figure 5.2: An anonymised example of a report sent to a GRRMS patient's referring optometrist.

Ensuring that patients monitored within the scheme were recalled for their scheduled visits presented another ongoing workload. There was administrative support within the NOC for booking appointments into the scheme but the SOG was tasked with managing any recalls. The approach to recalls was standardised, every patient due for follow up had two contacts from the SOG, either in the form of a phone call and follow up letter if the patient declined to book in for their visit immediately over the phone. Or, if the patient could not be reached over the phone, two letters were sent to their home address (refer to Appendix 6 for the recall letter template used).

5.5 Termination of the scheme

The project accepted new referrals for just over two years, running from November 2011 to January 2014 (refer to Appendix 7 for the information that was distributed to optometrists notifying them of the scheme's end). Follow up for those patients monitored within the service ran until August 2015. This was the maximum feasible timeframe within the confines of a PhD timeline. It took some time for the project to gain momentum within the optometric community so there were relatively few referrals within the first six months of the study. This limited the sample size of the study to 225 patients.

6. COMMUNITY REFINEMENT OF GLAUCOMA REFERRALS: MANAGING THE SENSITIVITY-SPECIFICITY PARADOX IN OPTOMETRIC PRACTICE.

6.1 Abstract

Purpose

GRR has proven a successful demand management strategy for glaucoma suspect cases in the UK. A GRR clinic was established in Dublin to investigate the clinical viability of this pathway outside the UK's NHS structures, and away from the influence of NICE guidance.

Methods

Glaucoma suspect patients were recruited into the scheme following referral from community optometrists in the greater Dublin area. The refinement exam protocol was designed in consultation with available international guidance. The refinement scheme optometrist, trained through apprenticeship style experience at a hospital outpatient clinic, made a tentative management decision after carrying out the refinement exam. The final management decision was made in a 'virtual clinic' by a glaucoma specialist consultant ophthalmologist.

Results

In total, 225 glaucoma suspect patients were seen in the scheme. After their first GRR visit, 29% were discharged back to their own optometrist, 42% were monitored in the GRR clinic, and 29% were referred to ophthalmology. After this monitoring cohort were

further assessed, a total of 38% of the patients seen within the scheme required referral to ophthalmology. 16% of the total participant group (n = 225) were lost to follow up.

Cohen's κ was used to determine the level of agreement between the scheme optometrist and ophthalmologist. There was substantial agreement, with $\kappa = 0.63$ for the first visit management decisions (n = 225). Agreement increased for subsequent monitoring visits with $\kappa = 0.85$ for second visits (n = 65), and $\kappa = 0.69$ for all management decisions within the scheme (n = 301).

We received management outcomes for 44 of the 86 patients referred to ophthalmology. Of these 44, 57% received medical treatment for glaucoma, 34% were monitored without treatment, 2% were discharged, and 7% had comorbidities that were assessed and managed.

Conclusion

Of the patients seen within the scheme, 62% did not require referral onward to ophthalmology thus releasing the significant majority of hospital clinic slots that would previously have been required to examine such patients. The high level of inter-professional decision agreement reflects positively on the undergraduate training of optometrists and the benefits of pre-scheme apprenticeship style training. The rate of loss to follow up compares favourably with ophthalmology led, hospital based glaucoma clinics. Nevertheless, the losses indicate that patient education remains a key priority for future planning.

6.2 Introduction

Glaucoma prevalence increases exponentially with increasing age.[160] Significant population growth and ageing[24] is accompanied, therefore, by a synchronous rise in the burden of care required for glaucoma and other age-related eye disease. In 2014, the number of people (aged 40-80 years) with glaucoma worldwide was estimated at 64.3 million, this is expected to increase to 76 million by 2020 and almost double to 111.8 million by 2040.[53]

Advances in diagnostic and screening tools, such as automated perimetry, and changes in professional guidance[132] with regard to glaucoma diagnosis and management protocols also have the potential to increase the demand for glaucoma related care. Clinical guidelines are developed with the aim of improving the quality of care received by patients and ultimately, improving health outcomes. The ability of clinical guidelines to deliver on these aims is questionable, and while appropriate guidelines can be a useful tool for making care more consistent and efficient, flawed guidelines have the potential to cause harm to both patients and the healthcare system.

As an example, in April 2009, the NICE guidelines for 'Glaucoma: Diagnosis and management of chronic open angle glaucoma and ocular hypertension' were published in the UK. Although the scope of these guidelines did not include case-finding or screening for glaucoma,[130] there was a requirement for all patients with 'repeatable pressures over 21 mmHg by applanation tonometry to be assessed by a suitably trained healthcare professional with a specialist qualification and relevant experience'. This part of the guidance was interpreted as relevant to case finding and guidance was issued by a

group of influential optometric organisations in the UK, advising optometrists to refer patients with a repeated IOP reading of above 21mmHg, regardless of any other clinical findings.[161] This led to a dramatic rise in glaucoma suspect referrals to ophthalmology.[71]

Glaucoma referral refinement (GRR) schemes, which had emerged in the early 2000's as a potential solution to the already high rate of false positive glaucoma referrals,[47] proliferated in the UK after 2009,[37,103–105] largely in response to the rise in glaucoma referrals following the publication of the NICE guidance. GRR describes a two-tier assessment in which an initial suspicious finding is validated by a subsequent enhanced assessment. The aim is to increase the positive predictive value (PPV) of optometric referrals to ophthalmology services, which has been shown to be both clinically[115] and financially[37,97] viable within the National Health Service (NHS) system.

In Ireland, as with many countries, there are no specific clinical guidelines relating to glaucoma diagnosis or case finding in primary care. Optometrists are obliged to 'carry out all tests judged to be necessary to determine the patient's need for vision care as in both sight and health'.[133] This implies that optometrists have a responsibility to detect pathologies such as glaucoma and to manage the case as they see fit, acting within 'the limits of (their) knowledge, skills, competence and experience'.[39] Although optometric referral patterns in Ireland have not been directly affected by NICE guidance, anecdotal evidence from the ophthalmology team within the Mater Misericordiae University Hospital (MMUH) in Dublin, indicates that the proportion of false positive glaucoma referrals is high. A recent multicentre review,[72] analysing data from five tertiary referral centres across Europe, found that only 10% of all newly referred glaucoma suspect patients actually had glaucoma, confirming that this issue is common in many

jurisdictions.

A number of factors contribute to the false positive glaucoma referrals from optometrists, including limited availability of diagnostic equipment and the relatively low prevalence of glaucoma among the population of patients seen in optometric practice. Overall POAG prevalence in Ireland is estimated at 1.88%, with prevalence rising to 3.2% in those over 70 years.[55] At this prevalence level, even tests with relatively high sensitivity and specificity will yield low PPVs.[74,106] GRR provides a method of offering enhanced diagnostic testing to a cohort of glaucoma suspect patients. In this likely higher prevalence population, the available diagnostic tests will have better PPV.[74,106]

The need for demand management within Irish ophthalmology services is clear. Figures for March 2017, show that 34,675 individuals in Ireland (total population 2016: 4.76 million[8]) were on a waiting list for a first appointment at a consultant-led ophthalmology outpatient clinic, with 9,309 individuals having spent 12 months or more on the waiting list.[162] The Health Service Executive (HSE), the publically funded body responsible for the provision of health and personal social services for everyone living in Ireland, recently published a report on eye care services acknowledging that they are 'experiencing considerable challenges in meeting current demand due to deficiencies in relation to staffing, processes and infrastructure'.[21] This echoes a pattern of systems overload that has been demonstrated in many developed countries: the need for new, more collaborative care paradigms in the face of increased longevity and subsequent increased demand for eye care services has also been recognised in Australia[28] and the US.[29] Worldwide shortages of ophthalmologists[142] are exacerbating this mismatch

between capacity and demand.[163] Strategic planning is needed if we are to deliver an improved service and avoid an increase in preventable visual impairment. This study was designed, therefore, to investigate the clinical viability of GRR outside the UK's NHS structures, and away from the influence of NICE guidance.

6.3 Methods

The project began as a collaboration between researchers and clinicians at DIT and the MMUH Dublin. It was agreed that a GRR scheme could be of benefit to the ophthalmology department and the NOC at DIT agreed to host the scheme. An optometrist was recruited into the training scheme and underwent a 2-month period of training that commenced in October 2011. This consisted of at home self-study and apprenticeship-style training through participation in consultant led hospital glaucoma clinics. The optometrist completed 24 hours of clinical training across six clinic sessions before the launch of the scheme, and continued to attend one clinic session per week throughout the duration of the scheme, examining both glaucoma patients and suspects under the supervision of a glaucoma specialist consultant ophthalmic surgeon.

The pilot scheme was announced to Irish optometrists through email leaflets, a publication in the periodical journal of the AOI, and a presentation at the AOI annual general meeting in November 2011. Glaucoma suspect patients were recruited into the scheme following referral from community based optometrists in the greater Dublin area. Optometrists were instructed that any new glaucoma referrals were eligible for the scheme though urgent cases should be directly referred to ophthalmology as usual. The purpose of the study was explained to each patient both verbally and through a written

consent form. Only those who gave written consent to have their clinical information used in the study were included in the analysis.

The GRRMS exam was designed to include gold standard examination strategies, both NICE[50] and European Glaucoma Society (EGS) guidelines[164] were referred to in this process. This also resulted in the examination protocol aligning well with the current practice within the participating ophthalmology department which provided reliable baseline information for patients that were referred to ophthalmology after the refinement exam. The exam was defined by protocol to include the following:

- Case history;
- Anterior chamber slit lamp examination, including Redmond Smith and van Herick's techniques;
- Goldmann tonometry;
- Ultrasound pachymetry;
- Visual field test (Humphrey Visual Field Analyser SITA-Fast 24-2);
- Dilated, slit lamp indirect ophthalmoscopy exam; and
- Fundus photography.

While the refinement scheme optometrist made a preliminary management decision after the GRR exam, the final management decision was approved by a glaucoma specialist consultant ophthalmic surgeon, who acted as the scheme's reference standard. Digital fundus photographs, copies of the visual field plots, and a summary of the patient record, which included case history information, slit lamp findings, IOP and pachymetry readings, and the optometrist's written record of the optic disc assessment,

were made available for the consultant to view in a 'virtual clinic', similar to that described by Trikha *et al.*[104] and Kotecha *et al.*[111] Patients were informed of their final management through phone calls from the scheme optometrist.

The clinical outcomes for the patients seen in the scheme were categorised into three broad groups:

1. Discharge from the GRR clinic back to the primary optometrist;

2. Monitor in the GRR clinic; or

3. Refer to ophthalmology.

It was decided that clinical guidelines indicating specific clinical findings at which to refer, monitor or discharge would be either unmanageably large or harmfully oversimplified, and could not represent best practice for many individual patients. For clinical tests such as IOP or CDR for example, there are no set values that can perfectly discriminate between early glaucoma and those who are non-glaucomatous. Thus, the scheme proceeded with no set protocols beyond defining the tests that should be carried out, and the clinicians made their management decisions after taking all of the relevant clinical findings into consideration.

The data collected were analysed on the statistical package for social sciences (IBM SPSS Statistics for Windows, Version 22.0 Armonk, NY: IBM Corp.). A frequency analysis was run to determine the management outcomes within the scheme. One-way ANOVA, Kruskal-Wallis H test, and Cohen's Kappa were used to further analyse the results.

6.4 Results

225 patients were recruited into the scheme. The management outcomes are outlined in Table 6.1.

Table 6.1: Management outcomes from the Dublin GRRMS. Percentages have been rounded to the nearest whole number resulting in some percentage totals differing from 100%.

	Visit 1 **n = 225**	**Visit 2** **n = 95**	**Visit 3** **n = 16**	**End of Study** **n = 225**
Discharge n (%)	62 (28%)	34 (36%)	5 (31%)	101 (45%)
Monitor n (%)	95 (42%)	16 (17%)	3 (19%)	3 (1%)
Refer n (%)	64 (28%)	13 (14%)	3 (19%)	80 (35.5%)
Refer comorbidity n (%)	4 (2%)	2 (2%)	0 (0%)	6 (2.6%)
Lost to follow up n (%)		30† (32%)	5 (31%)	35 (16%)

† *One patient in this cohort emigrated during the study and continued their care abroad.*

A proportion of those patients assigned to be monitored within the GRR clinic were lost to follow up. These were lost exclusively from the monitoring cohort who were not diagnosed with glaucoma but advised to continue regular monitoring of suspect features. Approximately one third of those recalled dropped out at each monitoring interval: the exact figures are shown in Table 6.1 above. Overall 16% of participants were lost to follow up.

Of the 225 patients seen within the scheme, 80 were referred to ophthalmology as glaucoma suspects, 2 of these 80 had comorbidities that were detected during the GRR

exam, both choroidal naevi. A further 6 were referred for other conditions that were detected during the refinement exam, 2 of which were also ocular naevi and the remainder ranging in severity from a routine referral for medical management of severe blepharitis to a neuro-ophthalmology referral for suspect neurological field loss.

Therefore 86 patients were referred onwards from the scheme, 38% of the total group.

Clinical variations between management groups

A one-way ANOVA was conducted to determine if central corneal thickness (CCT), IOP, and vertical cup-disc ratio (vCDR) were different for the three core management groups based on the first visit management decision (discharge n = 66, monitor n = 95, refer n = 64). The more suspect eye was chosen as the study eye or if neither eye appeared more suspect, if both eyes had evenly elevated IOP for example, the study eye was randomised.

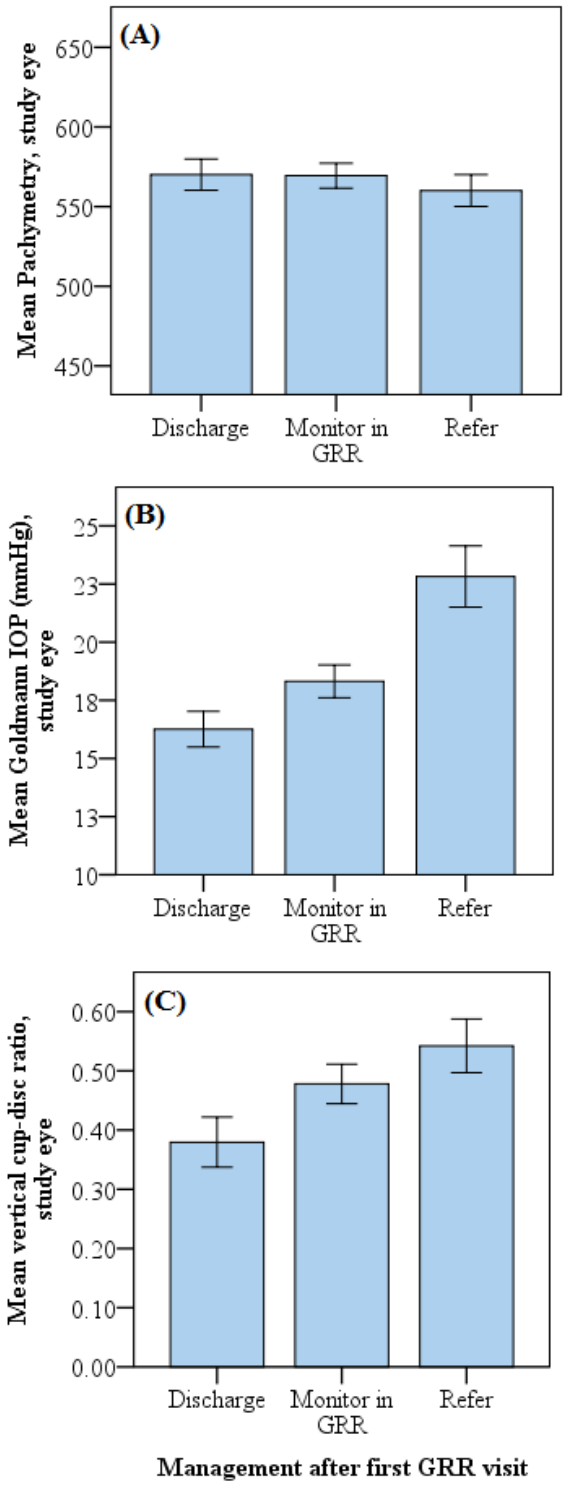


Figure 6.1: Mean values for central corneal thickness (A), intraocular pressure (IOP) (B), and vertical cup-disc ratio (C) in each first visit, refinement clinic management group (discharge n = 66, monitor n = 95, refer n = 64).

One outlier was removed from the CCT data as the patient had a pathologically thin cornea following previous ocular injury. Two more outliers were found, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box, but the data points were kept in the analysis as they represented the wide range of CCT values present in a normal population. The CCT values were normally distributed, as assessed by visual inspection of the Q-Q plots. There was homogeneity of variances, as assessed by Levene's test for equality of variances *(*$p = 0.97$). The differences in mean CCT between the management groups were not statistically significant, $F(2, 221) = 1.382$, $p = 0.25$ (Table 6.2).

There were no outliers in the IOP data and values in each cohort were normally distributed, as assessed by visual inspection of boxplot and Normal Q-Q plots respectively. The assumption of homogeneity of variance was violated, as assessed by Levene's test for equality of variances ($p = 0.001$). The difference between mean Goldmann IOP in the three management groups was statistically significant using Welch's ANOVA, Welch's $F(2, 37.22) = 129.21$, $p < 0.0001$ (Table 6.2). IOP increased from the discharge *(*n = 66, M = 16.26 mmHg, *SD* = 3.13), to monitor (n = 95, M = 18.32 mmHg, *SD* = 3.47), to refer (n = 63, M = 22.83 mmHg, *SD* = 5.22) management groups, in that order (Figure 6.1 and Table 6.2). Games-Howell post hoc analysis revealed that the mean increase from the discharge to monitor groups (2.06mmHg, 95% CI [0.82, 3.30]) was statistically significant ($p < 0.0001$), as was the increase from monitor to refer (4.51 mmHg, 95% CI [2.73, 6.29], $p < 0.0001$).

Welch's ANOVA was then repeated to determine if mean IOP was statistically significantly different for the three core management groups based on the second visit

management decision (discharge n = 35,‡ M = 16.4 mmHg, *SD* = 2.2), (monitor n = 16, M = 19.1, *SD* = 4.6), (refer n = 13, M = 20.15, *SD* = 5.2). The difference between mean second visit Goldmann IOP values in the three management groups was again found to be statistically significant, Welch's $F(2, 20.50) = 5.27$, $p = 0.014$, but Games-Howell post hoc testing showed no statistically significant pairwise comparisons. These apparently conflicting results are due to the differences in the distributions used in the one-way ANOVA and the Games-Howell post hoc test and show that a statistically significant difference between groups is questionable.

There were no outliers in the vCDR data and values in each cohort were normally distributed, as assessed by visual inspection of boxplot and Normal Q-Q plots respectively. There was homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.45$). There was a statistically significant difference between the three groups, $F(2, 222) = 14.97$, $p < 0.0001$ (Table 6.2). vCDR increased from the discharge *(n = 66, M = 0.38, SD = 0.17*), to monitor (*n = 95, M = 0.48, SD = 0.17*), to refer (*n = 64, M = 0.54, SD = 0.18*) management groups, in that order (see Figure 1C and Table 2). Tukey-Kramer post hoc analysis revealed that the increase from the discharge to monitor groups (0.10, 95% CI [0.03, 0.16]) was statistically significant ($p = 0.001$), though the increase from monitor to refer (0.06, 95% CI [0.001, 0.130], $p = 0.055$) was not. The difference between the discharge and refer groups was significant at the $p < 0.0001$ level (0.16, CI [0.09, 0.23]).

The one way ANOVA was then repeated to determine if mean vCDR was statistically significantly different for the three core management groups based on the second visit

‡ One outlier was removed from this group.

management decision (discharge n = 36, M = 0.50, *SD* = 0.14), (monitor n = 16, M = 0.45, *SD* = 0.19), (refer n = 13, M = 0.49, *SD* = 0.06). The difference between mean second visit vCDR values in the three management groups was not found to be statistically significant, $F(2, 23.70) = 0.50$, $p = 0.62$.

Table 6.2: A one-way ANOVA comparing the clinical findings for central corneal thickness (CCT), intraocular pressure (IOP), and vertical cup-disc ratio (vCDR) according to the first visit management group within the refinement clinic. *Welch's ANOVA*

	Discharge **n = 66**	**Monitor** **n = 95§**	**Refer** **n = 64**	**P value (ANOVA)**
CCT **Mean (SD)**	**570 µm** (±39.63)	**569 µm** (±38.41)	**560 µm** (±40.06)	0.253
IOP **Mean (SD)**	**16.26 mmHg** (±3.13)	**18.32 mmHg** (±3.47)	**22.83 mmHg** (±5.22)	<0.0005
vCDR **Mean (SD)**	**0.38** (±0.17)	**0.48** (±0.17)	**0.54** (±0.18)	<0.0005

§ One outlier was removed from the CCT data, n for the CCT monitoring cohort was 94

It was not possible to include visual field results in the ANOVA analysis as visual inspection of the normal Q-Q plots for all three global indices (visual field index (VFI), mean deviation (MD), and pattern standard deviation (PSD)) showed that the data was not normally distributed. For this non-parametric data, a Kruskal-Wallis H test was used to determine if there were significant differences between the means of the three management groups. The PSD score was chosen as the global index most relevant to early glaucoma. Distributions of PSD scores were similar for all groups, as assessed by

visual inspection of a boxplot. Median PSD scores were statistically significantly different between groups, $H(2) = 11.251$, $p = 0.004$. Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. Statistical significance was accepted at the $p < 0.0167$ level.

This post hoc analysis revealed statistically significant differences in median PSD scores between the discharge (1.47) and refer (1.81) ($p = 0.004$) management groups, but just approached significance between the monitor (1.51) and refer groups ($p = 0.024$), and no significant difference was observed between the monitor and discharge groups ($p = 1.000$).

This test was then repeated to determine if the differences in median PSD score were still statistically significant for second visit management decisions (discharge n =35, monitor n = 16, refer n = 19) which showed that median PDS scores were not statistically significantly different between the groups, $H(2) = 0.783$, $p = 0.68$.

Agreement between ophthalmologist and optometrist management decisions

Cohen's κ was used to determine if there was agreement between the scheme optometrist and ophthalmologist. There was substantial agreement,[165] with $\kappa \geq 0.63$ for all patient visits (*Table 6.3*).

Table 6.3: Inter-rater agreement within the virtual clinic

	Visit 1 *n = 225*	Visit 2 *n = 65*	Visit 3 *n = 11*	All management decisions n = 301
Kappa	0.63	0.85	0.72	0.69
(95% CI)	(0.54-0.72)	(0.73-0.97)	(0.36-1.08)	(0.62-0.89)
p	**p < 0.0005**	**p < 0.0005**	**p = 0.001**	**p < 0.0005**
Rate of agreement	76.0%	90.8%	81.8%	79.4%

The cross tabulation (Table 6.4) shows where the disagreements occurred.

Table 6.4: Cross tabulation showing the optometrist's preliminary management decision (rows), and the final management decided by glaucoma consultant (columns). Agreement is shaded in grey. Underlined figures represent occasions where the ophthalmologist was more conservative than the scheme optometrist.

		Final management decided by glaucoma consultant			Total
		Discharge	Refer	Monitor in GRR	
Optom decision	Discharge	83 (78%)	**1**	**19**	103
	Refer	1	64 (80%)	3	68
	Monitor in GRR	23	**15**	92 (81%)	130
Total		107	80	114	301

Table 6.4 shows that there were 35 decisions (see figures in bold and italics) where the scheme's reference standard, a glaucoma specialist consultant ophthalmic surgeon, had more conservative clinical management than the scheme optometrist. These 35 decisions represent 33 patients as there were two occasions where disagreement was on the same patient at different visits. Of the 33 patients, 7 were eventually discharged from the scheme, 7 failed to return for their follow up appointments, and 19 were eventually referred to ophthalmology. Of these 19, we were able to follow up on ophthalmology management outcomes for just 7 patients, 2 were started on treatment, 4 were monitored in ophthalmology, and 1 was discharged. The 2 patients who received treatment in ophthalmology had been marked for monitoring by the SOG. There was one occasion where a patient was marked for discharge by the SOG but subsequently referred to ophthalmology by the scheme's supervising ophthalmologist (Table 6.4), the management outcome for this patient was not available to us. We were able to follow up on management outcomes for 44 of the 86 patients referred to ophthalmology (Table 6.5).

Table 6.5: Management outcomes for patients referred to ophthalmology

Management Outcome	**n**	**%**
Medical treatment	25	57
Monitored without treatment	15	34
Discharged at first visit	1	2
Managed co-morbidity	3	7
Total	44	100

6.5 Discussion

Only 38% of the patients seen in the scheme required referral for specialist hospital care demonstrating the scheme's significant potential to release capacity within hospital eye services. Those patients referred to ophthalmology had significantly improved clinical information, including full threshold visual fields on the Humphrey Visual Field Analyser, Goldmann tonometry readings, and ultrasound pachymetry measurements. Providing all of these tests within one GRR appointment creates a reliable baseline for future monitoring and negates the need for those patients to have separate appointments for different diagnostic tests such as visual field testing for example, which is often the case within the MMUH glaucoma clinic.

With further training, the scheme could be expanded to include OCT and gonioscopy so that GRR could serve to provide best practice diagnostic testing for glaucoma suspects outside of the ophthalmology outpatient clinic, a model that has worked well elsewhere.[28]

Of the 8 co-morbidities detected in the scheme, 4 were retinal naevi. Future schemes should define a management protocol for this relatively common condition.

The first visit discharge rate (29%) is similar to rates documented in the UK after the NICE guidelines for 'Glaucoma: Diagnosis and management of chronic open angle glaucoma and ocular hypertension' were published.[37] This is an important finding in a jurisdiction that has no specific clinical guidelines relating to glaucoma diagnosis or case-finding. Sparrow[166] argued that 'hasty and ill-considered advice…(to optometrists by influential professional bodies)…produced an ongoing problem of unnecessary

flooding of NHS glaucoma services, with false positive referrals frequently based on poor quality IOP measurements'.

While there is truth in this statement, it is not the whole truth, as it places a distorted and arbitrary focus on false positive referrals and ignores the difficult role optometrists have in balancing their clinical judgement and their legal responsibilities. Optometrists have a responsibility to detect disease during routine eye examination, which inherently leads to false positive referrals in a population where the relative prevalence of glaucoma is low.[74] This effect is likely being compounded by a tendency for optometrists to preference sensitivity over specificity in their diagnostic testing,[145] a practice pattern that could be considered pragmatic, given that optometrists are required to detect pathology and are at risk of litigation[146,147] if they fail in this duty of care. Optometrists are faced with a paradoxical situation whereby rigorous, highly sensitive screening can often lower overall referral accuracy as it produces a high number of false positives, but the alternative, highly specific screening potentially increases the risk of missing disease that could lead to irreversible sight loss.

A number of approaches have failed to solve the problem of false positive glaucoma referrals. Vernon and Ghosh[126] established that the provision of specific referral guidelines, circulated to all optometrists working within the catchment area, had little effect on the proportion of false positive referrals. Yoshioka *et al.*[75] showed that short-term didactic teaching programs had most effect on false negative rates in glaucoma referrals, indicating that training may have a beneficial impact on the prevalence of undetected glaucoma, but is unlikely to significantly reduce false positives. GRR provides a safe method of offering enhanced diagnostic testing to a cohort of glaucoma

suspects. In this likely higher prevalence population the available diagnostic tests can produce better PPVs.[106,167]

Of course no medical test has perfect sensitivity and perfect specificity, and glaucoma detection is a particularly ambiguous area given the significant overlaps in the clinical features of suspicious, but normal individuals and those with early glaucoma.[74,75] Accurate diagnosis of early glaucoma often requires careful monitoring until progression, the hallmark of glaucoma, can be identified or ruled out.[168] This scheme has highlighted the existence of a monitoring need in suspect glaucoma, and careful consideration should be given to how this cohort of patients can be best served. We know that the burden of care for those with glaucoma is increasing,[24,53] which indicates that the burden of care will also rise for those who do not have glaucoma but have ocular hypertension or other suspicious features that require ongoing observation.

Recent changes in both the legislation[31] governing optometric scope of practice in Ireland and the fee structures of State funded eye examinations may see optometrists taking on more independent monitoring of suspect cases. Prior to the commencement of the Health (Miscellaneous Provisions) Act on the 31st of October 2015,[169] Irish registered optometrists had an obligation to refer any patient found suspect for pathology to a medical practitioner.[34] It was considered that optometric monitoring of glaucoma suspects was outside of their legislated scope of practice. The reformed legislation frames scopes of practice boundaries more loosely, stating that optometrists must 'act within the limits of (their) knowledge, skills, competence and experience' and 'practice only in areas in which (they) have relevant competence, education, training and experience'.[39]

Within this framework, there is clear scope for optometrists, with the appropriate skills, to become more involved in the diagnosis, monitoring and management of ocular pathology, as has happened in many other jurisdictions including Australia,[170] the UK[110,128] and the USA.[171]

There is a skills and experience gap however, in moving from a screening role to an enhanced diagnostic or management role. The survey detailed in Chapter 4, found a majority of Irish optometrists agreed that a lack of training limited their ability to detect glaucoma during routine eye exams.[172] Our collaborative care scheme allowed for optometric skill and equipment to be utilised in collaboration with ophthalmology expertise and experience, delivering better access to expert care. Ongoing hospital-based apprenticeship style training for the scheme optometrist facilitated real improvements in optometric clinical skill, which cannot be achieved through didactic training programmes alone.[75]

The level of inter-observer agreement ($\kappa \geq 0.63$ for all patient visits, Table *6.3*) was substantial, which likely reflects the benefits of pre-scheme apprenticeship style training and ongoing hospital clinic participation by the scheme optometrist. This which ensured adequate glaucoma experience while also facilitating communication between optometry and ophthalmology, as recommended by Lockwood *et al.*[115] and Trikha *et al.*.[104] A higher level of agreement was achieved for those who were monitored ($\kappa = 0.85$ for second visit management decisions, Table *6.3*). This aligns with the findings from Wright and Diamond who observed a kappa value of 0.69 for monitoring reviews of glaucoma patients and suspects.[173]

Some amount of disagreement in relation to glaucoma is to be expected from the scheme. It is well recognised that decision making algorithms in glaucoma are complex, and that even glaucoma specialist ophthalmic consultants exhibit a wide range of agreement with each other, and even themselves, when diagnosing or managing the condition.[174] The most common area of disagreement was between the discharge and monitor groups, likely due to the ambiguity in these suspect cases. There was one occasion where a patient was non-conservatively marked for discharge by the optometrist but subsequently referred to ophthalmology by the scheme's supervising ophthalmologist. Although the management outcome was not available to us for this isolated case, this example does highlight the advantage of close inter-professional cooperation and the utility of virtual clinic reviews in ensuring patient safety in the scheme.

The clinical measurements for IOP, vCDR, and PSD showed statistically significant differences between first visit management groups but the observed differences just failed to reach statistical significance at the second visit. It is possible that a larger sample size in the second visit cohort would have achieved statistical significance as the data is trending in this direction. This perhaps confirms that guidelines may be broadly applicable to a large cohort of patients, but not appropriate in many individual cases, particularly more ambiguous presentations that require monitoring. Thus clinical judgement needs to supersede guidelines at times. In fact, the diagnostic criteria for glaucoma have varied widely between studies. Wolfs et al[175] estimated that the overall prevalence of POAG may vary up to 12-fold with different criteria and screening algorithms.

It is notable that 33% of those we were able to follow up in ophthalmology were monitored without treatment (Table 6.5) even when a glaucoma subspecialist recommended they were referred (essentially a false positive ophthalmology referral, which provides further evidence as to the difficulty in finding the right sensitivity-specificity balance). This reflects the gap between the sensitivity required when screening for glaucoma and the specificity required when making decisions regarding treatment.

We believe that the GRRMS provides a way to manage this sensitivity-specificity paradox, which may not be achievable by other means. In fact, emphasis on false positive referrals could create a culture of diminishing sensitivity, where optometric glaucoma referrals are very specific but glaucoma diagnoses are missed because of reluctance to refer or inability to carry out appropriate follow up investigations. Approximately 50% of those with glaucoma in Ireland[55] and other developed countries[56] are unaware of their disease. To reduce visual impairment and thus loss of independence in the ageing population, detection of OAG is of utmost importance. Rather than placing arbitrary focus on false positive referrals, the scheme facilitated open communication between those screening for the disease and those responsible for treatment, as well as clearer acknowledgement and planning for the necessary work of monitoring suspect cases.

On first review, the rate of loss to follow up (approx. one third of patients in the monitoring group, Table 6.1) may be a cause for concern. However, the rate of loss to follow up is actually lower than that reported from ophthalmology led, hospital based glaucoma clinics,[176] demonstrating a potential advantage of community based care. A

similar loss to follow up for glaucoma suspect patients was reported in an optometry-led collaborative glaucoma care scheme in Australia.[28] It has been documented that glaucoma suspects are significantly more likely to drop out of follow up compared to those with established glaucoma[177] and that patients' understanding of glaucoma disease mechanisms, including the insidious and irreversible nature of the condition, has been shown to greatly influence their adherence to recommended follow-up visits.[178] This indicates that improved patient education and emphasis on good physician-patient communication should be a key priority for future planning.

6.6 Limitations

The voluntary nature of the study could have affected the sample of referrals obtained. The scheme was established through voluntary participation from optometrists and patients within the greater Dublin area. As referral to this scheme was optional, optometrists may have referred more highly suspect patients to ophthalmology preferentially, seeing referral to a refinement clinic as unnecessary when they were certain of their diagnosis. Access to all glaucoma referrals during the study time period would likely better represent the true nature of optometric referrals in Ireland. It should be noted however, that the referrals did represent a broad spectrum of glaucoma, from early to advanced stages.

Lack of access to ophthalmology patient records also limited the documentation of the final ophthalmology management outcomes for the referred patients and made it impossible to assess the positive predictive value (PPV) of the refined referrals. The scheme operated with cooperation from the glaucoma team at the MMUH, so we were able to access outcomes for the cohort of patients that were subsequently seen in the

outpatient glaucoma clinic at the MMUH. Some of the patients referred into the scheme were not within the MMUH catchment area. If these patients required referral to ophthalmology, they were sent to the appropriate public ophthalmology service, or if they so wished, to a suitable private ophthalmology service. Feedback from these services was difficult to attain, it was dependent on individual doctors within the services sending a response back to the SOG. Historically, optometry has remained a community-based profession in Ireland, and not been integrated into hospital services. Therefore, optometrists typically have no access to hospital eye service records and only sporadic feedback from the public ophthalmology services to which they refer. Initial findings indicate a high level of accuracy within the refined referrals, with only one patient being discharged from ophthalmological review at first visit. The PPV of GRR schemes has previously been calculated at 0.78,[104] a marked improvement over unrefined glaucoma referrals (0.37).[115] Further work needs to be done on the follow up of glaucoma referrals within an Irish hospital eye service. Determining the PPV for both refined and unrefined optometric glaucoma referrals in Ireland would give more insight into the value of the Dublin GRRMS.

The agreement rate between clinicians was high, but the scheme involved just one ophthalmologist and one optometrist. It might not be possible to achieve this level of agreement once the scheme is expanded. Future work should continue to assess inter-practitioner agreement to determine whether agreement remains high when multiple clinicians are employed.

The false negative rate of the scheme was not assessed. It is possible that some true glaucoma cases were discharged from the scheme. All patients who were discharged

from the GRRMS were advised to visit their optometrist for annual or biennial eye exams in the future and a detailed report of the GRRMS findings was sent to the referring optometrist. The false negative rate from similar schemes has been reassuringly low,[167,179] though the sample sizes in these false negative studies have also been low, leaving some uncertainly regarding the true false negative rate of GRR schemes. Any expansion of the Dublin GRRMS should look to incorporate a mechanism to assess false negatives.

While similar initiatives have produced substantial cost savings,[103,104] future work should provide an economic evaluation of the scheme. The cost effectiveness of GRR schemes has been shown to vary significantly[41] depending on the financial models used. The national average cost of an outpatient visit in Ireland was estimated to be €130 in 2011 using a top-down methodology (National Casemix Programme) however, no information is available on how this cost may vary across specialties. This is approximately treble the amount currently paid by the State for dilated eye examinations conducted by community optometrists (€45). Costing an outpatient ophthalmology clinic appointment will be an important step in assessing the financial viability of any community based, ophthalmic shared-care scheme in Ireland, but it appears likely that such a scheme could generate substantial cost savings.

6.7 Conclusion

The GRR scheme proved a safe and effective collaboration between optometry and ophthalmology, facilitating community refinement and monitoring of the majority of glaucoma suspect patients. Current waiting times for state funded ophthalmology-led clinic appointments are at unacceptable levels, in excess of eighteen months in some

hospitals,[162] leaving vulnerable patients at risk of permanent sight loss. The monitoring facility in this GRR scheme acted to bridge the gap between the sensitivity required when case finding for glaucoma and the specificity required when initiating treatment. This pilot scheme confirms that there is potential for GRRMS to release capacity within hospital outpatient clinics, although we cannot be sure what affect this might have on waiting lists until a larger scheme is implemented. Pending economic evaluation, State agencies should consider how care structures could be modified to support further development of GRRMS in Ireland.

7. COMMUNITY OPTOMETRIC REFERRALS FOR SUSPECT GLAUCOMA: AN ANALYSIS OF CLINICAL FINDINGS AND OUTCOMES

7.1 Abstract

Purpose

To assess the clinical information provided on optometrists' referrals for suspect glaucoma and to determine the positive predictive value (PPV) for community optometric referrals for glaucoma in Ireland.

Methods

All referral letters sent into the GRRMS were assessed for completeness regarding the traditional triad of glaucoma case finding procedures; optic disc assessment; tonometry; and perimetry. The PPV was calculated according to both the reasons provided for the referral and the parameters recorded on the referral letters. A positive outcome was defined when a patient was referred onwards to ophthalmology from the GRRMS. The clinical findings provided on the letters were also compared to the gold standard measures taken in the GRRMS.

Results

Of 219 referrals, 63% provided an assessment of all three core glaucoma case finding examinations. Perimetry was the most commonly absent core finding, 30% of referrals had no visual field assessment. The overall PPV was 0.36. The PPV for referrals which flagged all three core tests as abnormal was 0.58. The highest PPV in the study was for

referrals which flagged both IOP and optic disc appearance as suspect (0.61). Those referred with just one suspect finding had the highest rate of drop out from the study.

The vast majority of referrals (95%) used NCT to measure IOP. These NCT measures were statistically significantly different from the GAT measures taken in the GRRMS, especially for NCT measures above 21 mmHg, $t(92) = 9.6$, $p < 0.005$.

CCT measures were provided in only three referrals.

Mean CDR from the referral letters was just 0.01 higher than mean CDR in the GRRMS (0.52, ± 0.16 vs. 0.51, ± 0.16). The correlation was strong $r(127) = 0.80$, $p < 0.005$, and there was no statistically significant difference on paired t-test $t(128) = 0.89$, $p = 0.38$. Just one referral included a measurement of the disc diameter.

Conclusions

The overall PPV of community optometric glaucoma referrals is comparable to that in the UK. It may be difficult to drive PPV higher in the low prevalence population typically seen in optometric practice, though optometrists might have made different referral decisions if they had knowledge of the GAT, CCT or disc size values. Recent changes in the legislation governing Irish optometry alongside increases in State funding for eye examinations could facilitate more detailed diagnostic testing and influence future referral patterns. Even if the gains in PPV are small, any improvement could allow for better use of resources in secondary care and more detailed referral information can facilitate more accurate triage in ophthalmology services.

7.2 Introduction

Demand for ophthalmology services in Ireland is far in excess of current capacity. This is demonstrated by our ongoing waiting list problem: figures for July 2017 show that 37,402 individuals in Ireland (total population in 2016: 4.76 million[8]) were on a waiting list for a first appointment at a consultant-led ophthalmology outpatient clinic, with 11,275 individuals having already spent 12 months or more on the waiting list.[9]

The IMO have cited high levels of false positive referrals as a major cause of long waiting lists in ophthalmology, stating that the health care professionals screening for eye disease are in many cases 'inadequately trained to identify vision problems'.[13] Evidence form the UK has found the proportion of false positive referrals from optometrists is high,[57,180] and particular emphasis has been placed on false positive glaucoma referrals.[62,64–66,77,116,181,182] To date, there is no data on optometrists' referral patterns in Ireland.

An analysis of referral letters can serve a number of functions. By establishing an objective reference point for current optometric case-finding strategies and identifying the types of diagnostic tests routinely carried out within optometry practices we can establish recommendations for improving the quality of referrals to secondary services. These recommendations may reduce the number of unnecessary glaucoma referrals, lessen the proportion of 'worried well'[46] being sent for specialist investigations and thereby moderate the burden of glaucoma care in ophthalmology. It is important to acknowledge however, that the low prevalence of glaucoma typically seen in the population attending optometric practices engenders false positive referrals[183] and therefore even excellent case finding strategies will result in some false positives.

Even if false positives cannot be avoided, more informative referrals can allow better triage and prioritisation of patients based on their clinical need as ophthalmologists' decisions on appropriate appointment timeframes rely on the referral information provided.

Referral letters are also an important method of communication between health care professionals, providing opportunity to build trust in optometrists' skills and expertise. Strategic planning reports produced by the IMO[13] and the Irish College of Ophthalmologists (ICO)[40] show a disregard towards optometrists' roles in the ophthalmic care pathway in Ireland. Comprehensive and considered referrals that better demonstrate optometrists' clinical abilities might help improve the relationship between the professions.

Referral analysis can also identify potential training needs within the profession, informing the development of both undergraduate training and continuing professional development (CPD) programmes, and feeding into the ongoing development of optometric expertise.

This study was designed therefore to analyse community optometrists' referrals for suspect glaucoma, seeking to evaluate the positive predictive value of the referrals as well as the utility of the referral information being provided.

7.3 Methods

All referral letters sent into the joint optometry/ophthalmology GRRMS at the National Optometry Centre, Dublin were manually analysed. All participants included in the study gave written consent for their clinical information to be used for research purposes (refer to Appendix 5 for a copy of this consent form). Each letter was assessed in terms of three key metrics:

i. **Completeness:** A letter was considered complete if it provided an assessment of all three core glaucoma case finding examinations; optic nerve examination; intraocular pressure (IOP) measurement; and visual field testing. Provision of risk factor information was also assessed. A letter was considered to have included a description of the risk factor profile if there was any mention of the presence or absence of a known risk factor for glaucoma. For example, if it was stated that there was a family history of glaucoma or conversely, no known family history of glaucoma, it was considered that a risk factor profile for the patient had been included.

ii. **Positive predictive value (PPV) of the referral:** The PPV for referral from the GRR clinic to ophthalmology was determined according to both the reasons provided for the referral i.e. the findings which were flagged as abnormal, and the parameters documented on the referral letter. These parameters were categorised based on the three core glaucoma screening tests; tonometry, optic nerve assessment, and perimetry. All possible combinations of these three were considered, resulting in seven categories. Any referrals with none of the core triad

flagged as suspect were categorised based on their main reason for referral and also included in the analysis (Refer to Figure 7.1). The positive predictive value (PPV) was calculated as follows:

$$\text{PPV for those referred with suspect IOP only} = \frac{\text{IOP only referrals that were subsequently referred from GRR to ophthalmology for management}}{\text{all IOP only referrals}}$$

Figure 7.1: Calculation of positive predictive value (PPV) for referral from the glaucoma referral refinement (GRR) clinic using intraocular pressure (IOP) only referrals as an example.

PPV was calculated both for referral at first visit in the GRR clinic and referral at the end of the GRR study, after any necessary monitoring had been carried out. A positive outcome as a referral onwards from the GRRMS. The χ^2 test for trend was used to compare the PPV of different referral groups.

iii. **Alignment with gold standard methods:** The techniques used and the clinical findings provided by the referring optometrists were identified and compared to the findings from the GRRMS.

The NCT IOP values given on the referral letters were compared to the GAT readings taken in the GRRMS visit. Pearson's correlation and paired t-tests were used to determine whether differences between the IOP values were statistically significant. To further analyse these results, the data was split into two groups, NCT values $\leq$ 21.0 mmHg, and NCT values > 21.0 mmHg, and the difference between techniques was compared again using a paired t-test. Those referrals

which indicated IOP as the only suspect finding were also analysed separately, paired t-test was used to determine whether the was a significant difference between the NCT values on the referrals and the GAT values measured in the GRRMS.

The cup-disc ratio (CDR) values documented on the referral letters were compared with the values for CDR recorded through dilated binocular indirect ophthalmoscopy at the patients' visits in the GRR clinic. Pearson's correlation and paired t-test we used to determine whether differences between the values were statistically significant. The Bland-Altman method was used to graph the agreement between CDR estimates and linear regression was run to assess for proportional bias.

The information was recorded and analysed in the statistical package for social sciences (IBM SPSS Statistics for Windows, Version 22.0 Armonk, NY: IBM Corp.).

7.4 Results

Two hundred and nineteen glaucoma referrals were assessed in the study. Of 219 referrals, 63% provided an assessment of all three core glaucoma case finding examinations. Visual field testing was the most commonly absent core finding (Table 7.1).

Table 7.1: Percentage of referral letters missing each of the three core glaucoma case finding strategies: IOP measurement, optic nerve examination, and visual field testing (n = 219).

Missing one or more of the triad	No IOP value	No optic nerve description	No visual field findings
37%*	1.8%	11.4%	29.7%

**values do not add to 37% as some referrals had more than one missing finding i.e. referral flagged high IOP but optic discs and visual fields findings were not mentioned.*

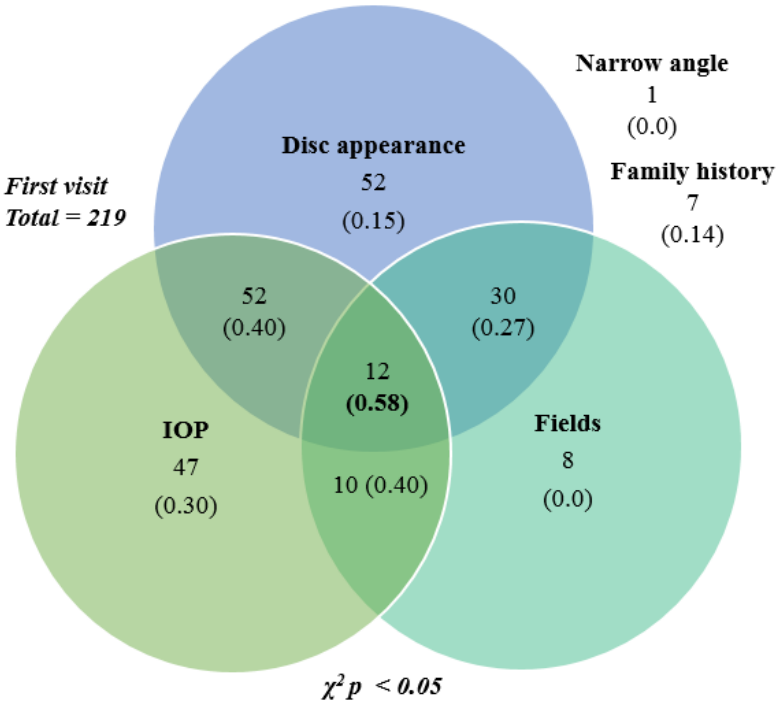
Some reference to the patient's risk factor profile for glaucoma was made in 62% of referrals. Family history of glaucoma was the most commonly mentioned risk factor and 31% of the cases seen to the GRR clinic had a family history of glaucoma. Other risk factors mentioned in the letters included; relevant medications e.g. steroid use; shallow anterior chamber or narrow angles; suspicion of low diastolic perfusion pressure; high myopia.

Positive predictive value of the referral

The overall PPV for referral to ophthalmology at the end of the study, after some suspects had been monitored, was 0.36.

Figure 7.2 shows the PPV according to the referring optometrists' reasons for referral. The highest PPVs were for referrals which flagged all three core techniques as abnormal (first visit) or indicated that both IOP and the optic nerve were suspect (final visit). None of the patients referred with isolated field loss were referred out of the GRR clinic, though this group only comprised 3.8% of the letters analysed. Chi square test for trend showed that the PPVs were statistically significantly different between referral groups (Figure 7.2), though the small numbers in some categories resulted in some expected cell frequencies below five.

To address this issue, the categories were collapsed together into three groups, comprising referrals with one, two, or three suspect findings. Altogether 53% (115 of 219) of the referrals were made on a single suspicious finding. Table 7.2 shows that corroborative findings did statistically significantly increase first visit PPV. It is also notable that those referred with a single suspect finding had the highest loss to follow up rate from the study.



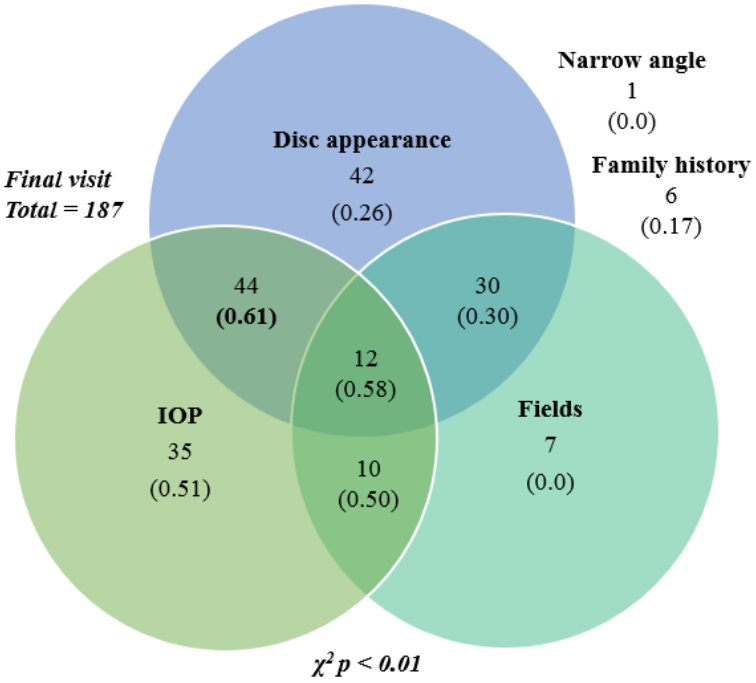


Figure 7.2: Reasons provided for referral; number of patients and positive predictive values (PPV) at first visit and at final visit. The highest PPV in each graph is highlighted in bold. PPVs are compared using the χ^2 test for trend.

Table 7.2: Positive predictive value (PPV) for referral from GRR clinic at first visit (PPV first visit) and referral from GRR after any necessary monitoring had been carried out (PPV final visit) based on the referring optometrist's reason(s) for referral for suspect glaucoma, which are categorised based of the number of suspect findings denoted on the referral letter. PPVs are compared using the χ^2 test for trend.

Reason(s) for referral	**First visit PPV (n)**			***n at end of study (% loss to follow up)***	**Final visit PPV (n)**		
One suspect finding (115)	0.20 (23)	**p < 0.05**	**p < 0.01**	***91 (20.1%)***	0.33 (30)	**p < 0.05**	p = 0.051
Two suspect findings (92)	0.36 (33)			***84 (8.7%)***	0.49 (41)		
Three suspect findings (12)	0.58 (7)			***12 (0%)***	0.58 (7)		

PPV was also calculated according to the parameters recorded on the referral letters (Figure 7.3). At first visit, those referrals containing information on the IOP and disc appearance resulted in the highest PPV (0.40). At the final GRR visit, after monitoring of some cases was carried out, referrals containing IOP information only, i.e. disc appearance or visual field assessment were not mentioned on the referral letter, actually had the highest PPV (0.57) though the number of referrals in this category was low. The chi square test for trend again showed that the PPVs for each category were statistically significantly different, Figure 7.3.

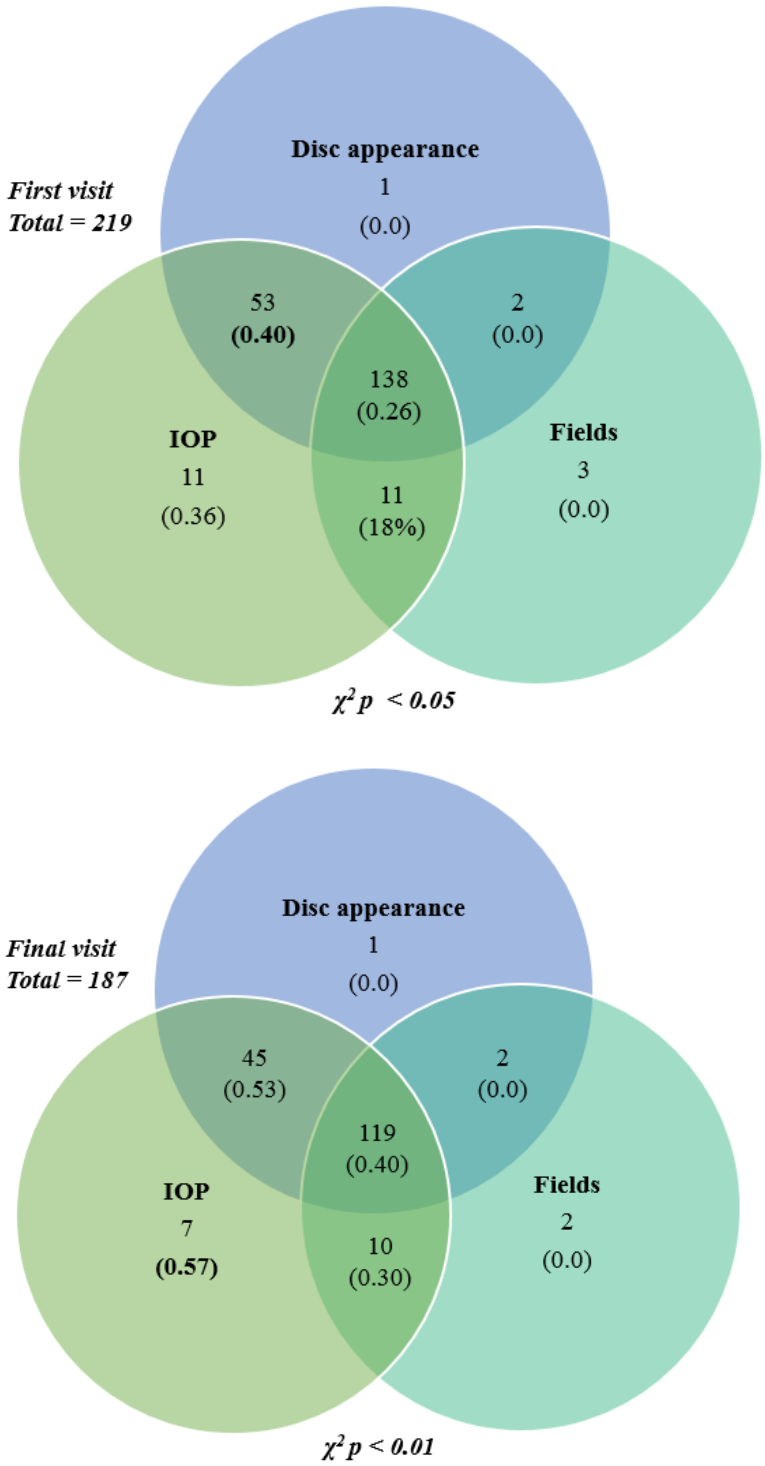


Figure 7.3: Parameters recorded in referrals: number of patients (PPV) for first and final visit in the GRR clinic. The highest PPV in each graph is highlighted in bold. PPVs are compared using the χ^2 test for trend.

Intraocular pressure

The vast majority of referral tonometry readings (95%) were taken using NCT, only 5% of the recorded IOP measures were taken using contact applanation tonometry (either Perkins or Goldmann). Of the NCT readings provided, 36% were an average value of three or more readings, 47% provided just one reading per eye but did not note the number of readings taken, and 17% were noted as less than three readings. Repeat IOP measures, where the IOP was measured on two or more separate occasions, were provided in 28% of referrals. The time of day was recorded in 69% of cases. CCT measures were provided in only three cases.

Mean findings for the NCT IOP values documented on the referral letters were, on average, 1.3 mmHg higher than the GAT IOP values recorded at patients' visits in the GRR clinic (20.2 mmHg, ± 5.8 vs. 18.9 mmHg, ± 4.6). The correlation between techniques was strong, $r(204) = 0.73$, $p < 0.005$, but the difference was shown to be statistically significant on paired t-test, $t(205) = 4.40$, $p < 0.005$.

The IOP data was also split into two groups, which showed that mean NCT was actually significantly lower than mean GAT for NCT values less than or equal to 21.0 mmHg, and significantly higher for NCT values above 21.0 mmHg (Table 7.3).

Table 7.3: Mean values for non-contact tonometry (NCT) IOP readings taken from the referral letters and Goldmann applanation tonometry (GAT) readings recorded in the

		Mean IOP (*SD*) mmHg	**Paired t-test**
NCT IOP ≤ 21.0 mmHg	NCT (referral) GAT (GRRMS)	15.7 (±3.1) 16.5 (±3.6)	$t(112) = -2.7$, $p < 0.005$
NCT IOP > 21.0 mmHg	NCT (referral) GAT (GRRMS)	25.6 (±3.2) 21.9 (±4.1)	$t(92) = 9.6$, $p < 0.005$

GRR clinic, split into two groups: values ≤ 21.0 mmHg, and values > 21.0 mmHg.

A scatter plot of NCT against GAT further demonstrates these trends, revealing a systematic overestimation of IOP by NCT relative to GAT for NCT IOP readings > 21.0 mmHg (Figure 7.4: note IOP values mostly displaced to the left of the line y = x).

For the ≤ 21.0 mmHg group, there does not appear to be a systematic over or underestimation between techniques, though there were some outliers where the GAT value was much higher than the NCT value (Figure 7.4).

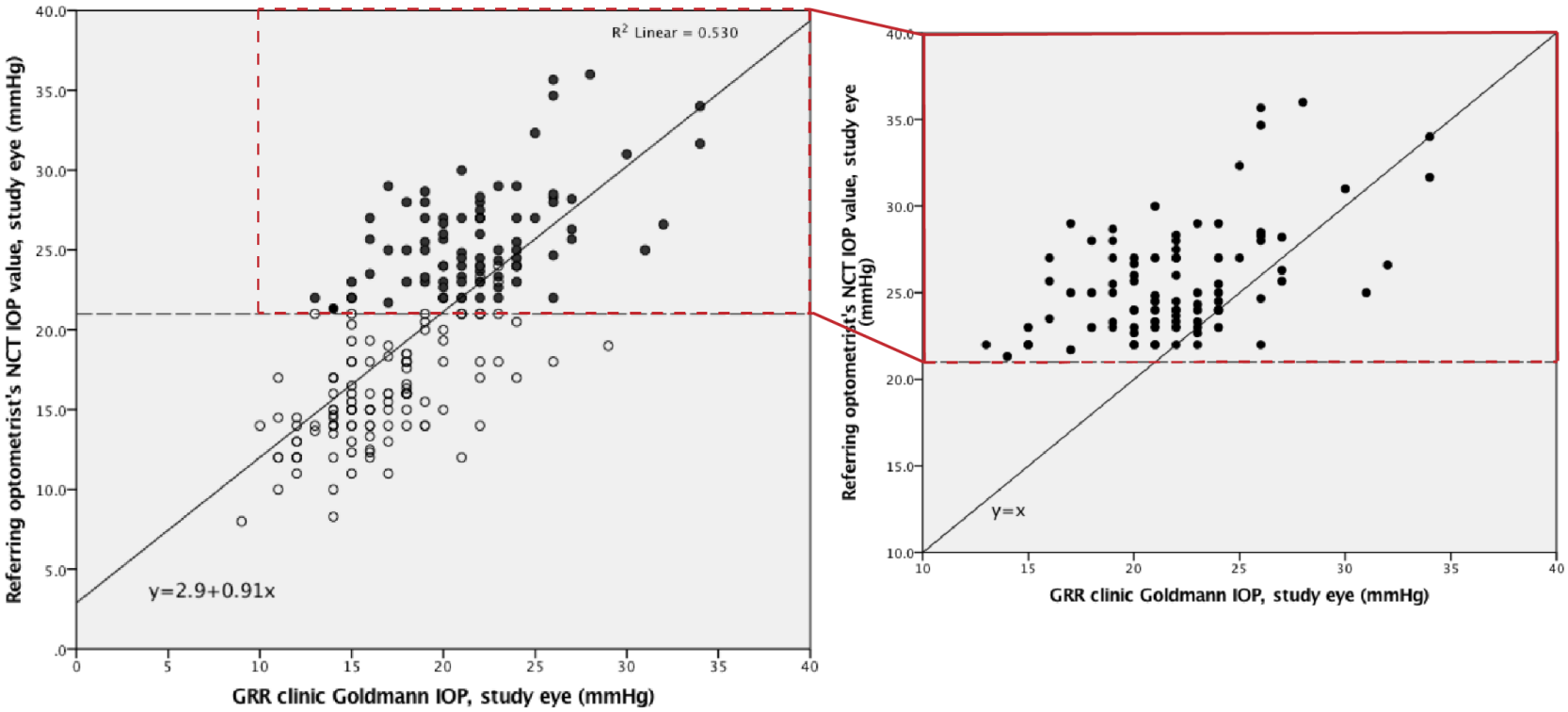


Figure 7.4: Scatter plots graphing the IOP value measured by Goldmann applanation tonometry (GAT) in the glaucoma referral refinement and monitoring service (GRRMS) against the referring optometrist's non-contact tonometry (NCT) intraocular pressure (IOP) value for all referrals (left) and isolating only NCT values > 21.0 mmHg plotted with reference to the fit line y=x (right).

There were 47 referrals with IOP identified as the only suspicious finding. In this group of 47 patients, the NCT IOP values documented on the referral letters were, on average, 3.2 mmHg (95% CI, 2.7 to 4.9) higher than the GAT IOP values recorded at patients' visits in the GRR clinic (25.2 mmHg ± 3.4 vs. 22.0 mmHg ± 4.1). This difference was again shown to be statistically significant on paired t-test, $t(46) = 6.8$, $p < 0.005$.

Optic disc assessment

The optic disc was described in 88.6% of referrals, though just 61% gave a value for CDR and only one referral included a measurement of the disc diameter. Though optometrists did state their impressions of the disc appearance, pointing out which features appeared suspicious, they did not appear to relate cupping to the disc size when describing the optic disc. The method of disc evaluation was generally not provided.

Mean CDR from the referral letters was just 0.01 higher than mean CDR in the GRR clinic (0.52, ± 0.16 vs. 0.51, ± 0.16). The correlation was strong $r(127) = 0.80$, $p < 0.005$, and there was no statistically significant difference on paired t-test $t(128) = 0.89$, $p = 0.38$.

A Bland Altman plot showed that there was no systematic over or underestimation of CDR (Figure 7.5), despite the GRR clinic protocol requiring stereoscopic disc examination through a dilated pupil. The Bland Altman limits of agreement for referring optometrists CDR versus the GRR clinic CDR was 0.01±0.20. Linear regression showed that there was no proportional bias, $t = -0.163$, $p = 0.870$.

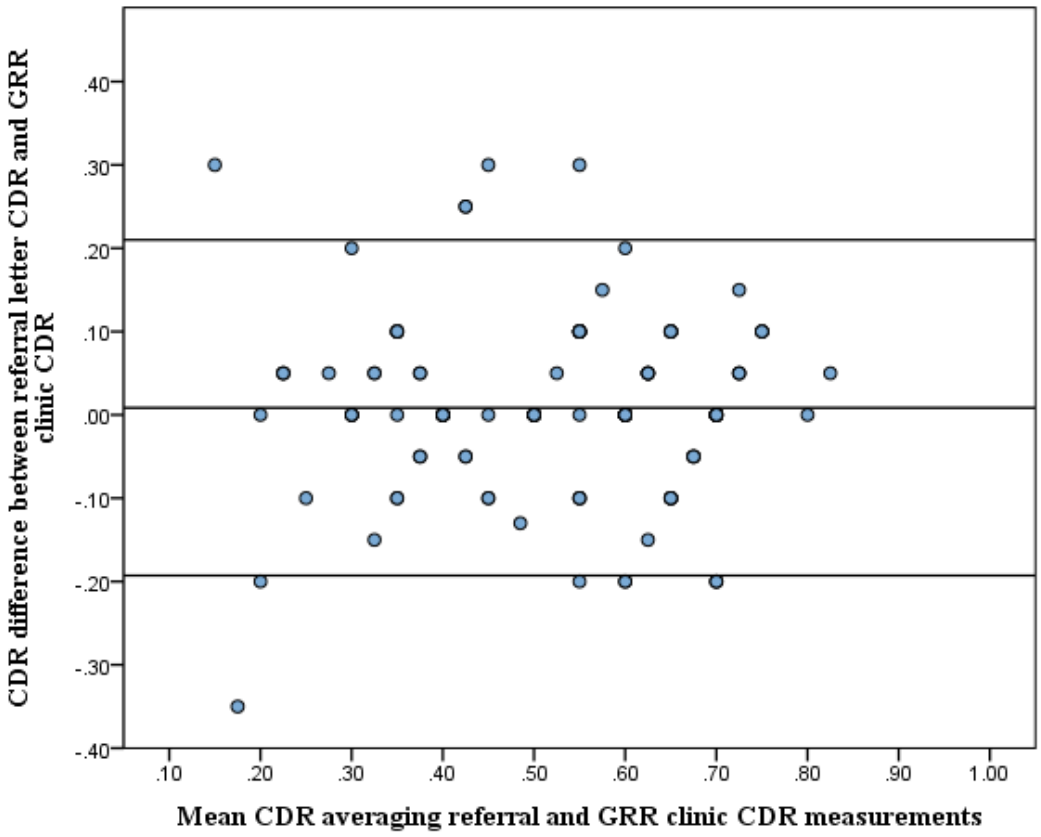


Figure 7.5: Bland Altman plot for referring optometrist's CDR vs. GRR clinic CDR. Y axis reference lines signify the mean CDR difference and the 95% CIs.

Perimetry

Automated perimetry was used to assess the visual field in 70.3% of cases though only 39% included a printed copy of the visual field plots. Of the letters that included visual field plots, 40% employed full threshold testing strategies, with the remainder providing suprathreshold screening results.

7.5 Discussion

The key finding that emerged from this study was that overall PPV was 0.36. The clinical findings varied between referrals, though there were some key trends identified including:

(i) a heavy reliance on NCT; and

(ii) an absence of CCT and optic disc diameter measures.

Optometric glaucoma referrals in the UK have been studied by various groups over the past 25 years, and estimates for PPV have ranged from 26%[180] to 80%.[57] Frequently studies present the data in differing ways, and have different definitions for a positive referral; therefore their results are not directly comparable. We defined a positive outcome as a referral onwards from the GRRMS, reasoning that our supervising glaucoma specialist consultant ophthalmic surgeon had judged that these patients required follow up in ophthalmology and equated this to a positive referral outcome. This metric relates well to a study by Lockwood *et al.*, which reasoned that a positive outcome for a referral was when the patient had a diagnosis of glaucoma, ocular hypertension, or if there was a high index of suspicion of glaucoma requiring follow-up in ophthalmology.[115] The overall PPV in Lockwood's study was 0.37, almost exactly matching our findings, indicating that Irish optometrists' glaucoma case finding strategies are approximately comparable to that in the UK.

When considering the PPV it is important to understand a number of factors influencing the referral patterns of optometrists in community practice, namely, optometrists' legislated scope of practice, State funding of optometry services, and the

low prevalence of glaucoma typically seen in the population presenting for routine eye exams which limits the PPV of the screening tests used.[183]

At the time of this study, optometrists in Ireland were strictly confined to a screening role, being required by legislation to refer any suspect pathology to a medical practitioner.[34] Thus monitoring of suspect findings such as raised IOP for example, was considered outside their legislated scope of practice. Furthermore, State funding of eye examinations was limited to a once off payment per exam. The contracts did not fund repeat appointments to refine clinical decision making.

In this context, it is likely that optometrists carried out only the tests deemed necessary for reasonable screening certainty. In total, 63% of the letters provided a complete glaucoma assessment, including all three core glaucoma case finding examinations. We found however, that referrals providing just optic disc and IOP information actually had a higher PPV (Figure 7.3). In these cases, the optometrists may have found that their optic disc and tonometry findings constituted reasonable grounds for referral and saw no need to carry out perimetry. In more subtle cases, optometrists may have tried to confirm initial suspect findings by carrying out the full glaucoma triad but still could not rule out glaucoma and so initiated referral.

This could be considered a reasonable time management strategy given the legal and financial constraints on optometric practice. Though corroborative findings did significantly raise PPV (Table 7.2), and cases referred with all three core clinical findings flagged as abnormal had high PPV (0.58, refer to Figure 7.1), those referrals with just a single suspect finding did have reasonable outcomes (PPV 0.33, Table 7.2).

This demonstrates the difficulty of reaching a conclusive diagnosis in early glaucoma where for example, IOP could be within the statistically normal range, but the disc appears suspect and there may be no conclusive defect on visual field testing. In early glaucoma, local depressions of sensitivity will often come and go for quite some time before finally resolving into stable and repeatable visual field defects.[184]

In our investigation of GRR (refer to Chapter 6), we referred to this as the 'sensitivity-specificity paradox', and indicated that appropriate monitoring of suspect cases may be the only way to bridge the gap between the sensitivity required when screening for glaucoma and the specificity required when making decisions regarding treatment. Whether this monitoring workload can be carried out safely by community optometrists (rather than SOGs in a shared care scheme) needs to be explored.

It is interesting to note that those referred with just one suspect finding had the highest rate of drop out from the study (Table 7.2). This demonstrates the limited opportunity that optometrists have to detect the disease. Even if a patient is advised that there are suspect findings they may not return for follow up within an appropriate timeframe, therefore risking irreversible sight loss. In our analysis of optometrists' perceived barriers to glaucoma detection (refer to Chapter 4), the majority of respondents agreed that poor continuity affected their ability to detect early glaucoma (Table 4.2). Optometrists moving towards more independent monitoring of suspect cases should be aware of the risk of drop out so that they can take appropriate measures to minimize this risk, perhaps by focussing on better patient education.

Recent increases and restructuring in the State eye exam fees paid to Irish optometrists could facilitate more detailed diagnostic investigations within community optometry (refer to section 2.6.1 for more information on State funding of optometry services in Ireland) and changes in the legislation[31] governing optometric practice could see some practitioners progressing to independent monitoring of suspect cases. There is a skills and experience gap however, in moving from a screening role towards diagnostic services. Our findings can direct us to key areas for upskilling.

The referrals showed a heavy reliance on NCT. Within the group of referrals with NCT IOP identified as the only suspect finding, and in fact for NCT values above 21 mmHg in general, we found that the GAT values were significantly lower than the referral NCT IOPs (Table 7.3). Though this result could simply represent regression towards the mean,[185] it is possible that the optometrist's referral decision would have been different for some of these cases had they known the GAT value. The most recent NICE guidance on glaucoma detection has increased the threshold for referral from an IOP of 21mmHg to 24mmHg, and it is specifically emphasised that those case finding for glaucoma should not make referral decisions based solely on IOP values measured with NCT.[186]

Knowledge of the CCT would add crucial information to the clinical picture. It is commonly understood that tonometers are calibrated to average corneal thickness and therefore a thinner than average cornea can lead to underestimation of the IOP while a thicker than average cornea can lead to an overestimation.[91] However, clinicians should avoid over-reliance on CCT correction formulas for GAT measurements, the interaction of IOP and CCT is complex and there are certainly other corneal factors,

such as hysteresis or corneal curvature for example, that influence tonometry readings. It is now understood that the influence of corneal thickness as a prognostic factor for POAG is not entirely from its effect on IOP measurement error, but rather that CCT is a biomarker for structural and physical factors involved in the pathogenesis of glaucoma.[92] The Ocular Hypertension Treatment Study (OHTS)[83] and the European Glaucoma Prevention Study (EGPS),[187] identified CCT one of the the strongest, independent predictors for the development of POAG (the other validated risk factors are age, IOP, vCDR, and PSD).[84] Therefore, in order to better identify those at risk of developing POAG, CCT needs to be measured an interpreted appropriately.

Knowledge of the CCT value is also crucial to determining which patients might be safely monitored, and indeed the appropriate monitoring intervals.[50] Those patients with higher CCT might be safely monitored in community practice whereas those with lower CCT might warrant referral, being at much greater risk of glaucoma development.[83,187]

The level of agreement between the CDRs taken from the referral letters and the values recorded in the GRR clinic comes close to the limits of inter-observer agreement shown in other studies[188] and is approximately the same level of agreement that has been demonstrated between ophthalmologists.[121,188] This demonstrates that the CDRs on the referral letters were comparable to those measured under gold standard conditions. Every patient in the GRR clinic had a stereoscopic disc examination using SLBIO through a dilated pupil. However, the lack of disc size measures, or even estimates, limits the value of the CDRs measured by the referring optometrists (refer to

Figure 2.4 for an explanation of the relationship between the optic disc diameter and the CDR).

The method of disc assessment was generally not provided on the letters but it is possible that use of direct ophthalmoscopy precluded the measurement of optic disc diameter. In direct ophthalmoscopy, the magnification of the image is significantly affected by the patient's refractive error, therefore the size of the disc cannot be determined. In our survey of optometrists (refer to Chapter 3) the majority of respondents reported using direct ophthalmoscopy as their first choice technique during routine eye examinations so it is likely that many of the referring optometrists could not determine the disc size. However, this doesn't fully explain the almost complete lack of disc size measurements, certainly there were some optometrists using SLBIO that could have measured disc size and did not or perhaps just did not report it. There may be utility in providing continuing professional development events emphasising the importance of considering optic nerve size when evaluating disc cupping.

Perimetry results were the most commonly absent of the three core clinical techniques, which may not be of great consequence considering there is evidence to show that the increased use of perimetry by optometrists has not necessarily led to an improvement in diagnostic accuracy[115] and may even lead to an increase in unnecessary referrals for glaucoma.[77]

None of the patients referred with isolated field loss were referred out of the GRR clinic (Figure 7.2), though the numbers in this cohort were low. A larger analysis of 87 referrals with suspect fields as their only abnormal finding found that 19 resulted in a

glaucoma diagnosis, demonstrating that some cases of glaucoma would have been missed if fields were not performed.[115] Thus optometrists would be remiss to ignore cases of repeatable field loss, even if both the IOP and optic appear normal. This highlights again the difficulty faced by optometrists in case finding for an insidious disease using tests with limited diagnostic accuracy.

Evidence from Scotland has been cited as an example of the benefits of increased investment in the optometric eye exam and we've speculated that increased funding of Irish optometric services could lead to similar benefits (refer to section 2.6.1 for a discussion on the new funding structures for Irish optometrists and the situation in Scotland). It is important to acknowledge however, that the Scottish Government also awarded equipment grants and NHS Education for Scotland (NES) provided training for optometrists on the new eye examination protocol. Similar investment in both equipment and training might be required to increase the use of gold standard techniques in optometric practice in Ireland. Training on pachymetry and the interpretation of CCT, as well as GAT and SLIBIO might be particularly useful.

Even if the resultant gains in PPV are small, any improvement will allow for better use of resources in secondary care and more detailed referral information can facilitate more accurate triage of cases in ophthalmology services.

7.6 Limitations

Referral to this scheme was optional, optometrists may have referred more highly suspect patients to ophthalmology preferentially, seeing referral to a refinement clinic as unnecessary when they were certain of their diagnosis. Hence the true PPV for

optometric glaucoma referrals in Ireland might actually be higher. Though the referrals did appear to represent a broad spectrum of glaucoma, from early to advanced stages, access to a broader base of referral letters would likely be more representative of the true nature of optometric referrals for glaucoma in Ireland.

Though 219 referrals were analysed in this study, they represent the referral practices of just 70 optometrists. Grouping referrals from each practitioner and looking for patterns across practitioners was considered, but it was felt that this type of analysis could become misconstrued as an attempt to find fault with individual practitioners. Therefore, all referrals were considered as a single cohort.

7.7 Conclusion

The overall PPV of community optometric glaucoma referrals is comparable to that in the UK. It may be difficult to drive PPV higher in the low prevalence population typically seen in optometric practice, though optometrists might have made different referral decisions if they had knowledge of the GAT, CCT or disc size values. Recent changes in the legislation governing Irish optometry alongside increases in State funding for eye examinations could facilitate more detailed diagnostic testing and influence future referral patterns. Even if the gains in PPV are small, any improvement will allow for better use of resources in secondary care and more detailed referral information can facilitate more accurate triage in ophthalmology services.

8. SUMMARY, CONCLUSIONS, AND DIRECTIONS FOR FUTURE WORK

8.1 Summary and conclusions

The research presented in this thesis has provided new insight into optometrists' practice patterns for glaucoma detection in Ireland.

In our national survey (Chapters 3 and 4), we demonstrated that optometrists in Ireland are well equipped to perform the traditional triad of tests necessary to conduct adequate glaucoma case finding. Moving towards enhanced services such as monitoring glaucoma suspects or ocular hypertension cases however, would require some investment in equipment and training, particularly for core gold standard techniques such as GAT and SLBIO, which are essential to glaucoma detection and referral decisions.

We found that optometrists in Ireland have a strong interest in furthering optometric professional development and expanding the traditional role boundaries of optometrists, an aspiration that could become a reality under new legislation which has removed previous constraints on optometric practice.[31] We have also shown that optometrists are cognizant of the need to support any change in scope with appropriate education and training. The majority of those surveyed (Chapter 3) agreed that postgraduate education should be incorporated as an essential prerequisite to an enhanced scope of practice.

In fact, Irish optometrists identified their own training as the key barrier to detecting glaucoma during routine eye examinations (Chapter 4). To deliver real improvements in clinical competence, the type of training made available should be carefully considered

by educators and regulators in Ireland. This process has already begun at DIT, where the Institute's first level 9, postgraduate CPD module for optometrists was launched in January 2017. This module, entitled 'Glaucoma detection and decision-making in optometric practice' was largely informed by the experience attained through this research.

Time and financial constraints on clinical practice were also identified, and more recent entrants into the profession and those working in large multiples or franchised stores in Ireland appear disproportionately affected by these barriers (Chapter 4). It is possible that these barriers will be addressed by the recent renegotiation of the Irish State's eye examination fees whereby increased fees and repeat measures allowances serve to provide more equitable access to refined clinical decision making. However, corresponding investment in both equipment and training might be required to fully capitalise on optometric skill in a community setting.

Our pilot collaborative care pathway, the Dublin GRRMS (Chapters 5 and 6), has shown that Irish optometrists can successfully transition to a co-management role. The scheme proved a clinically effective collaboration between optometry and ophthalmology, facilitating community refinement and monitoring of the majority (62%) of glaucoma suspect patients seen in the GRRMS. In POAG there is a long asymptomatic lead time, no ideal screening test, and early diagnosis often requires careful monitoring over a number of visits. These characteristics create a major diagnostic challenge. The monitoring facility in the GRRMS acted to bridge the gap between the sensitivity required when case finding for glaucoma and the specificity required when initiating

treatment. This saved valuable tertiary hospital outpatient clinic slots and delivered safe care to patients in a primary care setting.

Our analysis of optometrists' referrals to the GRRMS (Chapter 7), showed that those patients referred with just one suspect finding had the highest rate of drop out from the monitoring cohort of the study. This indicates a need to ensure good patient-practitioner communication in this cohort of patients in particular. Patients' understanding of glaucoma disease mechanisms, including the insidious and irreversible nature of the condition, has been shown to greatly influence their adherence to recommended follow-up visits.[178]

The PPV for unrefined glaucoma referrals was calculated as 0.36, and a further analysis allowed us to better understand the underlying reasons for the relatively low PPV (Chapter 7). We found that optometric referrals relied heavily on NCT IOP readings and that there was a lack of CCT and disc size measurements. Introducing these relatively simple techniques to Irish optometrists' examination strategies could facilitate more nuanced decision making within optometric practice, though the low prevalence of glaucoma typically seen in traditional optometric practice should also be recognised as a limitation on the PPV of referrals.

We also demonstrated that Irish optometrists appear to carry out just those examinations that are necessary to reach reasonable grounds for referral. This practical approach to screening is justified under the Opticians Act (1956)[34] where optometrists were required to refer suspect pathology to a medical practitioner and monitoring

suspect cases was outside their legislated scope of practice. Screening strategies may evolve in Ireland's new legislative environment.

8.2 Directions for future work

It is recommended that future work builds on the findings presented in this thesis by analysing the progression of optometric clinical practice patterns in Ireland. It appears that the profession is on the cusp of change, with new legislation enabling development in scope of practice, new public funding structures providing financial support for increased services, potential for unprecedented integration of optometrists into multidisciplinary ophthalmic care teams, and strong interest from optometrists themselves in furthering their scope of practice.

Follow up surveys of optometrists could be carried out in order to document changes in self-reported practice patterns. If resources allow, a standardised patient (SP) methodology might provide more accurate evidence regarding the use of supplementary diagnostic investigations such as GAT, pachymetry, or full threshold field tests for example. A study by Theodossiades *et al.*[189] found that self-reported clinical practice questionnaires overestimate routine tests undertaken by optometrists in practice, and while a survey of optometrists showed good correspondence to the SP reports for mandatory tests such as ophthalmoscopy for example, correspondence was poor for discretionary tests. These findings indicate that accurate assessment of the use of more advanced clinical investigative techniques might not be possible with surveys alone.

Further evidence on the content of typical optometric eye examinations in Ireland would also be useful in relation to new fitness to practice complaints procedures[119] that have

been implemented by CORU. Professional performance is now assessed in relation to perceived practice norms. In order to differentiate between realistic minimum standards of clinical competence and aspirational goals for best practice, definitive data on optometric practice in Ireland is required.

Accurate follow up of glaucoma referrals within our hospital eye services would allow us to calculate the PPV of both refined and unrefined glaucoma referrals more definitively, information that is vital to the proper evaluation of the GRRMS. Access to a broader base of referrals, rather than relying on optometrists to voluntarily refer patients to the scheme, could also provide more representative evidence on the practice patterns of optometrists in Ireland.

New training opportunities for optometrists should also be carefully developed and assessed. It has been shown that didactic teaching alone is unlikely to lead to significant improvements in clinical competence[113] and that longer term training, including ophthalmology feedback on referred patients, may be essential to improving the PPV of optometric glaucoma referrals.[117] An educational intervention study similar to those carried out by Patel *et al.*,[73] Myint *et al.*,[113] or Yoshioka *et al.*[75] would be useful in determining the utility of new educational programmes.

The longstanding inequities in access to ophthalmology services in Ireland are detailed in Chapter 1 of this thesis. Future health services research should continue to explore alternative ways to contribute to improved quality, equity, relevance, and cost effectiveness in our health care system.

The new PCETs that have been proposed in the HSE's recent report reviewing primary eye care services in Ireland[21] would be an ideal space for further research. These PCETs will represent a key milestone in the move towards collaboration between ophthalmology, optometry, and orthoptics. The impact of these new multidisciplinary teams should be carefully researched such that any further development of these services is informed by appropriate evidence. Governmental, HSE, and professional policy decisions should be based on objective data. Researching the types of referrals sent to these PCETs, the outcomes for the referred patients, and the changes in waiting times for public patients will be essential in evaluating the utility of such schemes. This analysis will also allow us to better identify the health imperatives of the nation so that service activities can be oriented towards priority health concerns.

Within the PCETs there may be scope for a joint optometry-ophthalmology GRRMS, similar to that piloted herein. Any expansion of this scheme should look to incorporate a mechanism to assess false negatives, perhaps following the examples of Kotecha *et al*.[167] and Ratnarajan *et al*.[179] where a proportion of the patients discharged from the scheme were recalled and reviewed in a face-to-face consultant-led clinic in order to evaluate the false negative rate.

An economic evaluation of both the increased State fees paid to community optometrists in Ireland and the new PCET structure in primary eye care is also essential in determining the validity of these services. Accurately costing hospital eye service outpatient ophthalmology clinic appointments in Ireland will also be essential to evaluating the economic viability of new systems.

Patient preference and experience should also be central to the development of our health services. Conjoint analysis could be used to determine patients' preferences for various models of care. This technique offers greater realism than traditional patient satisfaction questionnaires as patients are required to rank the various characteristics of a service, giving more differentiation between attributes.[190] A recent conjoint analysis of glaucoma patients' views on follow up care in the Nottingham area, showed that travel time and the training of the health professional were the most important factors for patients.[191] This technique could be useful in determining Irish patients' views on service provision in eye care. Future work should look to engage with patients and patient representative bodies so that this key stakeholder group can inform to process of reform.

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APPENDICES

Appendix 1. Online survey of optometrists

Detecting Glaucoma in Optometric Practice

It takes less than five minutes to complete the entire survey.
The questions are divided into four short sections.
All information gathered is anonymous and confidential.

Section A: Demographic Information

In what country did you qualify as an optometrist?

In what year did you qualify as an optometrist?

Have you completed any form of clinical optometric postgraduate qualification?
Certificate/Diploma/Masters etc. If yes, please specify e.g. OPT009 - Glaucoma Foundation Module at Cardiff University

What's your current mode of practice?
(you can select more than one option)

- ☐ Salaried optometrist in a 'multiple' (familiar High Street optometrists)
- ☐ Salaried optometrist in an independent private practice
- ☐ Self employed business owner with independent private practice
- ☐ Locum optometrist
- ☐ Academic
- ☐ Franchise director
- ☐ Other:

In which county do you work?

Does your practice provide support for continuing professional development or postgraduate education?

E.g. Contributing towards fees for courses, offering paid leave allow for course attendance etc. Please give details.

How many optometrists are employed in the practice? (full time or part time)

How long is your appointment slot for an eye exam?

How much does your practice charge for a standard eye exam?

Is there an extra fee for supplementary testing? e.g. visual field testing, repeat pressures, photography or other imaging. If so, please elaborate.

Continue »

25% completed

Detecting Glaucoma in Optometric Practice

Section B: Equipment Survey

All information gathered is anonymous and confidential.

Which tonometer(s) do you use in practice? (You can select more than one).

- [ ] iCare rebound tonometer.
- [ ] Table mounted non-contact tonometer
- [ ] Goldmann applanation tonometer.
- [ ] Perkins applanation tonometer.
- [ ] Pulsair handheld tonometer
- [ ] Schiotz tonometer
- [ ] Tonopen
- [ ] Other:

What's your first choice technique for routine fundus examination?

- ( ) Direct ophthalmoscopy
- ( ) Binocular indirect ophthalmoscopy using a slit lamp and Volk lens
- ( ) BIO using a headset and condensing lens
- ( ) Other:

Do you have an automated perimeter?

If so please specify the make e.g. Henson 8000

How competent do you feel using a Volk lens for binocular indirect ophthalmoscopy (BIO)?

Select on a scale of 1-5 where 1 means you are unable to use a Volk lens and 5 means you are very competent using a Volk lens (you can get a focused, steady view and can easily interpret the image).

	1	2	3	4	5	
I'm unable to use a Volk lens	○	○	○	○	○	Very competent

Do you have access to any of the following specialist equipment in your practice? Please select all that apply.

- ☐ Digital fundus photography
- ☐ Digital slit lamp camera
- ☐ Optical coherence tomography (OCT)
- ☐ GDx (scanning laser polarimetry)
- ☐ Goniscopy lens
- ☐ Ultrasound pachymeter
- ☐ Pentacam
- ☐ Other:

Do you carry out tonometry yourself or does another member of staff do this?

- ○ I carry out tonometry myself
- ○ Tonometry readings are usually taken by non-professional staff

« Back Continue »

50% completed

Detecting Glaucoma in Optometric Practice

Section C: Interest and attitudes towards enhanced scope optometry

All information gathered is anonymous and confidential

Have you completed any form of clinical optometric postgraduate qualification?

Certificate/Diploma/Masters etc. If yes, please specify e.g. OPT009 - Glaucoma Foundation Module at Cardiff University

To what extent would you be interested in providing enhanced optometric services for glaucoma? Select all that apply

- [ ] I have no interest in changing the scope of the eye exam beyond the traditional triad of IOP, fields and nerve examination during routine sight testing.
- [ ] I'm interested in providing a repeat measures services for suspect cases (including Goldmann tonometry, pachymetry, repeat fields, dilated stereo disc exam and anterior chamber examination).
- [ ] I'm interested in monitoring glaucoma suspects including ocular hypertension.
- [ ] I'm in interested in monitoring stable glaucoma patients (If progression is suspected these patients would have to return to their ophthalmologist for changes to treatment).
- [ ] I'd like to become involved in the medical treatment of glaucoma including independant prescribing.
- [ ] Other:

Would you consider postgraduate education an essential pre-requisite to becoming involved in a repeat measures service or for monitoring glaucoma suspects?

- ○ Yes
- ○ No

Would you consider postgraduate education an essential pre-requisite to becoming involved in monitoring stable glaucoma?

- ○ Yes
- ○ No

Would you consider postgraduate education an essential pre-requisite to optometric management of the medical treatment for patients with glaucoma?

- ○ Yes
- ○ No

Do you have any other area of interest for enhanced optometric services? Select all that apply

- ☐ Pre/post operative cataract services
- ☐ Hospital optometry positions within HSE outpatient clinics
- ☐ Expanded paediatric eye care services
- ☐ Shared care for ARMD
- ☐ Independent prescribing
- ☐ Other:

« Back Continue »

75% completed

Detecting Glaucoma in Optometric Practice

Section D: Perceived Barriers to Glaucoma Detection in Optometric Practice

How strongly do the following factors affect your ability to detect glaucoma during routine sight tests?
Please select where you fall on a scale of 1-5 where:
1 = Strongly disagree
2 = Disagree
3 = Neutral, this factor has no impact on my ability to detect glaucoma
4 = Agree
5 = Strongly agree

All information gathered is anonymous and confidential

Time

Time constraints limits my ability to carry out some tests and/or repeat tests.

	1	2	3	4	5	
Disagree	○	○	○	○	○	Agree

Finance

It's not financially viable to purchase specialist equipment and/or schedule repeat testing appointments

	1	2	3	4	5	
Disagree	○	○	○	○	○	Agree

Equipment

The equipment available where I work is inadequate for more accurate testing

1 2 3 4 5

Disagree ○ ○ ○ ○ ○ Agree

Practice management

Staffing and management issues affect my ability to perform necessary tests and/or schedule repeat testing appointments

1 2 3 4 5

Disagree ○ ○ ○ ○ ○ Agree

Patient education

Patients do not consider the eye exam an important health check and so may fail to attend for recommended follow up tests

1 2 3 4 5

Disagree ○ ○ ○ ○ ○ Agree

Clinical information

Patient's shopping around between practices leads to problems with access to previous clinical records and hampers my ability to detect change over time

1 2 3 4 5

Disagree ○ ○ ○ ○ ○ Agree

Record Keeping

Record keeping within the practice is inadequate and hampers my ability to detect change over time.

1 2 3 4 5

Disagree ○ ○ ○ ○ ○ Agree

Training/Education

I feel my training is inadequate and this hampers my ability to perform some tests and/or interpret some tests results.

1 2 3 4 5

Disagree ○ ○ ○ ○ ○ Agree

How do these barriers constrain your practice?

Feel free to elaborate on these themes, or add your own opinions, in the space below.

« Back Submit

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Appendix 2. Hard copy survey of optometrists

Detecting Glaucoma in Optometric Practice

It takes less than five minutes to complete the entire survey.
All information gathered is **anonymous and confidential.**

Section A: Demographic Information

1. In what country did you qualify as an optometrist? _____
2. In what year did you qualify as an optometrist? _____
3. Have you completed any form of clinical optometric postgraduate qualification? Certificate/Diploma/Masters etc.
   If yes, please specify e.g. OPT009 - Glaucoma Foundation Module at Cardiff University
   _____
4. What's your current mode of practice? (you can select more than one option)
   - ☐ Salaried optometrist in a 'multiple' (familiar High Street optometrists)
   - ☐ Salaried optometrist in an independent private practice
   - ☐ Self employed business owner with independent private practice
   - ☐ Locum optometrist
   - ☐ Academic
   - ☐ Franchise director
   - ☐ Other: _____
5. What county do you work in? _____
6. Does your practice provide support for continuing professional development or postgraduate education? E.g. Contributing towards fees for courses, offering paid leave to allow for course attendance etc.
   _____
7. How many optometrists are employed in the practice? (full time or part time) _____
8. How long is your appointment slot for an eye exam?
   _____
9. How much does your practice charge for a standard eye exam?
   _____
10. Is there an extra fee for supplementary testing? E.g. visual field testing, repeat pressures, photography or other imaging. If so, please elaborate.
    _____

Section B: Equipment and Examinations

All information gathered is **anonymous and confidential.**

1. Which tonometer(s) do you have in practice? (You can select more than one).
   - ☐ iCare rebound tonometer.
   - ☐ Table mounted non-contact tonometer
   - ☐ Goldmann applanation tonometer.
   - ☐ Perkins applanation tonometer.
   - ☐ Pulsair handheld tonometer
   - ☐ Schiotz tonometer
   - ☐ Tonopen
   - ☐ Other: _____

2. If you have more than one tonometer, how often would you use each? E.g. I use iCare rebound tonometer for routine tests (90% of the time), I have GAT but use it about 10% of the time.

   _____

3. Which technique is your first choice for routine fundus examination?
   - ☐ Direct ophthalmoscopy
   - ☐ Binocular indirect ophthalmoscopy using a slit lamp and Volk lens
   - ☐ BIO using a headset and condensing lens
   - ☐ Other: _____

4. Do you have an automated perimeter? If so please specify the make e.g. Henson 8000

   _____

5. How competent do you feel using a Volk lens for binocular indirect ophthalmoscopy (BIO)? Select on a scale of 1-5 where 1 means you are unable to use a Volk lens and 5 means you are very competent using a Volk lens (you can get a focused, steady view and can easily interpret the image).

	1	2	3	4	5	
I am unable to use a Volk lens						Very competent

6. Do you have access to any of the following specialist equipment in your practice?
   - ☐ Digital fundus photography
   - ☐ Digital slit lamp camera
   - ☐ Optical coherence tomography (OCT)
   - ☐ GDx (scanning laser polarimetry)
   - ☐ Goniscopy lens
   - ☐ Ultrasound pachymeter
   - ☐ Pentacam
   - ☐ Other: _____

7. Do you carry out tonometry yourself or does another member of staff do this?
   - ☐ I carry out tonometry myself
   - ☐ Tonometry readings are usually taken by non-professional/ancillary staff.

Section C: Interest and attitudes towards enhanced scope optometry

All information gathered is **anonymous and confidential.**

1. To what extent would you be interested in providing enhanced optometric services for glaucoma? Select all that apply

   - ☐ I have no interest in changing the scope of the traditional eye exam.
   - ☐ I'm interested in providing a repeat measures services for suspect cases (including Goldmann tonometry, pachymetry, repeat fields, dilated stereo disc exam and anterior chamber exam).
   - ☐ I'm interested in monitoring glaucoma suspects including ocular hypertension.
   - ☐ I'm in interested in monitoring stable glaucoma patients, if progression is suspected these patients would have to return to their ophthalmologist for changes to treatment.
   - ☐ I'm interested in managing the medical treatment of glaucoma, including independent prescribing.
   - ☐ Other:

2. For enhanced optometric services to be financially viable, how much would you consider appropriate to charge (per appointment) for each of the following:

Repeat measures appointment	Monitoring glau. suspects & OHT	Co-managing stable cases	Medical treatment of glaucoma
€	€	€	€

3. Would you consider postgraduate education an essential pre-requisite to becoming involved in a repeat measures service or for monitoring glaucoma suspects?
   ☐ Yes ☐ No

4. Would you consider postgraduate education an essential pre-requisite to becoming involved in monitoring stable glaucoma?
   ☐ Yes ☐ No

5. Would you consider postgraduate education an essential pre-requisite to optometric management of the medical treatment for patients with glaucoma?
   ☐ Yes ☐ No

6. Do you have any other area of interest for enhanced optometric services? Select all that apply
   - ☐ Pre/post operative cataract services
   - ☐ Hospital optometry positions within HSE outpatient clinics
   - ☐ Shared care for ARMD
   - ☐ Shared care for diabetic retinopathy
   - ☐ Independent prescribing
   - ☐ Expanded pediatric services
   - ☐ Other:

7. Should the undergraduate degree programme evolve to prepare graduates to provide the following services?
   - ☐ Monitoring of glaucoma suspects and OHT
   - ☐ Monitoring of stable glaucoma patients
   - ☐ Therapeutic services/independent prescribing

Section D: Perceived Barriers to Glaucoma Detection in Optometric Practice

All information gathered is **anonymous and confidential.**

How strongly do the following factors affect your ability to detect glaucoma during routine sight tests?
Please select where you fall on a scale of 1-5 where:
1 = Strongly disagree
2 = Disagree
3 = Neutral, this factor has no impact on my ability to detect glaucoma
4 = Agree
5 = Strongly agree

		Disagree		Neutral	Agree	
Barrier		1	2	3	4	5
1	Time constraints limit my ability to carry out some tests and/or repeat tests.					
2	It's not financially viable to purchase specialist equipment and/or schedule repeat testing appointments					
3	The equipment available where I work is inadequate; this limits the accuracy of my glaucoma exam.					
4	Patients do not consider the eye exam an important health check and so may fail to attend for recommended follow up tests					
5	Some patients are unwilling to pay an extra fee for supplementary tests that may aid detection of glaucoma. These tests cannot feasibly be offered during the routine exam.					
6	Practice staffing and management issues affect my ability to perform necessary tests and/or schedule repeat testing appointments					
7	Clinical information issues: Patients shopping around between practices leads to problems with access to previous clinical records and hampers my ability to detect change over time					
8	Record keeping within the practice is inadequate and hampers my ability to detect change over time.					
9	I feel I need extra training on some examination techniques and/or interpretation of some tests results. E.g. new technologies such as OCT.					
10	Training on glaucoma detection is not available or accessible to me.					

How do these barriers constrain your practice?
Feel free to elaborate on these themes, or add your own opinions, in the space below.

Appendix 3. Leaflet distributed to optometrists to recruit referrals

nationaloptometrycentre
An Lárionad Náisiúnta Radharcmhastóireachta

DIT OPTOMETRY

Glaucoma Referral Refinement Scheme

Glaucoma prevalence in Ireland is increasing as our population ages and life expectancy increases. A new referral scheme for glaucoma suspects has launched from the National Optometry Centre (NOC), in DIT. **It is anticipated that this scheme will be the first step towards expanding the role of optometrists in the care of glaucoma patients.** As optometrists we are well placed to meet the rising demands for eye care services, outside the hospital, within our communities.

Why is Referral Refinement necessary?

Optometrists initiate most referrals to secondary eyecare for glaucoma suspects.

- Research from the UK has consistently shown that referral refinement schemes reduce hospital referrals by 40%.
- Glaucoma is the most significant contributor to hospital waiting lists.
- The ageing population will create further demands on an already overburdened ophthalmology service.

Who is running this pilot scheme?

Optometrist, Catriona Barrett, is working with Dr James Loughman and Prof. Colm O'Brien to complete a research evaluation of the economic, social and patient care outcomes of glaucoma community care over a two year period.

What will the scheme provide?

The glaucoma assessment will include; binocular indirect ophthalmoscopy, Goldmann applanation tonometry, ultrasound pachymetry and visual field testing using the Humphrey Visual Field Analyzer. Other equipment available in the NOC, including GDx and OCT, will be used as required.

Patients referred into the scheme will be directed along one of three pathways.

- Discharge back to referring primary care optometrist.
- Routine monitoring at the NOC (e.g. where progression analysis using the Humphrey field analyser may be indicated) and direct back to primary care optometrist for other eyecare services (e.g. dispensing, refraction, contact lenses etc.).
- Referral to Mater or Eye and Ear hospital.

In all pathways, the primary care optometrist will receive a letter including the test results and explaining the management decision

Refraction or Spectacle Dispensing Services will <u>not</u> be provided to referred patients.

The project is running with supervision from Prof. Colm O'Brien, Consultant Ophthalmologist, Mater hospital, Dublin, who will oversee all management decisions.

What will the scheme achieve?

The expected achievements of the scheme can be summarised under two broad categories:

(1) Patient Care Outcomes

- Reduced glaucoma referrals to hospital
- Reduced waiting times between optometric referral and glaucoma assessment.
- Reduced hospital waiting lists.
- Cost benefits to patients and the HSE.
- Increased patient satisfaction.

(2) Profession Development Outcomes

- New referral pathway for glaucoma suspects established.
- Future training and accreditation of community optometrists to implement Referral Refinement nationally.
- Future scheme expansion to include optometric monitoring of stable suspects and management of stable glaucoma .

Referral Process

Please fax or post a referral letter to the NOC indicating referral to the glaucoma clinic. The patient will be contacted and an appointment made. It is important you include correct contact details for the patient and the patient is aware we will call them within a short timeframe. As patients will be dilated, they will be advised against driving.

Glaucoma Clinic,
The National Optometry Centre,
Dublin Institute of Technology,
Kevin St,
Dublin 8.

Ph: 01 4024900
Fax: 01 4024915

Any queries?

You can contact James Loughman or Catriona Barrett with any queries.

Phone: 01 4022841/4024749

Email: james.loughman@dit.ie
mscatrionabarrett@yahoo.ie

Enhanced primary eyecare responsibilities for optometrists cannot be achieved without the commitment and support of the profession. We invite you to support this scheme and see the evolution of a new primary healthcare focus for optometry.

Appendix 4. Recruitment article in 'Radharc', the periodical journal of the Association of Optometrists Ireland.

Glaucoma Shared Care for Ireland - A Referral Refinement Pilot Scheme.

Glaucoma prevalence is high in Ireland (Coffey *et al.* 1993), and increases significantly with age. Ireland's population is aging, and life expectancy is increasing. Over the past 25 years the proportion of the population over 65 increased from 15 per cent in 2004 to 16 per cent in 2009, an increase of approximately 100,000 people (most of whom require eyecare services for cataract, AMD, glaucoma etc.). It is projected that by 2034, over 23 per cent of the population will be aged over 65, and will be served by a shrinking proportion of working age adults to support them. By 2050, it is estimated that:

- Glaucoma cases will double
- AMD cases will double
- Cataract cases will increase 140%
- Diabetic retinopathy will increase 46%
- Other disease set to significantly rise

Glaucoma is the second leading cause of blindness in Ireland (12% versus 5% diabetes - Kelliher et al 2006). Blindness and visual impairment carry a substantial human and financial cost. Sight loss impacts greatly on the individual and can significantly affect independence and opportunity. Sight loss leading to visual impairment or blindness is a major cost to the public purse, through increased dependency on the HSE, social

services, benefits payments, and the impact on families. Early glaucoma detection can significantly alter the likelihood of progression to visual impairment and blindness. It also lessens the burden on other HSE resources, for example, early and effective disease management can lessen the incidence of personal accidents such as falls, can reduce the incidence of depression and can improve general physical and mental well-being. The gains from tackling visual impairment early and effectively in preventing downstream dependency will therefore be substantial, both in societal and economic terms. This can only be achieved through eyecare service reform.

Increasing life expectancy, an aging population, and ever improving detection and treatment strategies are combining to stretch current eyecare resources beyond their limits. Even on best predictions, over the next twenty years the ophthalmology workforce is going to remain limited, whilst at the same time taking on ever-increasing possibilities for treatment and additional burdens. The current system is not cost effective, and is simply unsuited to present and future eyecare needs. Without a radical overhaul, access to and quality of patient care will be compromised. Hospital ophthalmology departments are already struggling to manage current demands. Waiting lists continue to lengthen, and diagnosis and initiation of treatment is consequently delayed. Without a systems overhaul, hospitals will be even less able to cope with the inevitable increase in ophthalmology referrals. Given the current economic landscape, alternative solutions need to be explored, ones that will provide a less costly but more efficient service without compromising patient care.

Community optometry has the capacity to expand on its current role at the forefront of primary eyecare. We, as optometrists, can do even more to relieve pressure on hospital

eye services, saving money for the Health Service Executive (HSE), preventing downstream expenditure through blindness prevention, while at the same time, contributing to the overall enhancement of the scope and quality of patient care.

Referral to secondary eyecare for glaucoma suspects is initiated principally by optometrists. Indeed, optometrists are legally obliged to refer such cases (e.g. where IOP is elevated, or optic disc asymmetry exists). A significant proportion of these referrals are subsequently found to be false positives, i.e. the patient does not actually have glaucoma. Research in the UK has consistently shown that about 40% of glaucoma referrals do not have glaucoma. There are a number of explanatory factors that contribute to this high false positive rate, and include the low prevalence of undetected glaucoma within the community, as well as the low specificity of some of the diagnostic tests for glaucoma. For example, if we estimate that 1% of the population over the age of 40 have residual, undiagnosed glaucoma, and assume a very high specificity of diagnostic tests of 99%, and that optometrists detect all cases of glaucoma, then 50% of referrals will be false positives.

Precision rate is an issue in all areas of medicine. Improving the specificity of our investigative techniques is one way to tackle the problem of false positives. Most community optometrists will not have access to pachymetry or Goldmann applanation tonometry. Some will not have a visual field screener. False referrals contribute to long waiting lists (typically a patient will make two or three visits to the hospital eye department before being discharged), incur financial costs and cause unnecessary anxiety to the patient. Referral refinement is the first step we can take to improve the current care pathway for glaucoma suspects.

Referral refinement schemes have worked well in the UK, with some schemes reporting a 40% reduction in new glaucoma referrals to hospital. Academic research is needed to assess the feasibility of similar schemes in Ireland. The National Optometry Centre, at Dublin Institute of Technology, will host the first such scheme to be implemented in Ireland. Optometrist, Caitriona Barrett, will work with Dr. James Loughman and Prof. Colm O' Brien to complete a research masters in glaucoma shared care over a two year period. Following a period of specialist training at the Mater hospital, a pilot scheme will be launched, inviting optometrists to send their glaucoma referrals to the National Optometry Centre, where Caitriona will have access to the specialised equipment necessary to refine glaucoma referrals. A second scheme will launch in Waterford to service referrals in the southeast shortly thereafter. The scheme will seek to:

1. Reduce patient waiting times for initial assessment
2. Reduce glaucoma referrals to hospital
3. Improve the clinical information accompanying referral
4. Evaluate any cost-benefit generated
5. Analyse patient satisfaction

The successful implementation of the proposed scheme will result in a new referral pathway for glaucoma suspects. This pathway will include accredited community optometrists, who can refine primary optometric and GP referrals prior to engagement with hospital services. Optometry is a highly skilled and highly trained eyecare profession. We, as optometrists, are best placed to meet the rising demands for eyecare

services, outside of the hospital, within the community. It is anticipated that this pilot scheme will expand into a variety of future initiatives.

- DIT/AOI run continuous education events, in particular, workshops focused on glaucoma investigative techniques.
- Enhanced undergraduate optometry training in glaucoma management.
- DIT awarded Postgraduate Certificate in Glaucoma Management.
- Adoption of a glaucoma specific code of practice (e.g. based on NICE guidelines).

Caitriona will soon be inviting optometrists to participate by referring glaucoma suspects into this scheme (patients with any suspicious finding of relevance to glaucoma such as elevated IOP, visual field loss or optic nerve defect). The success of the initiative will be critically dependent on the support and involvement of optometrists. It is important to note that any patient referred into this scheme will remain under the primary care of the referring optometrist. No services, other than glaucoma assessment, will be provided to these patients at the National Optometry Centre. We hope that you will give your support to this project and look forward to publishing the outcome of the project following collection of clinical data.

This project is facilitated by support from the Association of Optometrists Ireland, and the staff at the National Optometry Centre.

Appendix 5. GRRMS patient consent form

CONSENT TO PARTICIPATE IN RESEARCH

Name of Study Subject: _____

WHY ARE WE ASKING YOU ABOUT THIS STUDY?

You are being invited to participate in this research study because your optometrist has identified clinical features leading to a suspicion of glaucoma.

DO I HAVE TO BE IN THIS STUDY?

You can decide whether to take part in this study or not. You are free to say yes or no.

WHAT WILL HAPPEN IF I TAKE PART IN THE STUDY?

- Findings from your eye examination will be recorded and analyzed as part of a data set with findings from other participants. Your details will be completely anonymous.
- You will be asked to complete a satisfaction questionnaire regarding your experience here today.

WHY IS THIS STUDY BEING DONE?

We are researching the economic, social, and patient care outcomes of examining glaucoma suspects outside the hospital.

CONSENT TO PARTICIPATE IN THE STUDY

By signing my name below, I confirm the following:

- I have read (or had read to me) this entire consent document. All of my questions have been answered to my satisfaction.
- The study's purpose and procedures have been explained to me.
- I agree to let the study team use and share the information gathered for this study.
- I voluntarily agree to participate in this research study.

Subject's Name *please print*	Subject's Signature	Date
Name of person taking consent	Signature of person taking consent	Date

Appendix 6. Recall letter template

nationaloptometrycentre
An Lárionad Náisiúnta Radharcmhastóireachta

<<Patient.First Name>> <<Patient.Surname>>
<<Patient.Flat Number>><<Patient.Building>><<Patient.Street Number>><<Patient.Address Line 1>>
<<Patient.Address Line 2>>
<<Patient.Address Line 3>>
<<Patient.Address Line 4>>
<<Patient.County>>

Dear <<Patient.Title>> <<Patient.Surname>>,

Dear <<Patient.First Name>>,

According to our records, it is time for your follow up glaucoma screening exam.

During the exam, eye drops are used to dilate the pupils of the eyes. The action of these drops usually lasts for 4-6 hours. During this time, patients are sensitive to daylight and some experience mild blurring of their vision. For this reason, we advise you not to drive for 6 hours following the exam. It would be useful to bring along sunglasses also, to reduce glare in daylight.

Please phone the practice to make an appointment for the glaucoma clinic.
You can reach us on 01 402 4900 to schedule your appointment, or for more information.

Sincerely,

FAOI

Catriona Barrett BSc FAOI
Clinical Optometrist

Appendix 7. Termination leaflet

Association of Optometrists Ireland

nationaloptometrycentre
An Lárionad Náisiúnta Radharcmhastóireachta

DIT OPTOMETRY

Glaucoma Referral Refinement Scheme.

A clinic for glaucoma suspects has been running in the National Optometry Centre at DIT since November 2011. This project was set up to facilitate research into the area of glaucoma shared care in Ireland. To date 225 patients have been seen within the scheme. We are now looking to analyse the data collected from this pilot study and to disseminate the results of the project. As the data collection element is now almost complete, we have decided to close the scheme to new referrals. From Friday, January 10th we will not be accepting new patients into the scheme. The response from optometrists in supporting the project has been greatly appreciated. There are some patients who are due recall appointments, all of these will be looked after over the next year and the referring optometrist will receive a report on the appointment as usual. Prof. Colm O'Brien has generously given of his time to facilitate the research and has supervised the clinic over the past 2 years by personally reviewing each patient file through a digital virtual clinic. It is our hope that this research can form part of an evidence base to support future investment in shared care systems for eyecare in Ireland. Sincere thanks to all who contributed to the scheme.

Preliminary analysis of referral procedures is aligning well with glaucoma referral refinement research in the UK.

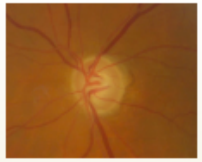
- We have reduced referrals to secondary care by 71%.
- 23% of referrals have been discharged back to their own optometrist.
- 48% of patients have been asked on their first refinement visit to return to the NOC for monitoring. Over the next year we will analyse the outcomes of these follow up visits

Any queries?

You can contact James Loughman or Catriona Barrett with queries.

Email: james.loughman@dit.ie

mscatrionabarrett@yahoo.ie



An Analysis of Optometry Referrals to Ophthalmology for Glaucoma Suspects.

POSTER 5567 - A0176
PRESENTATION 507
ARVO 2014

Catriona Barrett[1], Prof . Colm O' Brien[2], Prof. James Loughman[1]
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Introduction

The glaucoma care pathway in Ireland comprises an optometrist-led glaucoma screening service, with referrals channeled into ophthalmology services. Recent Irish findings indicate a 31% false positive referral rate in optometric referrals of suspect glaucoma. This aligns with research from the UK which shows a false positive rate of 40%[1]. Unnecessary referrals to secondary care services exacerbates the problem of escalating waiting lists in an under-resourced public health system.
This study was designed to assess the quality of glaucoma referrals from optometry as a means to understand and improve current practice in the context of a critical need to enhance the public health optometry role.

Study Aims

- To evaluate optometrists' referrals for glaucoma
- To provide recommendations for improving the accuracy of referrals for glaucoma suspects.

Kev Glaucoma Facts

- Glaucoma prevalence is roughly 2% for primary open angle and normal tension glaucoma in the Irish population over 50 years.[2]
- Glaucoma is the second leading cause of blind registration in Ireland.[3]
- At least 50% of glaucoma sufferers in the industrial world are undiagnosed.[4]
- 96% of new referrals to glaucoma clinics are initiated by optometrists.[5]

Methods

This study involved an analysis of glaucoma referrals from all 59 optometrists participating in a joint optometry/ophthalmology glaucoma referral refinement scheme at the National Optometry Centre, Dublin. Optometrists within the greater Dublin area were recruited into the scheme through postal and email leafleting. All the patients included in the study gave written consent for their clinical information to be used for research purposes.

Each of the 181 referrals included was assessed in terms of the :

I. screening techniques used,
II. clinical findings provided
III. comparison with clinical findings in the glaucoma refinement clinic.

Statistical Analysis

Each referral was analysed manually. The clinical information included was recorded in SPSS.
A simple frequency analysis was used to identify the screening techniques used and the reported clinical findings.
One sample t-test, paired samples t-test, and Bland Altman limits of agreement were used to test agreement between the referring optometrists clinical findings and the findings within the glaucoma clinic.

Results

The following clinical findings were most frequently reported among the 181 referrals assessed.

Non Contact Tonometry (NCT): 98%

- 98% of referrals included a tonometry reading.
- Only 5% of intraocular pressure (IOP) measures were taken using Goldmann applanation tonometry (GAT).
- Central corneal thickness (CCT) measures were reported in only three cases.

Optic disc evaluation: 87%

- The optic disc was described in 87% of cases.
- 61% gave a CD ratio.
- Only one letter included a value for disc height.
- The method of disc evaluation was generally not provided. Current convention among the majority of Irish optometrists is to use direct ophthalmoscopy.

Perimetry: 70%

- The referring optometrist had assessed the visual field in 70% of cases.
- Only 39% included a copy of the visual field plot.

Risk factor profile for glaucoma: 62%

- Some reference to the patient's risk factor profile for glaucoma was made in 62% of referrals.

IOP data

	Mean	Standard Dev.
NCT	20.2 mmHg	± 5.8
GAT	18.9 mmHg	± 4.7
CCT	563.8 µm	± 55.1
Corrected GAT	17.6 mmHg	± 4.9

	Pearson Correlation		Paired T test	
	R	P	T	P
NCT : GAT	0.72	0.00	4.33	0.00
NCT : C.GAT	0.45	0.00	6.79	0.00

The Bland Altman limits of agreement for NCT and GAT were 1.21±7.85mmHg, while for NCT and corrected GAT, the limits were wider at 2.69±11.06mmHg (Figure 1).

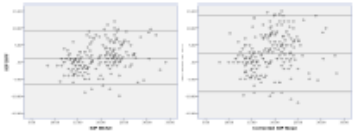

Figure 1. Bland Altman plots for referring optometrist's NCT reading vs. GAT in clinic, and referring optometrist's NCT vs. CCT corrected GAT in clinic.

Optic Disc Data

	Mean		Standard Dev.	
Referral CD ratio	0.52		± 0.16	
Clinic CD ratio	0.51		± 0.16	
Disc height	1.86 mm		± 0.24	
	Pearson Correlation		Paired T Test	
	R	P	T	P
R.CDR : C.CDR	0.80	0.000	0.879	0.38

The Bland Altman limits of agreement for referring optometrists CD ratio (CDR) versus the ophthalmology clinic recorded CDR was 0.01±0.20. (Figure 2).

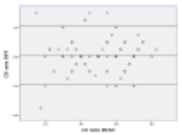

Figure 2. Bland Altman plot for referring optometrist's CDR vs. clinic CDR

Discussion

The optometric profession plays a fundamental role in glaucoma detection. 96% of new referrals to glaucoma clinics are initiated by optometrists[5]. Previous groups have looked at the diagnostic accuracy of referrals and shown that the highest overall detection rates, of glaucoma and glaucoma suspects, were among those optometrists who combined tonometry with either a visual field assessment, ophthalmoscopy or both[5]. Irish optometrists are following this convention with the majority of referrals including all three core clinical findings. The next step to improving referral accuracy is to improve the sensitivity and specificity of the examination techniques used.

Conclusions

Glaucoma referrals show a pattern of reliance on NCT and isolated CD ratios, which provide measures that are outside clinically acceptable limits of agreement with gold standard techniques.
To improve the accuracy of glaucoma referrals, optometrists should adopt the use of pachymetry and disc height measurement with indirect ophthalmoscopy and dilated examination.

Acknowledgments

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For further information please contact catriona.barrett@dit.ie or james.loughman@dit.ie

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LIST OF PUBLICATIONS

Barrett, C**.,** O'Brien, C., Butler, J. S. and Loughman, J. (2017), Barriers to glaucoma case finding as perceived by optometrists in Ireland. Clinical and Experimental Optometry. doi: 10.1111/cxo.12573

Barrett, C**.,** O'Brien, C., and Loughman, J. (In press), Glaucoma referral refinement in Ireland: Managing the sensitivity-specificity paradox in optometric practice. Ophthalmic and Physiological Optics

Barrett, C**.**, and Loughman, J. (2017) Expanding the traditional role of optometry: current practice patterns and attitudes to enhanced glaucoma services in Ireland. Manuscript submitted for publication.

Conference Presentations: Published Abstracts

Oral presentation: 'Outcomes from a Dublin based Glaucoma Referral Refinement Clinic.' The European Academy of Optics and Optometry Annual Conference. Barcelona, Spain, May 2017.

Oral presentation: 'To investigate the nature of optometric clinical practice for glaucoma detection in R.O. I.' The British Congress of Optometry and Vision Science. Ulster University, Coleraine, Northern Ireland, September 2016

Oral presentation: 'To investigate the viability of glaucoma referral refinement in an Irish context.' The European Academy of Optics and Optometry Annual Conference. Warsaw, Poland, May 2014. Awarded a conference prize for 'Outstanding Contribution to Research'.

Poster Presentation: ‘An Analysis of Optometry Referrals to Ophthalmology for Glaucoma Suspects.’ The Association for Research in Vision and Ophthalmology Annual Meeting, Orlando, Florida, USA, May 2014 (refer to Appendix 8 for the poster presented)

Co-chaired discussion forum: ‘Integrating Optometry into Primary Care’ The European Academy of Optics and Optometry Annual Conference. Dublin, April 2012.