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Glaucoma Referral Refinement in Ireland: Managing the Sensitivity-Specificity Paradox in Optometric Practice

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Glaucoma referral refinement in Ireland: managing the sensitivity-specificity paradox in optometric practice

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Abstract

Purpose: Glaucoma referral refinement (GRR) has proven a successful demand management strategy for glaucoma suspect cases in the United Kingdom (UK). A GRR clinic was established in Dublin, Ireland to investigate the clinical viability of this pathway outside the UK's National Health Service (NHS) structures, and away from the influence of National Institute for Clinical Excellence (NICE) guidance.

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

Results: Two hundred and twenty-five glaucoma suspect patients were seen in the scheme. After their first GRR visit, 28% were discharged back to their own optometrist, 42% were monitored in the GRR clinic, and 30% 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. Sixteen percent 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 likely reflects the benefits of pre-scheme apprenticeship style training and ongoing hospital clinic participation by the scheme optometrist. 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.

Introduction

Optometrists play a vital role in the detection of glaucoma, the world's leading cause of irreversible blindness.¹ Primary open angle glaucoma (POAG), the most common glaucoma sub-type,² is insidious, progressive and irreversible, presenting a significant public health challenge.² As population screening for POAG detection is neither cost effective³ nor viable,⁴ it is primarily detected through opportunistic case-finding during routine eye examinations. Evidence from the UK⁵ has shown that the vast majority of glaucoma and ocular hypertension cases are detected through opportunistic case-finding by community-based optometrists.

Glaucoma prevalence increases exponentially with increasing age.⁶ Continued population growth coupled with our increasing age profile⁷ are 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 76.0 million by 2020 and almost double to 111.8 million by 2040.⁸

Advances in diagnostic and screening tools, such as automated perimetry, and changes in professional guidance⁹ 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 National Institute for Health and Care Excellence (NICE) guidelines for glaucoma, 'Glaucoma: Diagnosis and management of chronic open angle glaucoma and ocular hypertension' were published in the UK.¹⁰ Although the scope of these guidelines did not include case-finding or screening for glaucoma, 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 21 mmHg, regardless of any other clinical findings.¹¹ This led to a rise in glaucoma suspect referrals to ophthalmology and a corresponding fall in the positive predictive value (PPV) of the referrals.¹²

Glaucoma referral refinement (GRR) schemes, which had emerged in the early 2000s as a potential solution to the already high rate of false positive glaucoma referrals,¹³ proliferated in the UK after 2009,^{14–17} 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 PPV of optometric referrals to ophthalmology services, which has been shown to be both clinically¹⁸ and financially^{16,19} 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. 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,²⁰ 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 primary care services, 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 is estimated at 1.88%, with prevalence rising to 3.2% in those aged over 70 years.²¹ At this prevalence level, even tests with relatively high sensitivity and specificity will yield low PPVs.^{22,23} 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.^{22,23}

The need for demand management within Irish ophthalmology services is clear; figures for March 2017, show that 34 675 individuals in the Republic of Ireland (total population 2016: 4.76 million²⁴) were on a waiting list for a first appointment at a consultant-led ophthalmology outpatient clinic, with 9309 individuals having spent 12 months or more on the waiting list.²⁵ 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 Australia²⁶ and the US.²⁷ Worldwide shortages of ophthalmologists²⁸ are exacerbating this mismatch between capacity and demand.²⁹ 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.

Methods

The project began as a collaboration between researchers and clinicians at the Dublin Institute of Technology (DIT) and the Mater Misericordiae University Hospital (MMUH) Dublin. It was agreed that a GRR scheme could be of benefit to the ophthalmology department and the National Optometry Centre (NOC) at DIT agreed to host the scheme. The project was established as part of a PhD project examining glaucoma case finding by optometrists in Ireland. The research student, being an optometrist, became the scheme's specialist optometrist in glaucoma (SOG). A 2 month period of pre-scheme training commenced in October 2011. This consisted of at home self-study and apprenticeship-style training through participation in consultant led hospital glaucoma clinics. This apprenticeship style training began with observation of senior medical staff and progressed towards independent examination of patients and case presentation by the SOG to the supervising consultant. This process of supervised practice was key to the development safe decision-making skills. There was no formal evaluation or assessment of the performance of the SOG before they began examining patients under the glaucoma referral refinement and monitoring service (GRRMS). The scheme began when the supervising ophthalmologist considered the SOG was ready, which was agreed after 24 h of training across six clinic sessions. 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. The SOG 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 Association of Optometrists Ireland (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. This study sought to investigate the clinical viability of GRR away from the influence of NICE guidance and the subsequent guidance from professional representative bodies in the UK,³⁰ therefore there was

no specific guidance issued to community optometrists as to which clinical findings warranted referral to the GRRMS.

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 NICE¹⁰ and European Glaucoma Society (EGS) guidelines³¹ were referred to in the process of drafting the examination protocol. 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 agreed GRRMS exam included the following assessments:

1. Case history.
2. Anterior chamber slit lamp examination, including Redmond Smith and van Herick's techniques.
3. Goldmann tonometry.
4. Ultrasound pachymetry.
5. Visual field test (Humphrey Visual Field Analyser SITA-Fast 24-2).
6. Dilated, slit lamp indirect ophthalmoscopy exam.
7. 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, intraocular pressure (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.*¹⁴ and Kotecha, *et al.*³² following the patient's GRR exam. 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;
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 cup-disc ratio (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 software package for social sciences, IBM SPSS Statistics (www.ibm.com). A frequency analysis was run to determine the management outcomes within the scheme. One-way Welch's analysis of variance (ANOVA), Kruskal-Wallis *H* Test and Cohen's kappa (κ) were used to further analyse the results.

Results

Two hundred and twenty-five patients were recruited into the scheme. The management outcomes are outlined in Table 1.

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 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, two of these 80 had comorbidities that were detected during the GRR exam, both choroidal naevi. A further six patients were confirmed as non-glaucomatous during their GRRMS exam though comorbidities were detected which were deemed to require referral. Of these six, two were ocular naevi and the remainder ranged in severity from a routine referral for medical management of severe blepharitis to a neuro-ophthalmology referral for suspect neurological field loss.

Table 1. Management outcomes from the Dublin GRR clinic. Percentages have been rounded to the nearest whole number resulting in some percentage totals differing from 100%

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

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

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). In cases where the referral indicated bilateral suspicious findings, the more suspect eye was chosen as the study eye, or, if the clinical findings were equivalent in each eye, the study eye was randomly selected through a coin toss.

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. However, these 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, $F(2, 221) = 1.382, p = 0.25$ (see Table 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 $F(2, 37.22) = 129.21, p < 0.0001$ (see Table 2). IOP increased from the discharge (*n* = 66, *M* = 16.26 mmHg, S.D. = 3.13); to monitor (*n* = 95, *M* = 18.32 mmHg, S.D. = 3.47); to refer (*n* = 63, *M* = 22.83 mmHg, S.D. = 5.22) management groups, in that order (see Figure 1b and Table 2). Games-Howell *post hoc* analysis revealed that the mean increase from the discharge to monitor groups (2.06 mmHg, 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, S.D. = 2.2); (monitor *n* = 16, *M* = 19.1, S.D. = 4.6); (refer *n* = 13, *M* = 20.15, S.D. = 5.2). The difference between

[†]One outlier was removed from this group.

Table 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

| | Discharge (<i>n</i> = 66) | Monitor (<i>n</i> = 95) [†] | Refer (<i>n</i> = 64) | <i>p</i> value (ANOVA) |
|---------------------|-----------------------------------|---------------------------------------|-----------------------------------|------------------------|
| CCT Mean (S.D.) | 570 μm (± 39.63) | 569 μm (± 38.41) | 560 μm (± 40.06) | 0.25 |
| IOP Mean (S.D.) | 16.26 mmHg (± 3.13) | 18.32 mmHg (± 3.47) | 22.83 mmHg (± 5.22) | <0.0001 |
| vCDR Mean (S.D.) | 0.38 (± 0.17) | 0.48 (± 0.17) | 0.54 (± 0.18) | <0.0001 |

*Welch's ANOVA.

[†]One outlier was removed from the CCT data, *n* for the CCT monitoring cohort was 94.

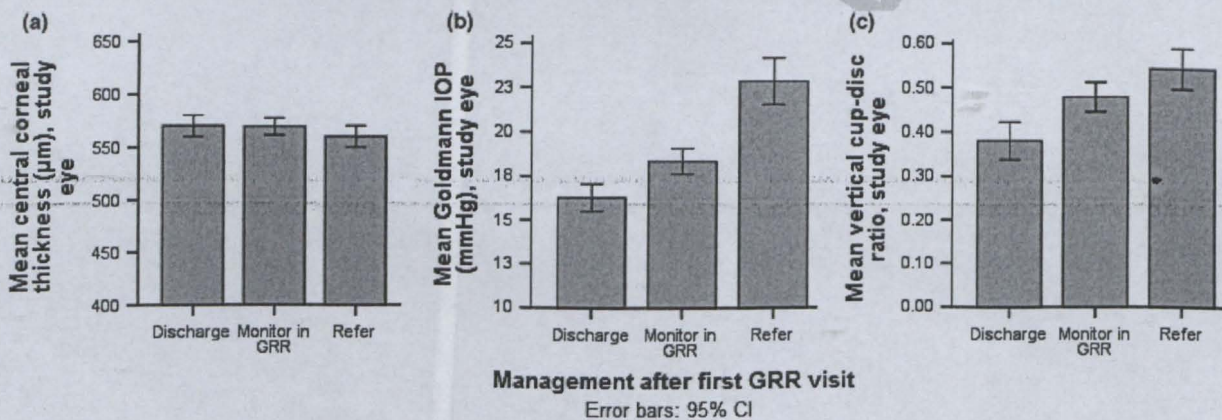


Figure 1. Mean values for central corneal thickness, intraocular pressure (IOP), and vertical cup-disc ratio (vCDR) in each first visit, refinement clinic management group (discharge *n* = 66, monitor *n* = 95, refer *n* = 64).

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, $F(2, 222) = 14.97$, $p < 0.0001$ (see Table 2). vCDR increased from the discharge ($n = 66$, $M = 0.38$, S.D. = 0.17); to monitor ($n = 95$, $M = 0.48$, S.D. = 0.17); to refer ($n = 64$, $M = 0.54$, S.D. = 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 management decision (discharge $n = 36$, $M = 0.50$, S.D. = 0.14); (monitor $n = 16$, $M = 0.45$, S.D. = 0.19); (refer $n = 13$, $M = 0.49$, S.D. = 0.06). The difference between mean second visit vCDR values in the three management groups was not found to be statistically significant, $F(2, 23.70) = 0.50$, $p = 0.62$.

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 medians 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 ($p = 1.00$).

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 PSD 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 kappa (κ) was used to determine if there was agreement between the scheme optometrist and ophthalmologist. There was substantial agreement,³³ with $\kappa \geq 0.63$ for all patient visits (Table 3).

The cross tabulation (Table 4) shows where the disagreements occurred.

Table 4 shows that there were 35 decisions where the scheme's reference standard, a glaucoma specialist consultant ophthalmic surgeon, had more conservative clinical management than the SOG. 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, seven were eventually discharged from the scheme, seven 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 seven patients: two were started on treatment, four were monitored in ophthalmology, and one was discharged. The two 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 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 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 further expanded to include optical coherence tomography (OCT) and gonioscopy so that the GRRMS could serve to provide best practice diagnostic testing for glaucoma suspects outside of the ophthalmology outpatient clinic, a model that has worked well elsewhere.²⁶

Of the eight co-morbidities detected in the scheme, four 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, 'Glaucoma: Diagnosis and management of chronic open angle glaucoma and ocular hypertension' were published,¹⁶ an important finding in a jurisdiction that has no specific clinical guidelines relating to glaucoma diagnosis or case-finding. Sparrow³⁴ 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.²² This effect is likely being compounded by a tendency for optometrists to preference

Table 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 | $p < 0.0001$ | $p < 0.0001$ | $p = 0.001$ | $p < 0.0001$ |
| Rate of agreement | 76.0% | 90.8% | 81.8% | 79.4% |

Table 4. Cross tabulation showing the optometrist's preliminary management decision (rows), and the final management decided by glaucoma consultant (columns)

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

Agreement is shaded in grey. Underlined figures represent occasions where the ophthalmologist was more conservative than the scheme optometrist.

Table 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 |

sensitivity over specificity in their diagnostic testing,³⁵ a practice pattern that could be considered pragmatic, given that optometrists are required to detect pathology and are at risk of litigation^{36,37} 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 Ghosh³⁸ 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.³⁹ showed that short-term didactic teaching programs had most effect on false negative rates in glaucoma referrals. This indicates that training may have a beneficial impact on the prevalence of undetected glaucoma, but is unlikely to significantly reduce false positives. GRR provided 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.^{23,40}

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.^{22,39} Accurate diagnosis of early

glaucoma often requires careful monitoring until progression, the hallmark of glaucoma, can be identified or ruled out.⁴¹ Our results have highlighted the existence of a monitoring need in suspect glaucoma (Table 1), and careful consideration should be given to how this cohort of patients can be best served.

Recent changes in the legislation governing optometric practice in Ireland, has framed scope of practice more broadly.⁴² This has created the potential for optometrists to become more involved in the diagnosis, monitoring and management of ocular pathology, as has happened in many other jurisdictions including Australia,⁴³ the UK^{44,45} and the USA.⁴⁶

There is a skills and experience gap however, in moving from a screening role to an enhanced diagnostic or management role: a recent survey about the barriers perceived by optometrists in relation to glaucoma care found a majority of Irish optometrists agreed that a lack of training limited their ability to detect glaucoma during routine eye exams.⁴⁷ 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, while 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.³⁹

The level of inter-observer agreement ($\kappa \geq 0.63$ for all patient visits, Table 3) was substantial, which likely reflects the benefits of pre-scheme apprenticeship style training and ongoing hospital clinic participation by the scheme optometrist, which ensured adequate glaucoma experience, while also facilitating communication between optometry and ophthalmology, as recommended by Lockwood, et al.¹⁸ and Trikha, et al.¹⁴ A higher level of agreement was achieved for those who were monitored ($\kappa = 0.85$ for second visit management decisions, Table 3). This aligns with the findings from Wright and Diamond⁴⁸ who observed a kappa value of 0.69 for monitoring reviews of glaucoma patients and suspects.

1 Some amount of disagreement in relation to glaucoma is
2 to be expected from the scheme. It is well recognised that
3 decision making algorithms in glaucoma are complex, and
4 that even glaucoma specialist ophthalmic consultants exhibit
5 a wide range of agreement with each other, and even
6 themselves, when diagnosing or managing the condition.⁴⁹
7 The most common area of disagreement was between the
8 discharge and monitor groups, likely due to the ambiguity
9 in these suspect cases. There was one occasion where a
10 patient was non-conservatively marked for discharge by the
11 optometrist but subsequently referred to ophthalmology by
12 the scheme's supervising ophthalmologist. Although the
13 management outcome was not available to us for this isolated
14 case, this example does highlight the advantage of
15 close inter-professional cooperation and the utility of virtual
16 clinic reviews in ensuring patient safety in the scheme.

17 Substantial agreement was achievable despite the lack of
18 predefined management protocols within the scheme. The
19 clinical measurements for IOP, vCDR and PSD showed statistically
20 significant differences between first visit management
21 groups but the observed differences just failed to
22 reach statistical significance at the second visit. It is possible
23 that a larger sample size in the second visit cohort would
24 have achieved statistical significance as the data is trending
25 in this direction. This perhaps confirms that guidelines
26 may be broadly applicable to a large cohort of patients, but
27 not appropriate in many individual cases, particularly more
28 ambiguous presentations that require monitoring. Alternatively,
29 these results could represent the historical reliance
30 on these measurements in glaucoma diagnosis. It is currently
31 understood that these markers are not sufficient to
32 characterise such a complex disease. Thus, clinical judgement
33 needs to supersede guidelines at times. In fact, the diagnostic
34 criteria for glaucoma have varied widely between studies; Wolfs, *et al.*⁵⁰
35 estimated that the overall prevalence of POAG may vary up to 12-fold
36 with different criteria and screening algorithms.

37 It is notable that 33% of those we were able to follow up
38 in ophthalmology were monitored without treatment
39 (Table 5) even when a glaucoma subspecialist recommended
40 they were referred (essentially a false positive ophthalmology
41 referral, which provides further evidence as to the difficulty
42 in finding the right sensitivity-specificity balance). This reflects
43 the gap between the sensitivity required when screening for
44 glaucoma and the specificity required when making decisions
45 regarding treatment. We believe that the GRRMS provides a way
46 to manage this sensitivity-specificity paradox, which may not be
47 achievable by other means. In fact, emphasis on false positive
48 referrals could create a culture of diminishing sensitivity, where
49 optometric glaucoma referrals are very specific, but glaucoma
50 diagnoses are missed because of reluctance to refer or inability
51 to carry out appropriate follow up investigations.
52
53

Approximately 50% of those with glaucoma in Ireland²¹
and other developed countries⁵¹ are unaware of their disease.
To reduce visual impairment and thus loss of independence
in the aging 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 dropout rate (approximately one-third
of patients in the monitoring group, see Table 1) may be a
cause for concern. However, the rate of loss to follow up
actually compares favourably with ophthalmology led,
hospital based glaucoma clinics,⁵² 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.²⁶
It has been documented that glaucoma suspects are significantly
more likely to drop out of follow up compared to those with
established glaucoma⁵³ 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.⁵⁴ This indicates that improved patient education
and emphasis on good physician-patient communication
should be a key priority for future planning.

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 rate (PPR) 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 0.78,¹⁴ a marked improvement over unrefined glaucoma referrals (0.37).¹⁸ 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. Furthermore, the scheme optometrist was involved in this project as part of their PhD research and therefore may have been more invested in the training and literature review than might be typical of most community based optometrists. 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,^{40,55} though the sample sizes in these false negative studies have also been low, leaving some uncertainty 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 for the state,^{14,17} future work should provide an economic evaluation of the scheme. The cost effectiveness of GRR schemes has been shown to vary significantly⁵⁶ 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 cost savings.

Conclusions

The GRRMS 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 18 months in some hospitals,²⁵ leaving vulnerable patients at risk of permanent sight loss. The monitoring facility in this 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.

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