AN EVALUATION OF THE EMERGENCY MACULAR ASSESSMENT CLINIC (EMAC): REFERRAL, DIAGNOSIS AND TREATMENT OUTCOMES.

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As the burden on Hospital Eye Services in the government sector continues to escalate, due to an ageing population and a shortfall in ophthalmologists' numbers, optometrists are becoming increasingly involved in diagnosis and management of patients with macular disease. Virtual clinics have been introduced as means of alleviating this burden. This thesis evaluates a virtual clinic, Emergency Macular Assessment Clinic (EMAC) at Manchester Royal Eye Hospital (MREH) by examining referral patterns to the service, management outcomes of referred macular conditions, and the impact of socioeconomic factors on these patterns. Agreement between secondary care optometrists with specialist interest (OSIs) and ophthalmologists for incoming referrals to the service was also analysed. The impact of further education and training on optometrists' confidence levels and diagnostic performance was evaluated.

In-depth analyses of referrals to EMAC over a three-month period (August to October 2019) were performed to address the aforesaid objectives. The efficacy of additional training was examined through two surveys and delivery of an interactive workshop.

Demographics of conditions referred to EMAC were mostly in line with pre-existing literature. Age-related macular degeneration (AMD) accounted for nearly half of referrals. About 94% of patients with wet AMD were treated within 2 weeks of referral and achieved visual gains comparable to current studies. EMAC OSIs and ophthalmologists had near perfect agreement in diagnosis and management of AMD and agreement of 92.7% for all other macular disorders. Health deprivation significantly impacts referral patterns and presentation onset of macular disease. Further education has a significant positive impact on optometrists' confidence levels in assessing OCT and their overall diagnostic performance.

Findings of the studies performed will help streamline the EMAC service, encourage training of more OSIs, and implementation of regular educational events for optometrists.

Keywords: virtual clinic; macula; co-management; health deprivation; education and training

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List of Abbreviations

Abbreviation	Explanation
ACORN	A Classification of Residential Neighbourhoods
AMD	Age-related Macular Degeneration
Anti-VEGF	Anti-Vascular Endothelial Growth Factor
ARC	Acute Referral Centre
AVMD	Adult-onset Vitelliform Macular Dystrophy
BRAO	Branch Retinal Artery Occlusion
BRVO	Branch Retinal Vein Occlusion
CACI	Consolidated Analysis Centres, Inc.
CAR	Cancer-Associated Retinopathy
CI	Confidence Intervals
CMO	Cystoid Macular Oedema
CNV	Choroidal Neovascularisation
CNVM	Choroidal Neovascular Membrane
COGS	Cambridge Optometry Glaucoma Scheme
CPD	Continuing Professional Development
CRVO	Central Retinal Vein Occlusion
CSMO	Clinically Significant Macular Oedema
CSR	Central Serous Retinopathy
CSW	Clinic Support Worker
DED	Diabetic Eye Disease
DESP	Diabetic Eye Screening Programme
DMO	Diabetic Macular Oedema
DR	Diabetic Retinopathy
EDAC	Enhanced Diabetic Assessment Clinic
EED	Emergency Eye Department
EMAC	Emergency Macular Assessment Clinic
ERM	Epiretinal Membrane
F2F	Face-to-Face
FAF	Fundus Autofluorescence
FFA	Fundus Fluorescein Angiogram
FP	False Positive
FTMH	Full-Thickness Macular Hole
GM	Greater Manchester
GOC	General Optical Council
GP	General Practitioner
HM	Hand Movements
HES	Hospital Eye Service
HRA	Health Research Authority
HRVO	Hemiretinal Vein Occlusion
ICG	Indocyanine Green
IDACI	Income Deprivation Affecting Children Index
IDAOPI	Income Deprivation Affecting Older People Index
IHDD	Index of Health Deprivation and Disability
IMD	Index of Multiple Deprivation
IOP	Intraocular Pressure
IRF	Intraretinal Fluid
IT	Information Technology
IVI	Intravitreal Injection

LMH	Lamellar Macular Hole
LOC	Local Optical Committee
LogMAR	Logarithm of the Minimum Angle of Resolution
LSOA	Lower-layer Super Output Area
LVA	Low Vision Assessment
MacTel	Macular Telangiectasia
MacTest	Macular Test
MARRC	Macular Assessment Referral Refinement Clinic
MDT	Multidisciplinary Team
MR	Medical Retina
MRAC	Medical Retinal Assessment Clinic
MREH	Manchester Royal Eye Hospital
MTC	Macular Treatment Centre
NDESP	National Diabetic Eye Screening Programme
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NPL	No Perception of Light
NRES	National Research Ethics Service
OCT	Optical Coherence Tomography
OCT-A	Optical Coherence Tomography-Angiography
ONS	Office for National Statistics
OSI	Optometrist with Specialist Interest
OSP	Ophthalmic Science Practitioner
PCC	Primary Care Clinic
PCO	Posterior Capsular Opacification
PDR	Proliferative Diabetic Retinopathy
PDT	Photodynamic Therapy
PED	Pigment Epithelial Detachment
PL	Perception of Light
Post-Op CMO	Post-Operative Cystoid Macular Oedema
PP CNV	Peripapillary Choroidal Neovascularisation
PPS	Pentosan Polysulfate Sodium
RCOphth	Royal College of Ophthalmologists
RCT	Randomised Controlled Trial
RD	Retinal Detachment
RP	Retinitis Pigmentosa
RPE	Retinal Pigment Epithelium
SD	Standard Deviation
SD-OCT	Spectral-Domain Optical Coherence Tomography
SE	Standard Error
SHRM	Subretinal Hyperreflective Material
SRF	Subretinal Fluid
UK	United Kingdom
USA	United States of America
VA	Visual Acuity
VC	Virtual Clinic
VMA	Vitreomacular Adhesion
VMRC	Virtual Medical Retina Clinic
VMT	Vitreomacular Traction
VR	Vitreoretinal
YAG	yttrium-aluminium-garnet

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Chapter I – Introduction

The Healthcare Burden

Figures produced by the United Kingdom (UK) Office for National Statistics suggested an estimated 2.5-fold increase in the population of individuals over 85 years of age by 2035.[1] Numerous ophthalmic conditions occur more frequently with increasing age. Conditions such as age-related macular degeneration (AMD) and diabetic retinopathy (DR) are predicted to surge by nearly 60% between 2015 and 2035,[2] resulting in increased pressure on hospital ophthalmic units for eyecare provision. This is further exacerbated by increased referrals resulting from earlier identification of ocular disease by optometry practices through screening and more widespread and improved imaging instrumentation.[3] Whilst a larger proportion of these referred patients may not require active treatment, optometrists are obligated to refer patients with abnormal ocular conditions, in line with the Opticians Act 1989, where appropriate.[4] Reasons for referral may include confirmation of diagnosis and counselling, monitoring for potential progression, or sight impairment certification. The rapid adoption of intravitreal pharmacological agents over the last fifteen years for treatment of various retinal conditions compounded this pre-existing burden of increased demand for hospital visits.[5]

The increased workload as a result of the aforementioned factors has already started to be felt in hospital ophthalmic units. In 2019/2020, ophthalmology had the highest number of annual outpatient attendances (7.93 million patients) within the National Health Service (NHS) in the UK.[6] This increase in demand for hospital eye service (HES) appointments is reflected in all subspecialties in ophthalmology, including medical retina (MR). Despite the increased demand for ophthalmology services, there is a significant shortfall of ophthalmologists globally.[7] In 2015, there were approximately 233,000 ophthalmologists across 194 countries.[7] Whilst this supply-demand imbalance is evident globally,[8] the UK has one of the lowest number of ophthalmologists per capita amongst developed countries, estimated at 52 practitioners per one million inhabitants.[7] In comparison, the UK has one of the highest number of optometrists per capita amongst developed countries, estimated at 230 practitioners per one million inhabitants.[9] Though the number of practitioners is steadily rising in developed countries, the population of individuals aged 60 years or older is growing at twice the rate of the profession.[7] These doctor shortages are problematic, and consequences of this imbalance coupled with increasing demand have been evident. A report published by the Royal College of Ophthalmologists (RCOphth) in 2016 estimated at least twenty patients per month suffer severe visual loss secondary to delays to their hospital appointment, and consequently, their ocular assessment.[10] This becomes increasingly significant since vision impairment has been associated with mortality. A meta-analysis showed the risk of mortality was 29% higher for individuals with visual acuity (VA) of <6/12 versus those with VA ≥6/12, 43% higher for individuals with VA <6/18 versus those with VA ≥6/18, and 89% higher for individuals with a VA of <6/60 versus with those VA ≥6/18.[11]

In the UK, a clear policy has been established to address these shortages through development of ophthalmic multidisciplinary teams (MDTs) and expanding the roles of other healthcare professionals such as optometrists and nurses.[12] A study supporting this reported a significant inverse correlation between density of optometrists and prevalence of blindness.[13] Combining optometrists and ophthalmologists' numbers also showed a significant inverse correlation between density of practitioners and prevalence of blindness, as well as mild to severe visual impairment.[13] Moreover, the RCOphth commissioned a national project, 'The Way Forward Project', which identified solutions to cope with the increasing burden on HES.[2] One of the proposed recommendations to reduce the burden through increasing service capacity was the introduction of virtual clinics (VCs).

The Advent of Virtual Clinics

A virtual clinic (VC) is defined as one in which the face-to-face clinical consultation element is removed. It can be categorised into two types: synchronous and asynchronous.[14] In a synchronous model, the clinician and patient interact in real time; for example, a real-time, web-based video consultation via a webcam. In an asynchronous model, the interaction elements (attendance and consultation) occur at different times; for example, the healthcare professional subsequently reviews collected data from a patient visit, and dissemination of results to the patient and general practitioner (GP) is achieved via a letter.

In the UK, the National Diabetic Eye Screening Programme (NDESP), previously known as the Diabetic Retinopathy Screening Service, is an example of a successful and cost-effective asynchronous virtual clinic model established in 2003. It is widely credited for the successful reduction of visual loss secondary to diabetic eye disease (DED) in the working age group nationally.[15-17] The incidence of blindness secondary to DED has fallen in the UK, and 2009 marked the first year in five decades where DR was no longer the leading cause of blindness in the working age group in England and Wales.[17,18] Early detection of DR through yearly screening saves patients from attending the HES for an eye examination. However, the low referral threshold levels set by screening services to enable early detection can result in an increase of referrals to HES. Whilst the retinopathy and/or maculopathy may be 'referable', it may not necessarily be 'treatable'. A study revealed only about a tenth of patients referred for DR require treatment,[19] while a national study revealed that diabetic maculopathy accounted for about 75% of new referrals from NDESP to HES.[20]

NDESP is usually described as a screening programme rather than a 'virtual clinic' model. Virtual clinics were first described in ophthalmology in the subspecialty of glaucoma. The Portsmouth-based glaucoma refinement scheme, commissioned in 2008 streamlines glaucoma referrals through utilising VCs, digital technology, and community optometrists. A study evaluating the scheme revealed that 94% of disc images were gradable in the VC, and only 11% of patients 'attending' VCs required HES follow-up with the remaining 89% discharged for community follow-up.[21] The scheme released 1400 HES clinic slots per year and produced a significant cost-saving of over £244,000 per year for Portsmouth Hospitals' Trust.[21]

The Cambridge community optometry glaucoma scheme (COGS), initiated in 2010, was set up for clinical assessments to be carried out by an optometrist at a remote site. A clinical decision is then made whether the patient has glaucoma (or is a suspect) requiring HES referral or can be discharged. If the patient is not discharged, findings of the clinical assessment are sent electronically for virtual review by a consultant ophthalmologist. A study evaluating the scheme between 2010 and 2013 revealed that of 1733 patients, over 52% (906 patients) were discharged during the initial clinical assessment or following virtual review, as having no evidence of glaucoma.[22] COGS provides another example of a safe and effective VC model for evaluating glaucoma referrals and reducing false-positive referrals to HES. Similar results were observed in the technician-delivered glaucoma referral triaging service at Moorfields Eye Hospital NHS foundation trust, where 'virtual review' of resultant data was completed by a consultant ophthalmologist. A study assessing the scheme between 2014 and 2016 revealed that of 1380 patients, 62% were discharged following consultant virtual review, significantly reducing the number of onward referrals to the HES glaucoma outpatient department.[23]

The aforementioned schemes demonstrate reliability, cost-effectiveness, reduce the burden on the HES and even the ability to increase HES capacity, thus, promoting the recent successful implementation of VCs in MR departments. The 'Way Forward' report by RCOphth revealed 63% (17) of 27 eye departments in the UK have been running virtual AMD clinics, although their models differed in their structure.[2] Within the MR subspecialty, eye departments in the UK use various VC models to triage new referrals to HES, monitor pre-existing stable HES patients, or a combination of both.

A study assessing the implementation and outcomes of a virtual MR clinic (VMRC) at Moorfields Eye Hospital looked at 1729 patients who attended between September 2016 and May 2017.[3] The clinic was open to non-urgent external referrals as well as pre-existing HES patients seen in a face-to-face (F2F) MR clinic. A total of 1543 were internal referrals, and the remaining 186 were external. Of the internal referrals, the majority of patients (54.5%) remained in VC, with 30.9% brought for a F2F assessment, and 14.6% were discharged. Of the external referrals, 37.1% remained in VC, 17.4% required F2F assessment, and 45.5% were discharged. The model showcased successful and efficient use of pre-existing HES resources and acted as a first-line rapid access clinic for low-risk referrals, thus, releasing MR outpatient clinic slots, allocated for those requiring treatment.

Another study at Moorfields Eye Hospital evaluated outcomes of 728 patients seen in a VMRC between November 2016 and July 2018.[24] Out of the 712 patients who received a clinical outcome, about 70% of patients remained in VC, 15% were discharged, and 15% were referred to F2F clinic. Only eight patients were unsuitable for further virtual review and only 17 patients required urgent treatment. The most common diagnosis was DR, accounting for 82% of patients who attended. This further illustrates an effective example of the VC model.

A retrospective cohort study by Moorfields Eye Hospital assessed the scope of an integrated VMRC for diabetic patients referred by the UK's national diabetic eye screening program (DESP) to HES between January 2015 and December 2018.[25] Although 8833 (70.7%) out of 12563 patients qualified for a virtual review, only 2306 (18.4%) patients were offered virtual consultation due to capacity constraints. For routine referrals, the mean time between referral and first HES appointment was shorter for VC (66.9 days) compared to F2F consultation (80.9 days). Similarly, the mean time from referral to discharge was also shorter for VC (71.7 days) compared to F2F consultation (86.3 days). There was no statistical difference in mean time between referral and treating maculopathy for either group, and there was no difference in attendance rate between VC and F2F clinics.

A similar retrospective study by St. Thomas' Hospital evaluated 920 patients referred from the local DESP to a spectral-domain optical coherence tomography (SD-OCT) VC between January 2011 and January 2012.[26] Only 76% of patients attended their appointment, with the remaining 24% failing to attend or cancelling their appointments. Roughly 39% (272) of attending patients were referred for a F2F MR clinic, 43% required monitoring in the VC, 15% were discharged, and 3% had their appointments rescheduled for various reasons. Only 15% (41 out of 272) of patients referred to an MR clinic required treatment.

Similar patterns were observed in a retrospective study of 610 newly referred patients to a VMRC in Newcastle HES between April 2016 and May 2018.[27] Results were subsequently reviewed by two consultant ophthalmologists, which showed DED as the most common diagnosis (59.9% of patients). Moreover, 44.1% were offered further VC review, 27.8% were booked F2F clinic review, and 28.1% were discharged. The primary reason for requesting F2F clinic appointment was to offer treatment, and appointments occurred on average 11.9 days following VC attendance. Inadequate image quality for retinal assessment and clinical management was evident in only two cases.

Sheffield's HES has been running weekly fast-track triaging clinics for newly suspected wet AMD referrals, led by highly experienced and trained nurse practitioners.[28] Based on imaging, patients are either discharged (false positives), referred to other specialities, or counselled if diagnosed with wet AMD. Patients whose vision falls outside treatment criteria are referred to low vision assessment (LVA) services and the eye clinic liaison officer for support and discussion about potential fellow eye involvement. Those diagnosed with wet AMD are booked for further imaging (if necessary) and provided information about disease management and treatment.

The 'virtual' model was also implemented by Leicester's retinal department for following up patients treated with intravitreal injections for wet AMD. A retrospective study compared two periods; a two-year period of 2011-2012 and 2012-2013 when the virtual clinic model was implemented.[29] The average time interval between two appointments for the virtual model was 5.3 weeks compared to 6.9 weeks for the conventional system. Mean VA improvement of over 15 letters was achieved in 23.1% of patients attending during the virtual model period compared to 6.9% of patients attending during the regular appointments period. The average appointment time was notably shorter for a virtual visit (47.3 minutes) compared to 71.4 minutes for a conventional visit. Key features and findings of the aforementioned VCs are summarised in table 1.

Table 1. A summary of VC studies carried out across multiple subspecialities at various sites. Abbreviations: *HES* hospital eye service and *MR* medical retina. *Denotes new referrals.

HES	Subspeciality	Patient Numbers, n	Discharge Rate, n (%)
Portsmouth	Glaucoma*	76	68 (89%)
Cambridge	Glaucoma*	1733	906 (52%)
Moorfields	Glaucoma*	1380	856 (62%)
Moorfields	MR	1729	310 (18%)
Moorfields	MR	712	107 (15%)
St. Thomas	Diabetes*	699	105 (15%)
Newcastle	MR*	610	171 (28%)

At Manchester Royal Eye Hospital (MREH), various asynchronous VCs are used within the MR department. An MRVC known as the medical retinal assessment clinic (MRAC) is used to monitor stable pre-existing low-risk patients seen in MR clinic, as well as new referrals triaged as low risk by MR consultant ophthalmologists or a senior optometrist. All reviews are carried out by MR consultants and speciality ophthalmology doctors. Another VC known as Macular Test (MacTest) is used to monitor stable or inactive wet AMD, myopic choroidal neovascularisation (CNV), and peripapillary CNV (PP CNV) patients for up to two years following their last intravitreal injection (IVI). In the first year, they are reviewed every six weeks, and in their second year, they are reviewed every eight weeks. If the patient's condition remains stable after two years from their last IVI treatment, they are offered a F2F MR appointment with a view to discharging them. Patients in MacTest clinics are exclusively reviewed by optometrists working in macular clinics. The enhanced diabetic assessment clinic (EDAC) is another VC used to monitor pre-existing diabetic patients with low risk or stable retinopathy. All reviews are carried out by specially trained optometrists with an interest in diabetes (optometrists with specialist interest; OSIs). A project assessing the quality and safety of EDAC in comparison to F2F diabetic clinics revealed high agreement in DR grading and management, reinforcing its high quality and safety profile for reviewing diabetic patients.[30] Of 139 patients assessed, full agreement was achieved in about 83% of patients, which increased to 89% when accounting only for patients who fit the criteria for review in EDAC (n= 95). No studies are yet to be carried out on efficacy of the other aforesaid VCs. The main focus of this text will discuss the VC known as the emergency macular assessment clinic (EMAC).

The Emergency Macular Assessment Clinic Service

EMAC is a macular triaging service set up at the MREH, officially commencing on May 11th, 2015. It is a streamlined version of its predecessor, the macular assessment referral refinement clinic (MARRC), set up in September 2006 by a consultant ophthalmologist and a principal optometrist working at MREH, with the initial proposal submitted in late 2005.[31] The primary objective of MARRC was to accelerate the referral pathway for patients with suspected wet AMD. The availability of photodynamic therapy (PDT) and anti-vascular endothelial growth factor (anti-VEGF) IVI treatments meant it was of utmost importance these patients were reviewed and treated by a retinal specialist at a macular treatment centre within three weeks of referral, as per local guidelines set following the Greater Manchester Primary Care Trust meeting in 2004 (Parkes J. Personal communication September 2020).[32] Historically, the referral pathway prior to MARRC resulted in significant delays between occurrence of symptoms and treatment, taking up to three months for patients to be reviewed by a retinal specialist. The delays led to a proportion of patients suitable for treatment at onset of symptoms being deemed unsuitable on review by a specialist in a treatment centre. The new referral pathway removed several referral steps, allowing direct access to a specialist retinal clinic and thus, reducing the time to potential treatment, as illustrated in figure 1.

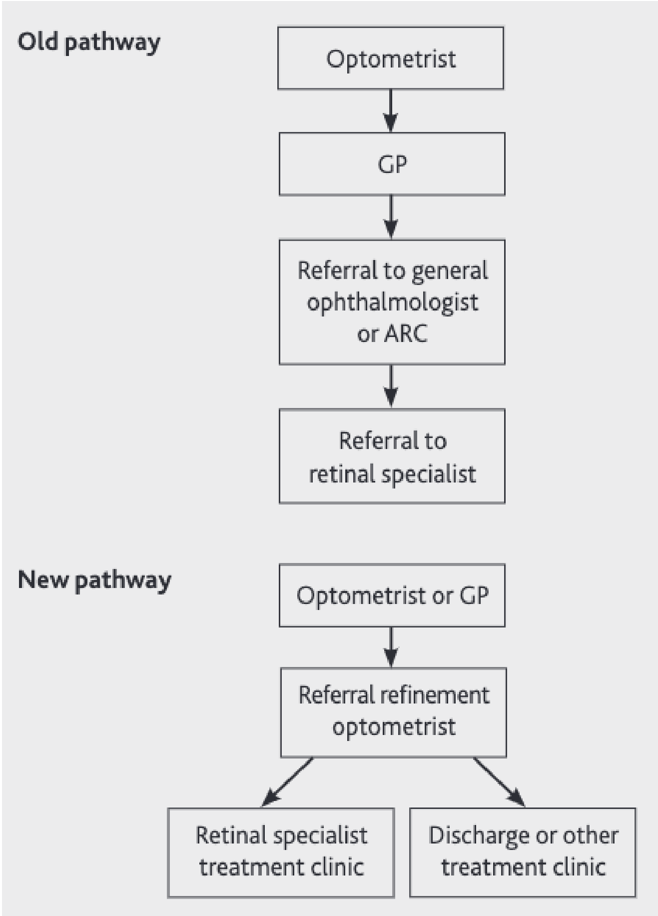

Figure 1. Contrast between the old pathway and the new pathway following introduction of the MARRC model.[31] Abbreviations: *ARC* acute referral centre and *GP* general practitioner.

Patients referred to MARRC were seen by a hospital referral refinement optometrist within 72 hours. The format of a MARRC appointment was as follows:

- Detailed history and symptoms including onset of symptoms, nature of visual disturbance, distortion and scotoma, general health, and smoking history.
- Visual status assessment: Logarithm of the Minimum Angle of Resolution (LogMAR) VA, refraction, contrast sensitivity function, and Amsler grid.
- Anterior segment assessment: pupil reactions, corneal check, angle and anterior chamber assessment, and measurement of intraocular pressure (IOP) with a Goldmann tonometer.
- Dilation with Tropicamide 1% and Phenylephrine 2.5%.
- Slit-lamp assessment of lens and posterior segment; fundus assessed stereoscopically with a Volk super 66D or 78D lens.
- Optical Coherence Tomography (OCT) scan of the macular region. A fundus fluorescein angiogram (FFA) was carried out, if necessary.
- Discussion of results with the patient: referral to macular treatment centre (MTC) for further treatment, another outpatient clinic (e.g., MR or vitreoretinal [VR] clinic), low vision clinic, or discharging from hospital, as appropriate.

The service started with two sessions per week, two patients per session, for a total of four patients. It was later expanded in 2007 to ten sessions per week as the demand increased, again with two patients per session, for a total of twenty patients. Not only did the new model allow for significantly reduced referral-to-hospital review time (three weeks versus three months) through training of hospital referral refinement optometrists, but it also led to a lower false positive referral rate, and estimated annual savings of £22,000.[31] A retrospective audit of MARRC evaluating 129 patients reviewed between October 2006 and October 2008 revealed 74% of patients were referred by community optometrists.[33] The majority of patients (63%) were diagnosed with wet AMD by the refinement optometrist; about 24% of patients were diagnosed with dry AMD, and the remaining 13% having alternative diagnoses. There was agreement between the refinement optometrist and consultant in all but eight cases, and only one case was a false negative of dry AMD, showing 99% agreement on wet AMD. Over 23% of patients were discharged after the initial MARRC consultation without attending a consultant's clinic. This successful model was further refined, expanded, and transformed into a virtual clinic currently known as EMAC, which officially started in May 2015.

EMAC is an asynchronous virtual macular triaging service where patients are seen following referral by community optometrists, the local DESP, regional GPs, other departments within Manchester University NHS Foundation Trust, other NHS trusts, or self-referral through the Emergency Eye Department (EED). The standard set by the hospital's MR department is to review patients referred to EMAC within three working days. The format of an EMAC visit is as follows:

- Upon arrival, the patient fills out a two-part questionnaire, which can be completed alone, with the help of a carer or a member of the nursing staff, if the patient is unaccompanied.
    - The first part includes general demographic information including name, address, date of birth, gender, occupation, and GP information.
    - The second part enquires about the onset and nature of visual disturbance(s) or symptoms, distortion, previous ocular history, general history (with specific polar questions about diabetes, hypertension, and cholesterolaemia), smoking history, medications, and allergies.
- A nursing staff member checks LogMAR vision, measures IOP with iCare rebound tonometer (iCare Finland Oy), dilates the patient's eyes with Tropicamide 1% and Phenylephrine 2.5%, and patient is sent to the imaging team to have an OCT and OCT-Angiogram (OCT-A) scan taken for each eye. The imaging is carried out by ophthalmic science practitioners (OSPs).

- The patient is issued with an EMAC patient information sheet and sent home. A specially trained EMAC hospital optometrist reviews the patient's notes and scans within one working day and sends a results letter to the patient and referrer; the GP always receives a copy of results letter (if they are not the referrer).
- The EMAC optometrist decides the clinical outcome, which includes referral to MTC to initiate or resume IVI treatment, other outpatient ophthalmology clinic (e.g., MR clinic, primary care clinic [PCC], or VR clinic), or discharge.

A schematic diagram of the EMAC service pathway is detailed in figure 2. The EMAC service initially ran five days a week (Monday to Friday) with up to six patients booked per day. Typically, an average of one hundred patients are seen in EMAC monthly, ages ranging between 18 to 90+ years, although the majority of patients are 50 years or older. EMAC was later expanded in September 2020 to five sessions a week (Monday to Friday) with up to eight patients booked per day. The evolution of EMAC service is schematically illustrated in figure 3. Whilst there is a degree of variability of presenting symptoms and signs, as well as technology available to different optometric practices driving referrals to the EMAC service by different healthcare practitioners, only a subset of ocular conditions, classified as urgent or emergency are deemed appropriate for referral to EMAC. In line with referral guidelines for ocular pathology in the Greater Manchester (GM) area, published by the GM local optical committee (LOC),[34] only conditions where the patient is deemed to require urgent anti-VEGF IVI treatment should be referred. Furthermore, a referral can be made if diagnosis is not possible solely from clinical examination, but there is high suspicion of an urgent macular pathology. All other conditions should be referred in an appropriate timescale through the patient's GP or using the standard electronic referral system Healthi (Cegedim Healthcare Solutions, Leyland, UK).

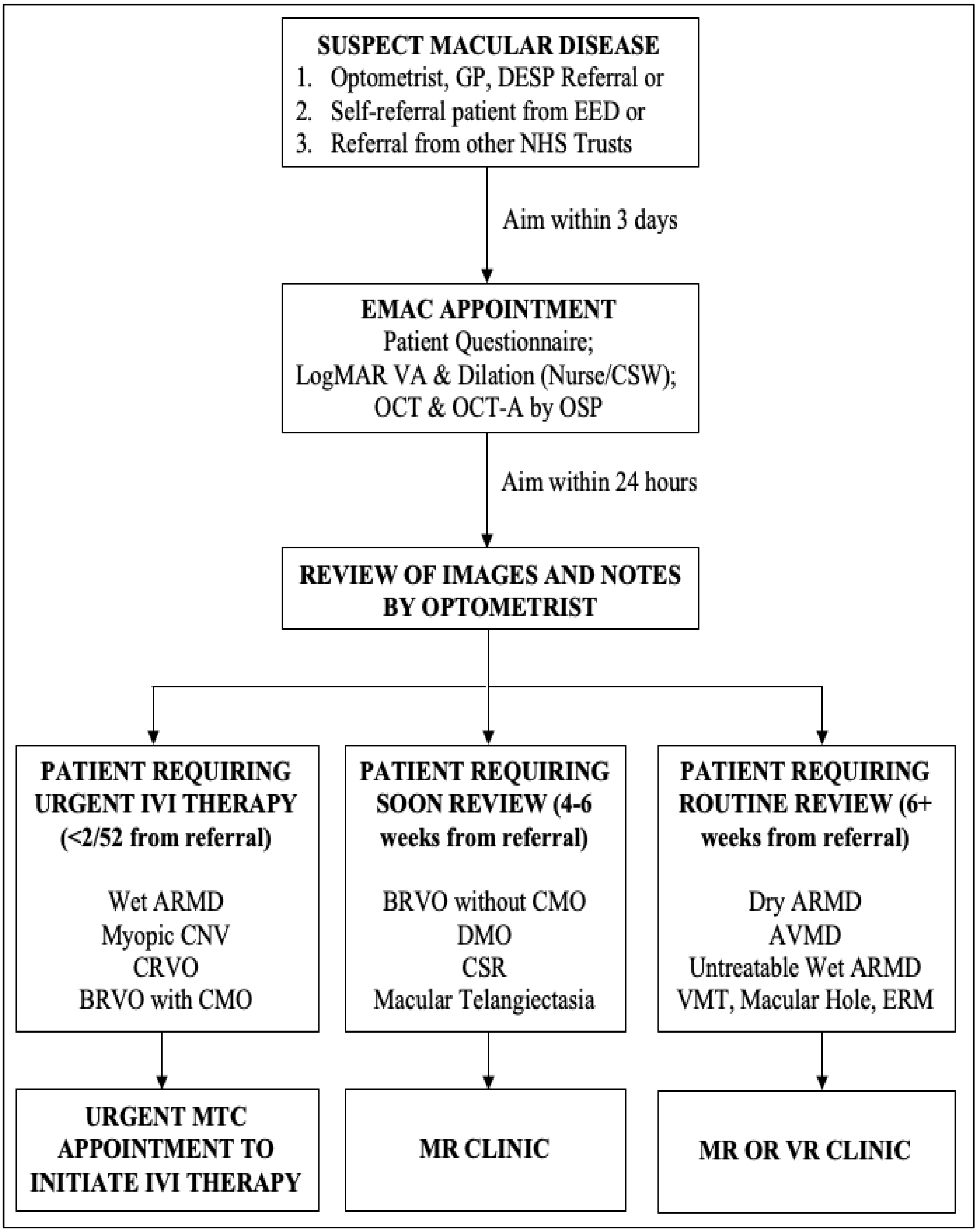

Figure 2. Flow diagram of the EMAC service. Abbreviations: *GP* general practitioner, *DESP* diabetic enhanced screening programme, *EED* emergency eye department, *NHS* national health service, *VA* visual acuity, *LogMAR* logarithm of the minimum angle of resolution, *CSW* clinic support worker, *OCT* optical coherence tomography, *OCT-A* OCT-angiography, *OSP* ophthalmic science practitioner, *ARMD* age-related macular degeneration, *CNV* choroidal neovascularisation, *CRVO* central retinal vein occlusion, *BRVO* branch retinal vein occlusion, *DMO* diabetic macular oedema, *CMO* cystoid macular oedema, *CSR* central serous retinopathy, *AVMD* adult-onset vitelliform macular dystrophy, *VMT* vitreomacular traction, *ERM* epiretinal membrane, *MTC* macular treatment centre, *IVI* intravitreal injection, *MR* medical retina and *VR* vitreoretinal. Updated flowchart; original version courtesy of Mr. Sajjad Mahmood, consultant ophthalmologist, Optegra Eye Health Care, Manchester, UK.[28]

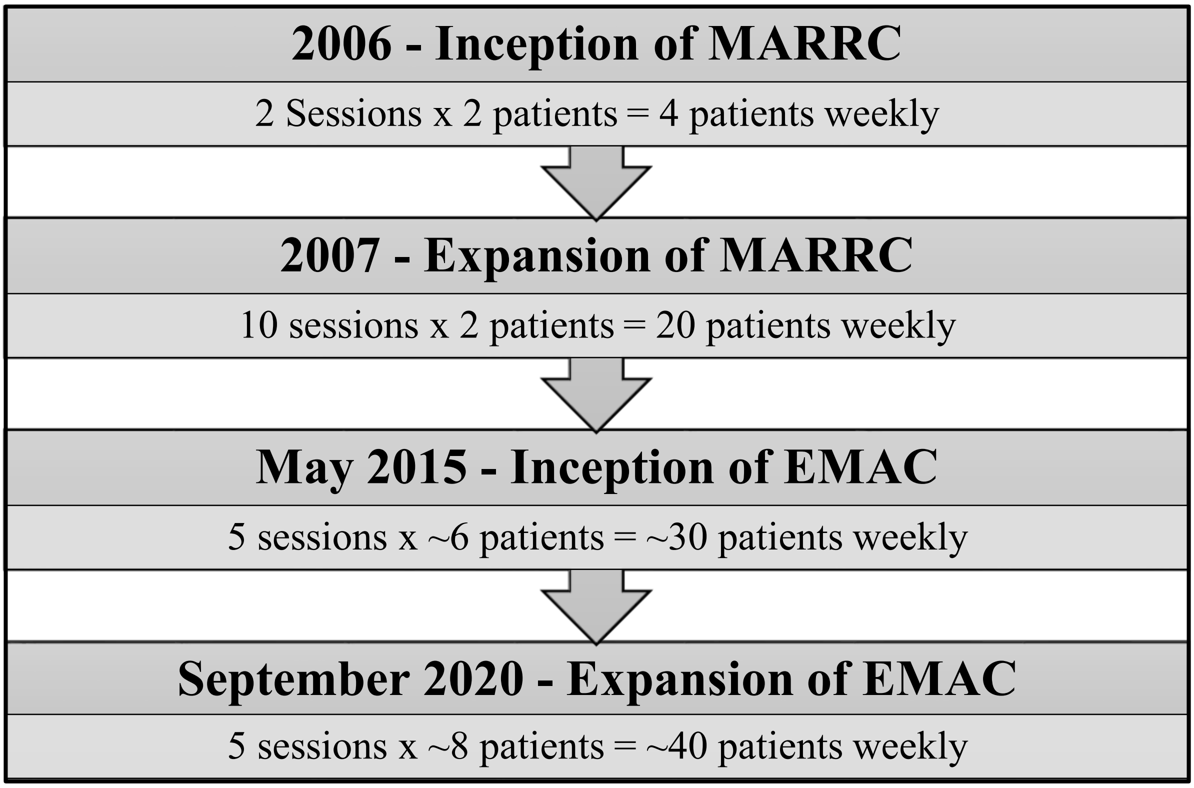

Figure 3. Evolution of EMAC service. Abbreviations: *MARRC* macular assessment referral refinement clinic and *EMAC* emergency macular assessment clinic.

The EMAC Optometrist

Since the inception of EMAC in May 2015 and up until late 2018, all patient notes have been exclusively reviewed by EMAC OSIs. An EMAC OSI is especially trained for this clinic, and certain prerequisites are needed prior to training. The OSI must have extensive knowledge of macular conditions and must have at least three years of experience working in macular clinics at MREH, though previous experience elsewhere is also considered. Initially, training involves shadowing of an experienced EMAC OSI for multiple sessions to understand the workings of the clinic. The OSI in training independently completes multiple EMAC sessions, though the management outcomes are checked over by an experienced EMAC OSI. Once the experienced OSI adjudicates the OSI in training is competent, their training is officially complete, and they can autonomously do future clinics. At present, there are eight trained EMAC OSIs at MREH, and all of them have a minimum of seven years' experience working in macular clinics.

In late 2018, in a bid to fast-track treatment of wet AMD patients even further to improve their visual outcomes, two advanced OSPs at MREH have been trained to identify features of wet AMD on OCT and OCT-A scans and refer patients to MTC for same-day IVI treatment. This is only applicable to clearcut wet AMD cases where classic features of the disease are seen on the OCT scan, and a choroidal neovascular membrane (CNVM) must be detected on the OCT-A scan. Usual features include a combination of macular haemorrhage, subretinal fluid (SRF), intraretinal fluid (IRF), pigment epithelial detachment (PED), and subretinal hyperreflective material (SHRM). Since these patients were sent to MTC for same day treatment, their notes were not assessed by an EMAC OSI. However, all other macular cases, including suspect wet AMD cases that required additional specialist imaging for formal diagnosis such as FFA and indocyanine green (ICG) angiography were subsequently reviewed by OSIs. The two trained advanced OSPs have extensive knowledge about imaging techniques in general and in relation to macular conditions and wet AMD in specific. Their training involved keeping a logbook of a minimum of fifty wet AMD cases seen in EMAC where an MR consultant fully agreed with their provisional diagnosis and signs seen on OCT and OCT-A scans. Once their logbook was complete, MREH's lead MR consultant signed it off, adjudicating their training was complete, and allowing them to refer wet AMD patients from EMAC to MTC for same-day treatment.

Gaps in the Literature & Project Objectives

The aforesaid studies carried out to assess VCs within the MR subspecialty largely focused on auditing VMRCs for pre-existing patients within HES, VMRCs triaging patients referred from the DESP, and VMRCs triaging all external (urgent and non-urgent) referrals. No studies have been carried out to evaluate an emergency macular triaging VC service such as EMAC. This project aims to evaluate and optimise the EMAC service, inform optometrists' widening scope of practice as means of reducing the burden on HES, and encourage implementation of similar optometry-led triaging services in eye units across the UK. The project has four objectives to explore these aforementioned aspects.

The primary objective of this retrospective service-enhancement project is evaluating referral patterns to EMAC and the impact of deprivation and socioeconomic factors on these patterns. Referrals will be assessed against EMAC's referral guidelines to ascertain the proportion of urgent or emergency referrals and studying reasons non-urgent referrals are sent to the service. Demographics of referred macular conditions will also be compared to those in pre-existing literature. These findings may encourage more optometric practices to offer further enhanced imaging investigations such as OCT, thus, improving diagnosis and management of macular conditions in primary care setting, and reducing referrals of non-urgent conditions to EMAC.

Another objective is to evaluate the management and treatment outcomes of referred macular conditions to EMAC. Particular emphasis will be placed on the role OCT-A plays in diagnosis and management of newly referred patients with wet AMD to the service. Findings will allow exploration of the importance of OCT-A technology in HES, and whether there is a shift from using FFA to OCT-A in the initial diagnosis of wet AMD patients. Treatment outcomes for patients with macular conditions requiring IVI treatment will also be evaluated and measured against national treatment guidelines. The third objective of this report is to assess agreement levels between EMAC OSIs and MR ophthalmologists for the diagnosis and management of new referrals to the service, with particular emphasis on AMD. Findings will highlight EMAC OSIs' efficacy levels in leading the service and whether the EMAC model requires any further optimisation. The final objective of this text is to consider the value of further education and training to primary care optometrists on referral optimisation to EMAC. The results will guide further development of continuing professional development (CPD) courses for optometrists.

Chapter II – Methods & Materials

Literature Review Process

A systematic process was formulated to conduct a thorough literature review, which involved several key steps, detailed as the following:

- The review objectives were clearly defined prior to initiating the process. This included identifying the healthcare burden in HES with particular focus on ophthalmology, the advent of virtual clinics in ophthalmology, particularly in the subspeciality of medical retina, and the impact of these two factors on patient care and their visual outcomes.
- An extensive list of relevant keywords was developed to address the review objectives. Terms included in the list were 'healthcare burden', 'ophthalmology', 'virtual clinic', 'urgent macular triage clinic', 'medical retina', 'macular disease', 'age-related macular degeneration', 'diabetic retinopathy', 'glaucoma', and 'teleophthalmology'.
- Appropriate databases were identified and used to search for relevant academic articles and research papers including PubMed, Google Scholar, and Web of Science.
- Preliminary searches using aforementioned keywords were conducted using aforesaid databases. This outlined the full extent of literature available including any gaps, which helped in refining the search strategy.
- The search strategy was refined using several Boolean operators such as 'AND', 'OR', and 'NOT' to combine or exclude keywords, as necessary.
- Search results were evaluated with abstracts reviewed and assessed against the review objectives. Relevant articles found in the 'similar articles' section of search databases were also reviewed. Pertinent abstracts were organised using a reference management software, Mendeley (Elsevier, Amsterdam, Netherlands).
- Full texts were obtained either through links provided by the search databases or access by Aston's library resources. Articles were thoroughly read and analysed, summarising key findings, methodologies, limitations, and relevance to the review objectives.
- Article summaries were analysed to identify trends, common themes, and gaps in the literature that can be addressed by the project. This analysis was used to systematically organise the literature review into appropriate sections, comprehensively outlining and addressing its objectives. It was repeatedly and carefully proofread and edited to ensure accuracy, clarity, and coherence.
- All articles used in the literature review were appropriately cited and referenced using the Vancouver referencing style.

Utilised Facilities & Set-up

The project was conducted in the optometry department at MREH in Manchester, UK. The hospital's internal electronic patient record Chameleon (Information Technology [IT] team, Manchester University NHS Foundation Trust, Manchester, UK), and the software MediSight (Medisoft Ltd., Leeds, UK) were used to review patient's records and for data collection. An Excel spreadsheet compiled by MREH's macular administrative team for all patients attending EMAC at MREH was also used to aid with data collection.

Sample of Population

Data was collected for all patients who attended EMAC between August 1st, 2019, and October 31st, 2019 (three-month period).

Inclusion Criteria

- Patients who attended EMAC at MREH between August 1st, 2019, and October 31st, 2019, aged 18 years and older.

Exclusion Criteria

- There were no exclusion criteria for partaking in this project for patients who attended EMAC at MREH between August 1st, 2019, and October 31st, 2019.

Ethics Approval

This retrospective service-enhancement project has been formally registered on the Trust's clinical audit database as 'EMAC Audit: treatment of newly referred wet AMD patients' with reference number 9145. The project is sponsored by MREH and received governance approval from Aston University's Ethics committee. MREH adheres to the Data Protection Act of 2018, and all processing of patient personal data will be in line with the Act's principles. All patient personal data will be anonymised throughout the entirety of the project, and results will solely be used for the purpose of enhancing the EMAC service, and for academic publication and presentations at relevant professional conferences. Please see the Appendix for a copy of the approved ethics forms.

Data Collection

For chapter three, an Excel (Microsoft corporation, Redmond, Washington, United States of America [USA]) spreadsheet was used to compile patient data for those who attended EMAC between August 1st, 2019, and October 31st, 2019. Examples of data collected include:

- The EMAC clinic date and length of time (in days) between referral and EMAC appointment.
- Patient's demographics: initials and a number (for anonymisation purposes), age, gender, and postcode.
- Source of referral or referrer (e.g., optometrist, GP, DESP, etc.) and their postcode.

- The hospital optometrist's diagnosis.
- EMAC clinic outcome (e.g., MTC, medical retina clinic, vitreoretinal clinic, etc.).
- If the hospital optometrist's diagnosis was wet AMD, specify whether diagnosis was made using FFA or OCT-A:
    - If FFA was used, specify reason(s).
- If EMAC outcome was referral to MTC, specify whether patient received treatment within two weeks (irrespective of condition):
    - If treatment was received over two weeks, specify reason(s).

For chapter four, three Excel spreadsheets were utilised to compile further information about treatment outcomes, in addition to some of the abovesaid collected data. The first spreadsheet was focused on wet AMD, the second focused on retinal vein occlusions (RVOs) and all other macular conditions requiring IVI treatment, while the third focused on vitreoretinal conditions, other macular conditions, and those deemed to having no macular pathology. Additional data collected in the first of those three spreadsheets include:

- Laterality of eye condition.
- Baseline vision at EMAC visit, recorded in number of letters.
- Name of IVI treatment received, and number of IVIs received in the first year.
- Post IVI-treatment vision after one year, recorded in number of letters.
- Classification of wet AMD (e.g., classic, occult, etc).
    - If classified as classic (type II), CNV size was recorded in µm.

Data collected in the second spreadsheet were identical to the first spreadsheet, but additional information was collected including:

- Classification of RVOs (e.g., central, branch, hemi-retinal, etc).
- CNV size is recorded in µm for myopic CNV and CSR with secondary CNV.

Data collected in the third spreadsheet also included patient demographics, laterality, as well as baseline vision, but additional information was collected including:

- For full-thickness macular holes, hole size was recorded in µm.
- Interventional procedures (laser treatment, ocular surgery, etc).
- Post-treatment visual acuity, recorded in number of letters.
- Clinic outcome of patient's first clinic appointment following EMAC visit.

For chapter five, an additional Excel spreadsheet was used, which comprised of information collected in previous spreadsheet. The only addition to it was:

- The ophthalmologist's formal diagnosis, noted at the patient's first outpatient clinic visit following EMAC.

Estimation of Deprivation & Socioeconomic Status

Deprivation levels of patients were estimated from the patients' residential postcode using the index of multiple deprivation (IMD). The IMD measures relative deprivation across England by combining data from seven domains to rank areas into deciles; decile 1 comprises of areas in the most 10% deprived in England, while decile 10 includes areas in the least 10% deprived in England. One of the domains is the health deprivation and disability domain, which will be referred to in this text as the index of health deprivation and disability (IHDD). IMD and IHDD scores and deciles, as well as the Greater Manchester borough associated with each postcode were obtained from an online tool developed by the Department for Levelling Up, Housing & Communities' Geographic Information Systems team.[35] This public tool has been published and periodically updated by the Ministry of Housing, Communities, and Local Government.
The socioeconomic status of patients was estimated from the patients' residential postcode using the ACORN (a classification of residential neighbourhoods) index. The index, produced by Consolidated Analysis Centres, Inc. (CACI), uses various data sources to outline social and economic characteristics of the population and categorise households into six different groups, each with subclassifications.[36]

For chapter six, another Excel spreadsheet was used to include all IMD, IHDD, and ACORN index scores in addition to previously mentioned patient demographic data. Information about areas within boroughs of Greater Manchester were also included in the spreadsheet.

CPD Event: OCT & Emergency Macular Assessment Clinic (EMAC) Workshop – Design

The educational event delivered remotely through MREH comprised of three elements: a 90-minute educational workshop, and two surveys, labelled 'Pre-Workshop Survey', and 'Post-Workshop Survey'. The event was registered using the MREH optometry department's CPD provider account on the General Optical Council (GOC) website. The CPD reference is C-102964 and two interactive CPD points were approved for the event. Attending the workshop and completion of the two surveys were required to attain full points, however, completion of the surveys remained optional. The workshop took place on Wednesday, August 3rd, 2022, at 19:00, delivered through Microsoft Teams by an optometrist colleague at MREH and myself.

CPD Event – Survey Design

Two identical surveys were designed using SurveyMonkey, comprising of thirteen questions. The registrant was asked about their GOC number (for CPD purposes only), primary mode of practice, total years of experience, and whether they have an OCT in practice. Using a five-point categorical scale (limits specified in brackets), they were asked to answer four questions:

- Confidence in assessing OCT scans ('Very confident' to 'Not confident at all').

- Understanding of the EMAC referral criteria (‘Understand very well’ to ‘Do not understand at all’).
- Adequacy of their training to assess macular conditions (‘Very well trained’ to ‘not trained at all’).
- Benefit of further OCT training (‘Very beneficial’ to ‘Not beneficial at all’).

For the last five questions, the registrant was presented with five clinical case scenarios and asked about their management decision. For all cases, they had to choose one of the following five options: ‘Refer to Emergency Eye Department’, ‘Refer to EMAC’, ‘Refer to Vitreoretinal Clinic’, ‘Refer to Medical Retina Clinic’, or ‘No Referral Required’. A copy of the survey as well as all five clinical scenarios in both surveys can be found in the Appendix. The deadline for completing the pre-workshop survey was August 3rd, 2022, at 17:00 (two hours prior to the workshop). The deadline for completing the post-workshop survey was August 10th, 2022, at 23:59.

CPD Event – Ethics

Ethics approval was not required by the National Research Ethics Service (NRES) as per the decision tool on the NHS Health Research Authority (HRA) website. Results of this tool can be found in the Appendix. As part of the event’s promotional flyer, registrants were informed the workshop has been designed as part of a research project into referrals and results of the surveys will be anonymised and solely used for research purposes. Completion of the surveys and attending the workshop were voluntary. Registrants willing to partake in the event filled out a registration form, providing their first and last names, email address, and GOC number. A URL to the registration form was included in the promotional flyer.

CPD Event – Recruitment and Delivery Protocol

Registrants were recruited after an email including the promotional flyer was disseminated by MREH’s Referrer Relationship Specialist to members of the GM LOC. The event was also digitally promoted on professional networking websites and groups. The event was primarily aimed at optometrists working in GM. In addition to the URL for the registration form, a URL to the pre-workshop survey was also included in the flyer. Two email reminders were sent out to registrants to fill out the survey. A URL of the post-workshop survey was included in one of the presentation slides and sent in the ‘chat’ function on Microsoft Teams. The URL was emailed to all attendees along with a summary presentation and other educational material for referring to EMAC. A further email reminder was sent out to registrants to fill out the survey.

CPD Event – Data Collection

For chapter seven, an Excel spreadsheet was used to compile all optometrists’ data for those who attended the workshop and filled out both surveys. Examples of data collected include:

- A number assigned for anonymisation purposes.
- Primary mode of practice (e.g., primary care, secondary care, etc).
- Total years of optometric experience.
- Availability of OCT technology in practice.
- Pre- and post-workshop confidence levels in assessing OCT scans.
- Pre- and post-workshop understanding levels of EMAC criteria.
- Pre- and post-workshop perceptions about own macular training.
- Pre- and post-workshop degree of benefit from further OCT training.
- Pre- and post-workshop answers to the five clinical case records.

For the purpose of analysis, for questions with a five-point categorical scale, the lower limit (e.g., not confident at all) is given a score of one, while the higher limit (e.g., very confident) is assigned a score of five. Likewise, for the clinical case records, a correct answer is given a score of one, while an incorrect answer is given a score of zero.

Data Analysis & Statistical Methods

Sample size calculations were computed using G*Power[37], and results reported in the Appendix. For statistical analyses across all chapters, data from Excel were used in statistical software SPSS (IBM, New York, US). For all analyses, normality of data was checked in SPSS using the Shapiro-Wilk test.

Chapter III – EMAC Referrals & Demographics of Referred Macular Conditions

Chapter one described the evolution of the EMAC service and its key role for triaging urgent macular conditions to the HES. This chapter provides in-depth reporting and data analysis of demographics of patients who attended EMAC over a three-month period, with focus on how they align to existing literature. Acknowledging and accounting for these characteristics can serve as a key additional tool utilised by primary care practitioners, especially optometrists, to aid in the diagnosis and management of patients with macular conditions.

Data collected between August 1st, 2019, and October 31st, 2019, showed a total of 314 patients attended EMAC during that period. In total, 168 (53.5%) were female and 146 (46.5%) were male. The mean age of female patients attending clinic was 75.0 years with standard deviation (SD) of 13.2 years. The mean age of male patients was 72.1 years (*SD*= 14.0 years). In 2019, an average of 105 patients (SD= 3.1 patients) attended per month; the lowest monthly attendance of 100 patients was in February, and the peak monthly attendance of 110 patients was in June. A two-tailed unpaired t-test showed no statistical significance ($p > 0.05$) between the number of patients who attended over the three-month period used in this study and any other three-month period combinations in 2019. Figure 4 illustrates the monthly EMAC patient attendance in 2019.

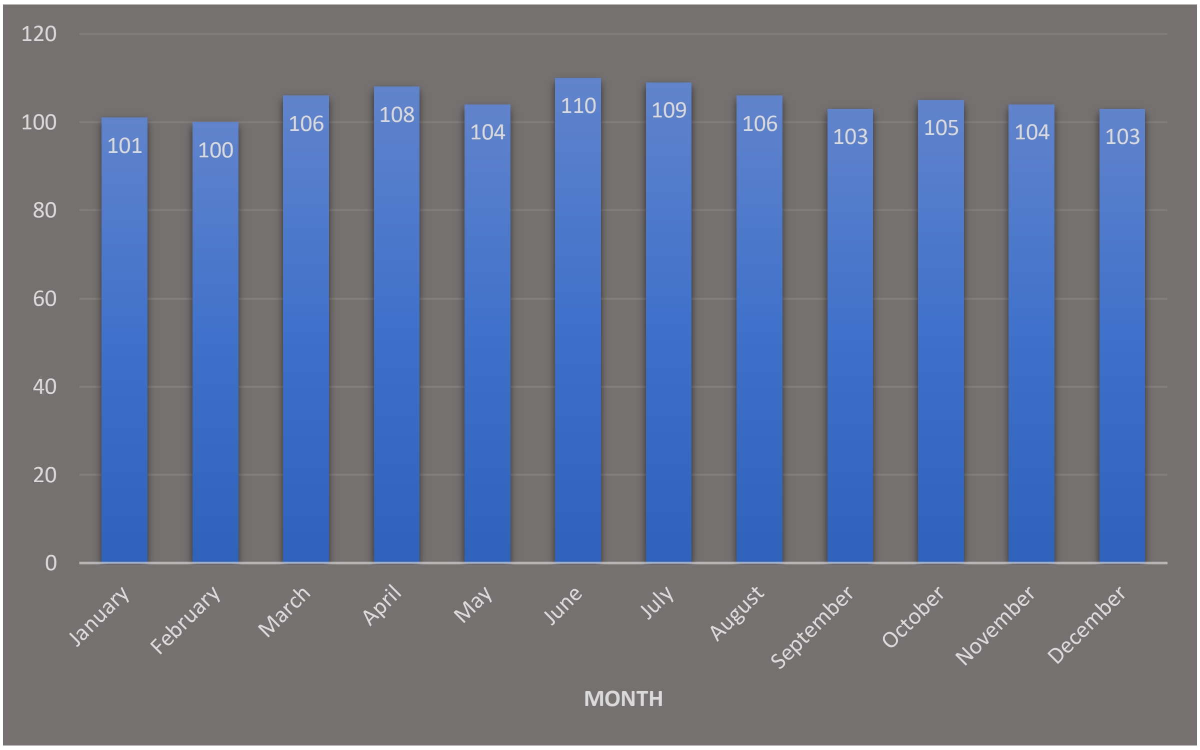

Figure 4. The number of patients attending EMAC each month in 2019.

As previously mentioned, a chief objective of this service is to review patients referred to EMAC in three days or less from referral date. Once a referral is made to the EMAC service and received by a member of the administrative staff, the patient is called and offered an appointment within three days from the referral date. Within that three-month span, the average length of time between referral and EMAC review was 4.25 days (*SD*= 4.18 days), with only 58.3% (183) of patients reviewed within that timescale. Figure 5 describes reasons the remaining 131 patients were seen outside that timescale.

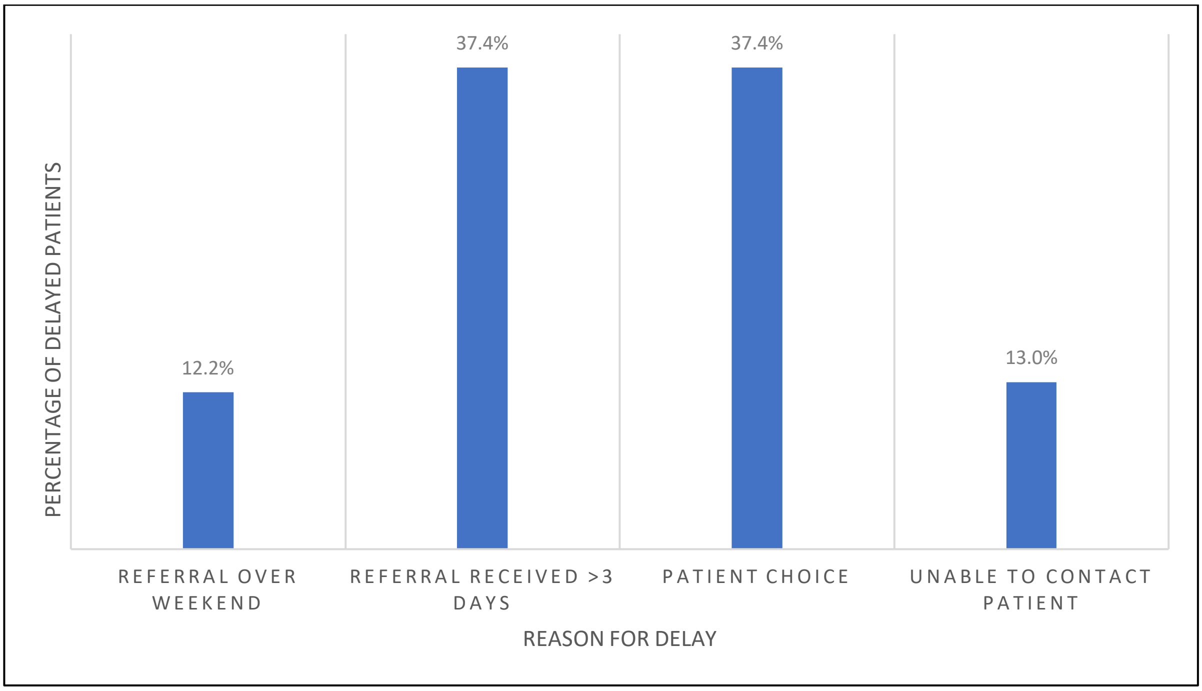

Figure 5. Reasons patients referred to EMAC seen over three days from referral (n= 131).

As observed in figure 5, over 50% (66) of patients were not seen within the timescale due to patient factors; 49 patients chose a date that falls outside the three-day range despite being offered one within the range, or in the case of 17 patients, they could not be contacted by phone, and a letter had to be posted out with an appointment date that falls outside the three-day range to allow the patient sufficient time to receive the letter. Over 12% (16) of patients were seen outside the timescale due to delays of processing referrals over the weekend. As previously noted, EMAC operates Mondays to Fridays. Similarly, the administrative team works Mondays to Fridays. Referrals sent on Friday, especially late afternoon may not get processed till the following Monday, already breaching the three-day range. Similarly, referrals processed on Friday may be booked for a Tuesday appointment due to lack of availability on the following Monday. Another issue that affected four out of the sixteen patients was the summer bank holiday (last Monday of August) that meant all patients referred on the preceding Friday would automatically breach the timescale, since Tuesday was the earliest appointment that could be offered.

A repeat analysis looking at the number of patients seen in EMAC in three working days or less rather than three total days or less from referral date showed that all 16 patients would meet the timeframe, increasing the total from 58.3% to 63.4%. Similarly, the average length of time between referral and an EMAC review drops from 4.25 days to 3.86 days (*SD*= 3.77 days). The final 49 patients were seen outside the proposed timescale due to delays in receiving and processing of referrals sent by some GPs and DESP or those sent by optometrists through the standard electronic referral system. Some referrals may be sent by the referrer as 'urgent' to be seen by the hospital eye service in two to six weeks, but may otherwise get triaged by the on-call ophthalmologist to EMAC to rule out any macular conditions requiring prompt treatment (e.g., Wet AMD). This multi-step process inevitably breaches the three-day period between referral and EMAC review.

All referrals from various sources (healthcare professionals and organisations) were evaluated, and the proportion of patients requiring urgent treatment was computed for each source. For the purpose of this report, urgent treatment constitutes both intravitreal anti-VEGF injections, and topical treatment for conditions such as post-operative cystoid macular oedema (CMO). The results are summarised in figure 6.

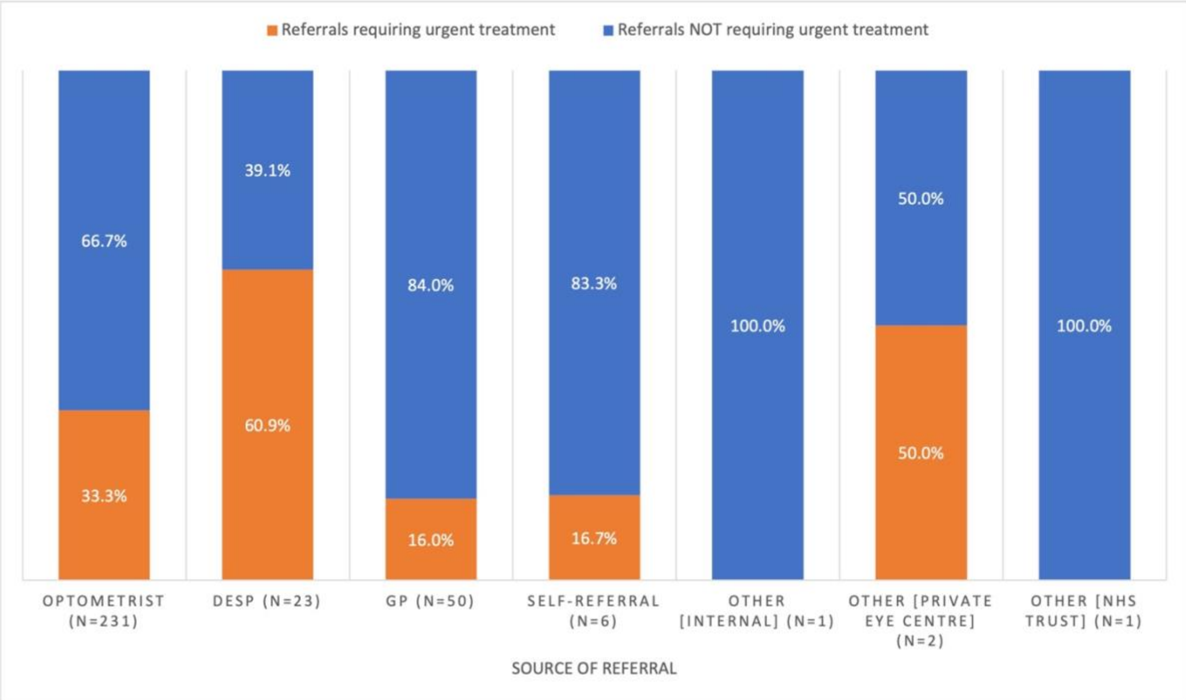

Figure 6. Proportion of patients referred to EMAC requiring urgent treatment. Abbreviations: *DESP* diabetic enhanced screening programme, *GP* general practitioner, and *NHS* national health service.

Nearly 74% (231) of all patients reviewed in EMAC over the three-month period were referred by optometrists. Only a third of patients (77) referred required urgent treatment; 74 required anti-VEGF injections and three required topical treatment for post-operative CMO. For the other two-thirds of patients (154), a 'soon' or routine appointment was requested in a HES outpatient clinic, or they were discharged back to the referrer. For the 23 patients referred from

DESP, about 61% (14) of patients required urgent treatment, all referred to MTC for intravitreal anti-VEGF injections. About 16% (50) of all patients seen in EMAC were referred by the GP, but only eight patients (16%) required urgent intervention. For the remaining 10 patients, six self-referred to EED, two were sent from a private eye centre, one was referred from another NHS trust, and one was referred internally from an outpatient clinic in Manchester Royal Infirmary. Only one self-referred patient required urgent anti-VEGF IVI treatment, and one of the two patients referred from the private eye centre required topical treatment for post-operative CMO.

EMAC Referrals by All Sources

Approximately 50% (156) of all referrals to EMAC over the specified three-month span were tentatively diagnosed by OSIs as AMD, nearly split evenly between dry (79) and wet AMD (77). The three next most common conditions after AMD were branch retinal vein occlusion (BRVO), adult-onset vitelliform macular dystrophy (AVMD) and macular hole. BRVO accounted for nearly 10% (31) of referrals, while AVMD and macular holes each accounted for over 5% (17) of referrals. No macular pathology was noted in nearly 7% (21) of referrals to the service. Figure 7 illustrates diagnoses found after referrals to the service by all sources.

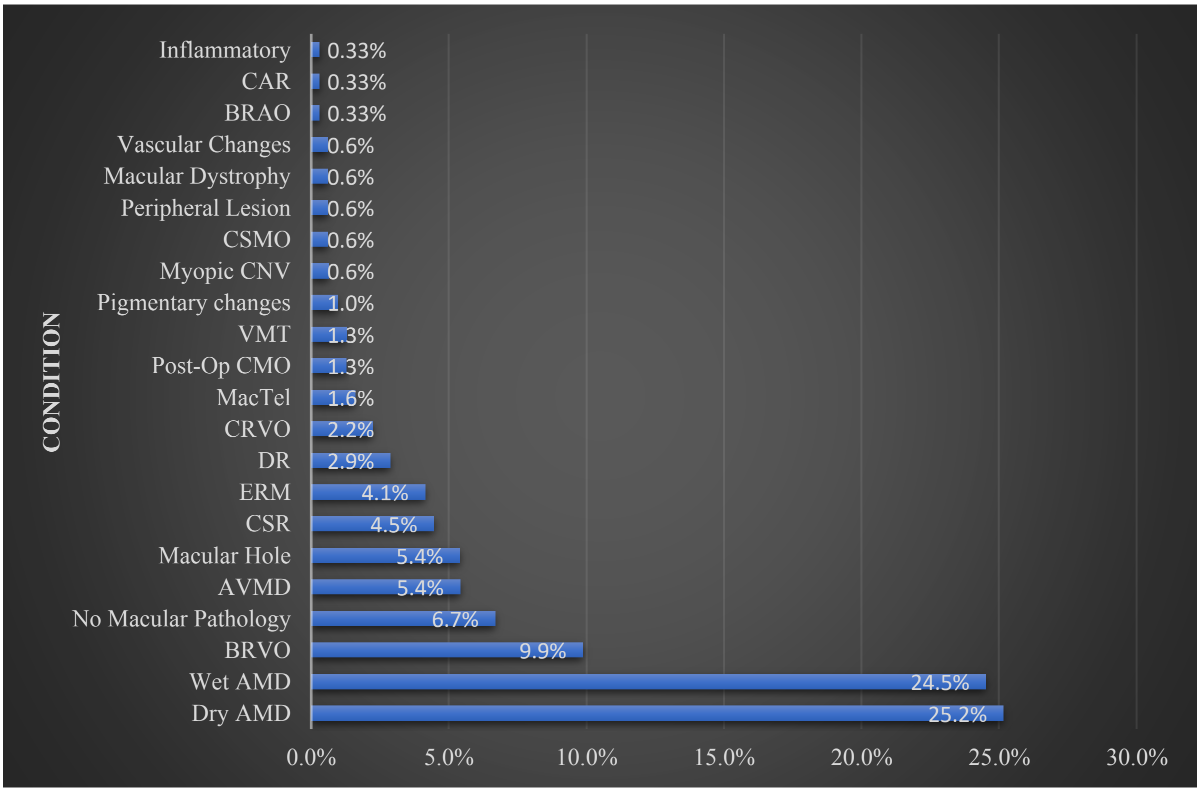

Figure 7. Ocular conditions diagnosed following referrals to EMAC (n= 314). Abbreviations: *CAR* cancer associated retinopathy, *BRAO* branch retinal artery occlusion, *CSMO* clinically-significant macular oedema, *CNV* choroidal neovascularisation, *VMT* vitreomacular traction, *Post-Op CMO* post-operative cystoid macular oedema, *MacTel* macular telangiectasia, *CRVO* central retinal vein occlusion, *DR* diabetic retinopathy, *ERM* epiretinal membrane, *CSR* central serous retinopathy, *AVMD* adult-onset vitelliform macular dystrophy, *BRVO* branch retinal vein occlusion, and *AMD* age-related macular degeneration.

EMAC Referrals by Optometrists

As previously noted, community optometrists accounted for nearly three-quarters (231) of all referrals to the service. About 46% (106) of those referrals were tentatively diagnosed by OSIs as AMD; 59 patients had wet AMD and 47 patients had dry AMD. BRVO, macular hole, and AVMD were the commonest conditions detected after AMD, accounting for 11.3% (26), 7.4% (17), and 6.1% (14) of referrals, respectively. Over the three-month period, optometrists were the only referral source who referred patients subsequently diagnosed with macular hole (17), pigmentary changes (three), macular dystrophy (two), vascular changes (two), branch retinal artery occlusion (BRAO; one), cancer-associated retinopathy (CAR; one), and inflammatory condition (one). However, over 5% (12) of referrals by optometrists revealed no macular pathology. Diagnoses made after referrals by optometrists are summarised in figure 8.

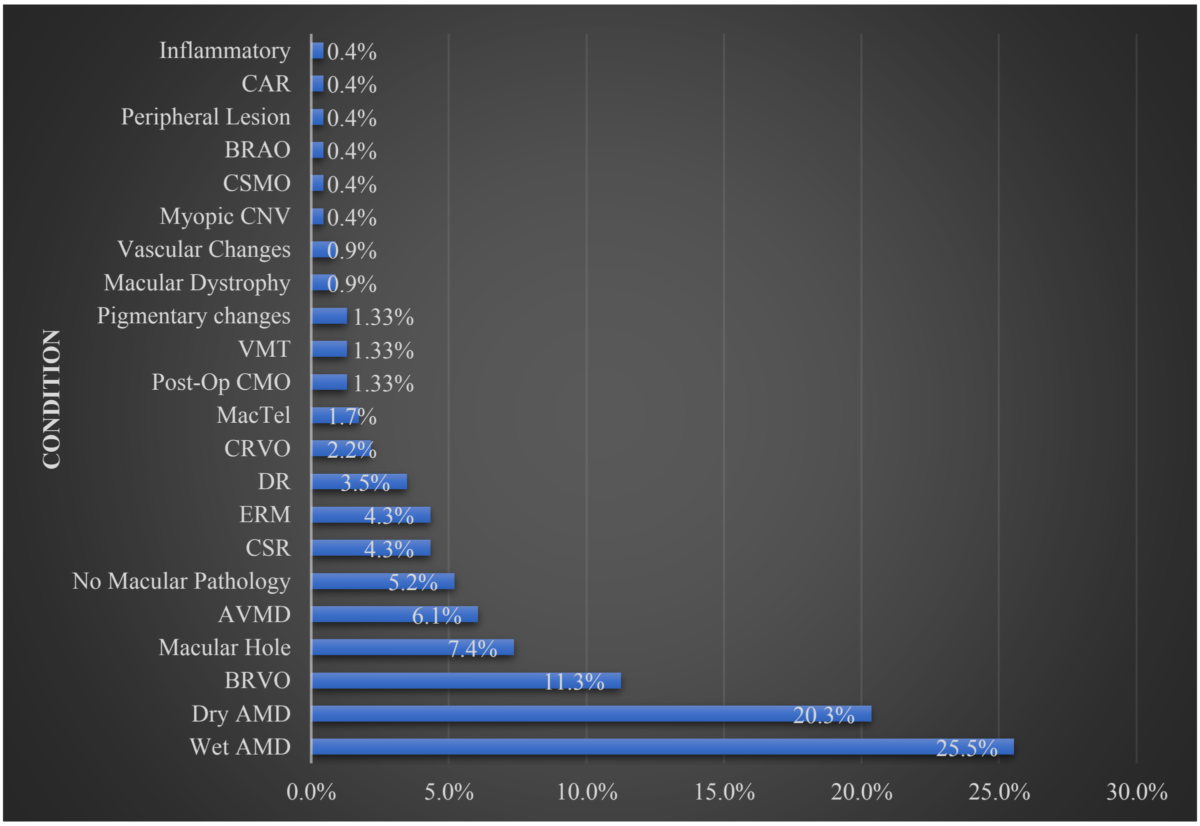

Figure 8. Ocular conditions diagnosed following referrals by optometrists to EMAC (n= 231). Abbreviations: *CAR* cancer associated retinopathy, *BRAO* branch retinal artery occlusion, *CSMO* clinically-significant macular oedema, *CNV* choroidal neovascularisation, *VMT* vitreomacular traction, *Post-Op CMO* post-operative cystoid macular oedema, *MacTel* macular telangiectasia, *CRVO* central retinal vein occlusion, *DR* diabetic retinopathy, *ERM* epiretinal membrane, *CSR* central serous retinopathy, *AVMD* adult-onset vitelliform macular dystrophy, *BRVO* branch retinal vein occlusion, and *AMD* age-related macular degeneration.

EMAC Referrals by GPs

GPs accounted for 16% (50) of all referrals to the service. AMD was the most diagnosed ocular condition by OSIs, making up 64% (32) of referrals; 26 were tentatively diagnosed as dry

AMD, and six as wet AMD. Seven patients (14%) were found to have no macular pathology. Other diagnosed conditions include BRVO (three), central serous retinopathy (CSR; three), AVMD (two), myopic CNV (two), DR (one), and epiretinal membrane (one). A summary of diagnoses made after referrals by GPs is illustrated in figure 9.

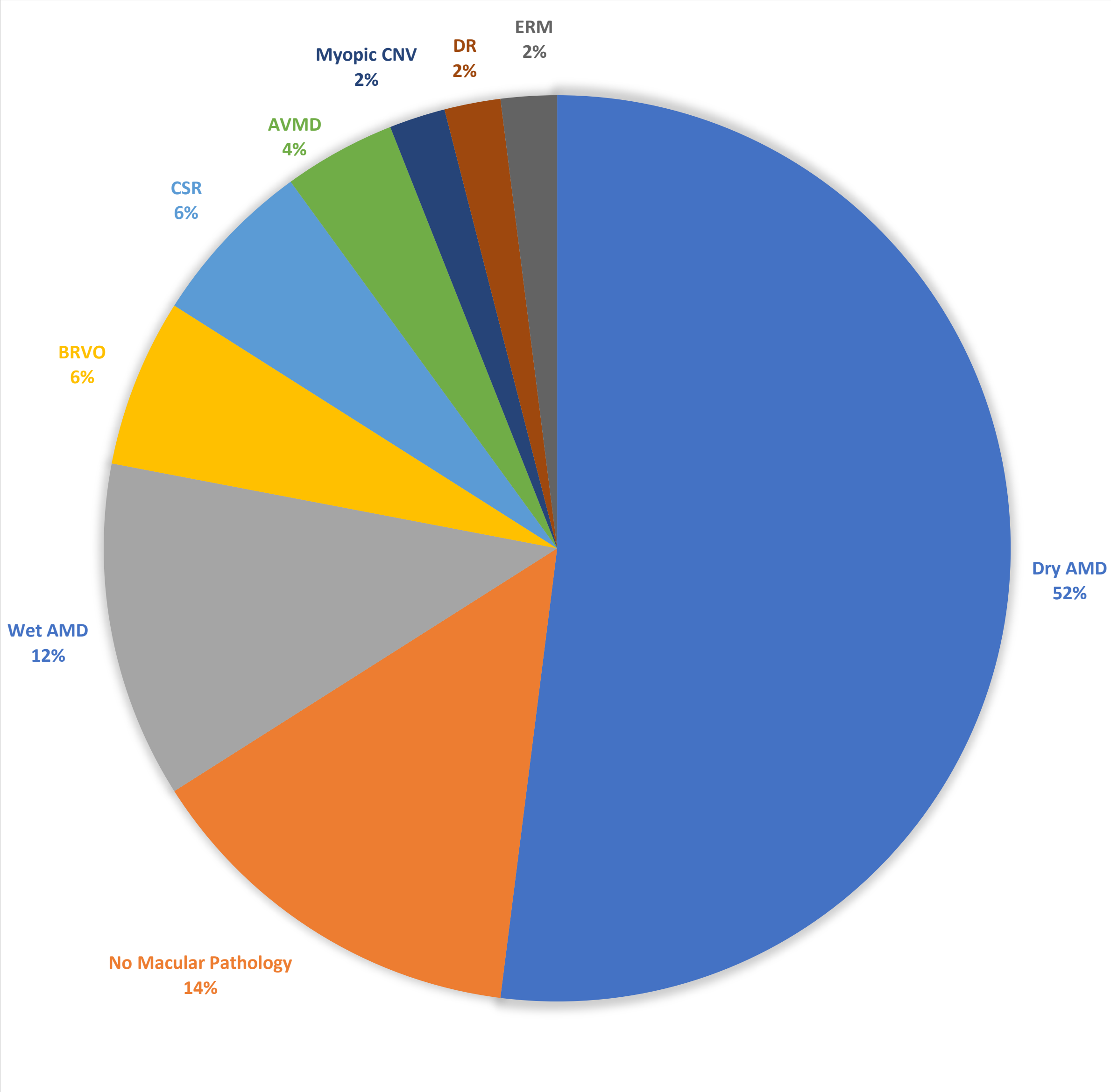

Figure 9. Ocular conditions diagnosed after referrals by GPs to EMAC (n=50). Abbreviations: *GP* general practitioner, *AMD* age-related macular degeneration, *BRVO* branch retinal vein occlusion, *CSR* central serous retinopathy, *AVMD* adult-onset vitelliform macular dystrophy, *CNV* choroidal neovascularisation, *DR* diabetic retinopathy, and *ERM* epiretinal membrane.

EMAC Referrals by DESP

Over 7% (23) of referrals to EMAC were made by the DESP. AMD was the most diagnosed ocular condition by OSIs, accounting for 61% (14) of referrals; 11 were tentatively diagnosed as wet AMD, and three were diagnosed as dry AMD. One patient was found to have no macular pathology. Other diagnosed conditions were central retinal vein occlusion (CRVO), BRVO, AVMD, clinically significant macular oedema (CSMO), vitreomacular traction

(VMT), macular telangiectasia (MacTel), and peripheral retinal lesion. Diagnoses made after referrals by the DESP are illustrated in figure 10.

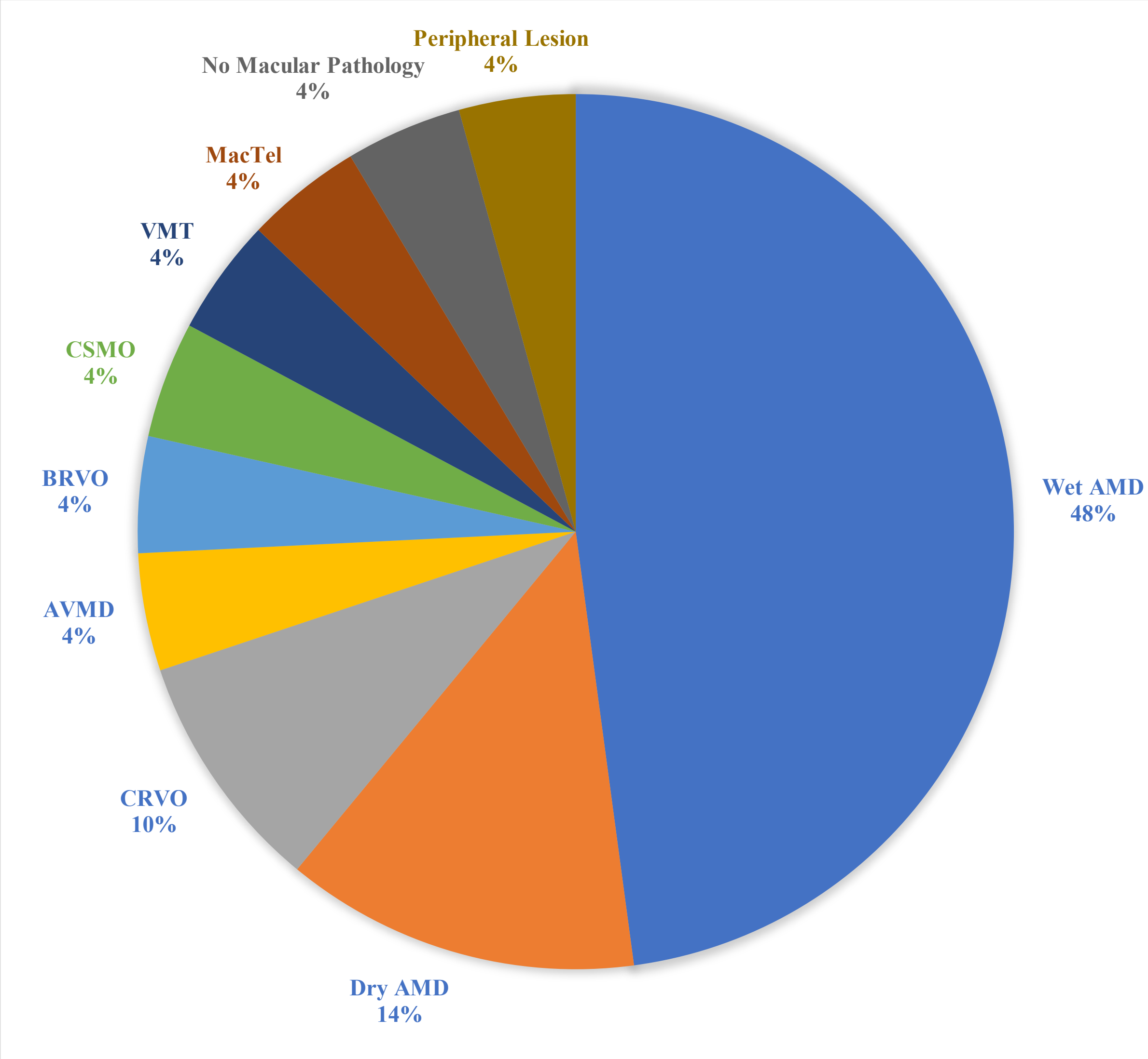

Figure 10. Ocular conditions diagnosed after referrals by DESP to EMAC (n= 23). Abbreviations: *DESP* diabetic enhanced screening programme, *AMD* age-related macular degeneration, *CRVO* central retinal vein occlusion, *AVMD* adult-onset vitelliform macular dystrophy, *BRVO* branch retinal vein occlusion, *CSMO* clinically significant macular oedema, *VMT* vitreomacular traction, and *MacTel* macular telangiectasia.

EMAC Referrals by Other Sources

The remaining 10 (3.2%) referrals to EMAC were made by other sources. Six patients self-referred either through presenting to EED or by means of communication with a healthcare professional over the phone regarding new visual symptoms; all patients were subsequently referred to EMAC. Three of these patients were diagnosed with AMD by OSIs (one had wet AMD and two had dry AMD). One patient was found to have no macular pathology, one was diagnosed with a BRVO, and the last patient was diagnosed with an ERM. Of the remaining four patients, referred from various other sources, one was diagnosed with dry AMD, one diagnosed with ERM, one diagnosed with post-operative CMO, and one diagnosed with CSR. A summary of diagnoses made after referral by other sources is illustrated in figure 11.

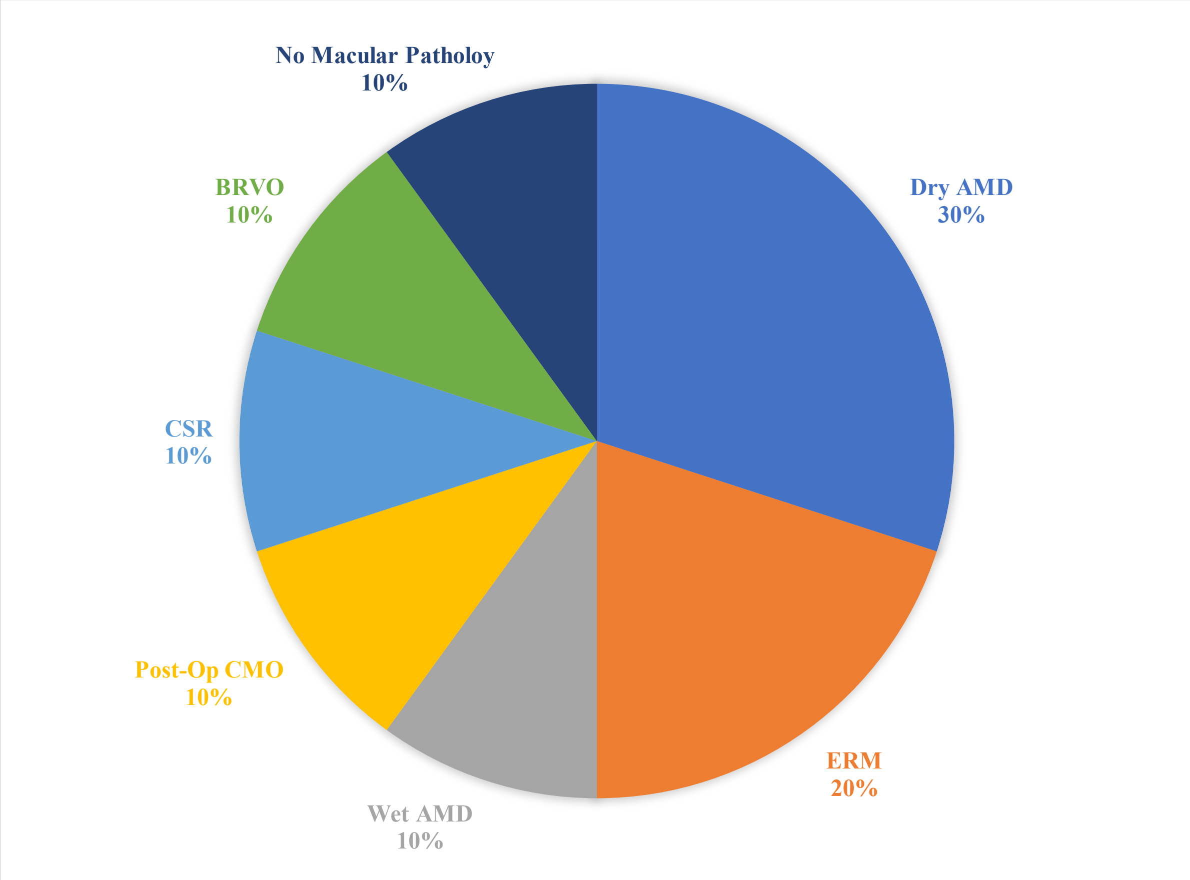

Figure 11. Ocular conditions diagnosed following referrals by other sources to EMAC (n= 10). Abbreviations: *AMD* age-related macular degeneration, *ERM* epiretinal membrane, *Post-Op CMO* post-operative cystoid macular oedema, *CSR* central serous retinopathy, and *BRVO* branch retinal vein occlusion.

The following sections will explore demographics of some of the most commonly diagnosed conditions by OSIs following referral to EMAC by all sources.

Demographics of Ocular Conditions – Wet AMD

Wet AMD was the second most diagnosed ocular condition by OSIs, accounting for 24.5% of all referrals to EMAC within the three-month period. Out of 77 patients diagnosed with wet AMD, 42 were female and 35 were male. The average age of diagnosed female patients was 83.2 years (SD= 7.2 years); the youngest diagnosed at 66 years and the oldest diagnosed at 96 years. The average age of diagnosed male patients was 80.9 years (SD= 8.0 years); the youngest diagnosed at 63 years and the oldest diagnosed at 95 years. A two-tailed unpaired t-test showed no statistical significance between the mean ages of the two groups (p= 0.18). No patients under the age of 55 years were diagnosed with wet AMD. A large majority of patients diagnosed (85.7%) were over the age of 75 years. Findings are summarised in figure 12.

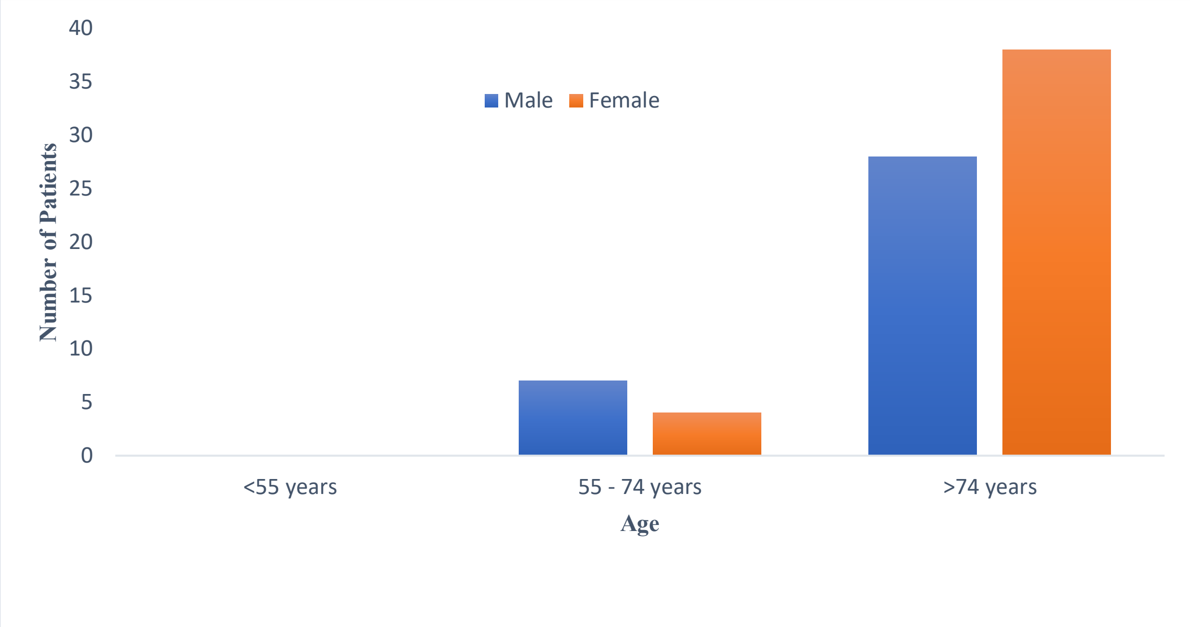

Figure 12. Demographics of patients diagnosed as wet AMD by OSIs following referral to the EMAC service (n= 77).

Demographics of Ocular Conditions – Dry AMD

Dry AMD was the most diagnosed condition by OSIs, accounting for 25.2% of all referrals to EMAC within the three-month period. Nearly 66% (52) of the 79 patients diagnosed with dry AMD were female and the remaining 27 were male. The mean age of diagnosed male patients was 75.8 years (SD= 11.5 years); the youngest diagnosed at 53 years and the oldest diagnosed at 96 years. The average age of diagnosed female patients was 78.3 years (SD= 9.7 years); the youngest diagnosed at 54 years and the oldest diagnosed at 97 years. A two-tailed unpaired t-test showed no statistical significance between the mean ages of the two groups (p= 0.32). A summary of these findings is illustrated in figure 13.

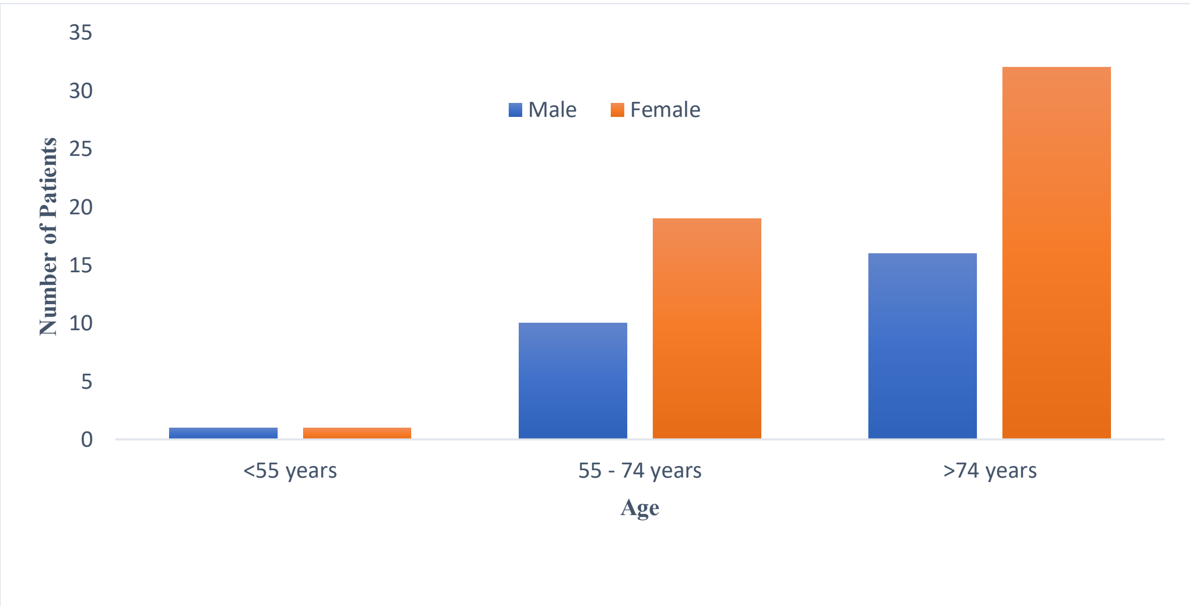

Figure 13. Demographics of patients diagnosed as dry AMD by OSIs following referral to the EMAC service (n= 79).

Demographics of Ocular Conditions – BRVO

BRVO was the third-most diagnosed condition by OSIs, accounting for 9.9% of all referrals to EMAC within the three-month period. In this text, hemi-retinal vein occlusion (HRVO) and macular RVOs were categorised under BRVO. Over two-thirds (21) of 31 patients diagnosed with BRVO were male and the remaining 10 were female. The average age of diagnosed male patients was 68.2 years (SD= 9.2 years); the youngest diagnosed at 49 years and the oldest diagnosed at 79 years. The average age of diagnosed female patients was 81.4 years (SD= 6.0 years); the youngest diagnosed at 72 years and the oldest diagnosed at 91 years. A two-tailed unpaired t-test showed a statistically significant difference between the mean ages of the two groups (p= 0.0003). Nine male patients and four female patients diagnosed with BRVO had secondary CMO that required IVI treatment. Out of the nine male patients, one had a macular RVO, and one had an HRVO. One of the four female patients had an HRVO. The average age was 68.4 years (SD= 9.1 years) and 83.8 years (SD= 6.6 years) for male and female patients, respectively. A summary of these findings is illustrated in figure 14.

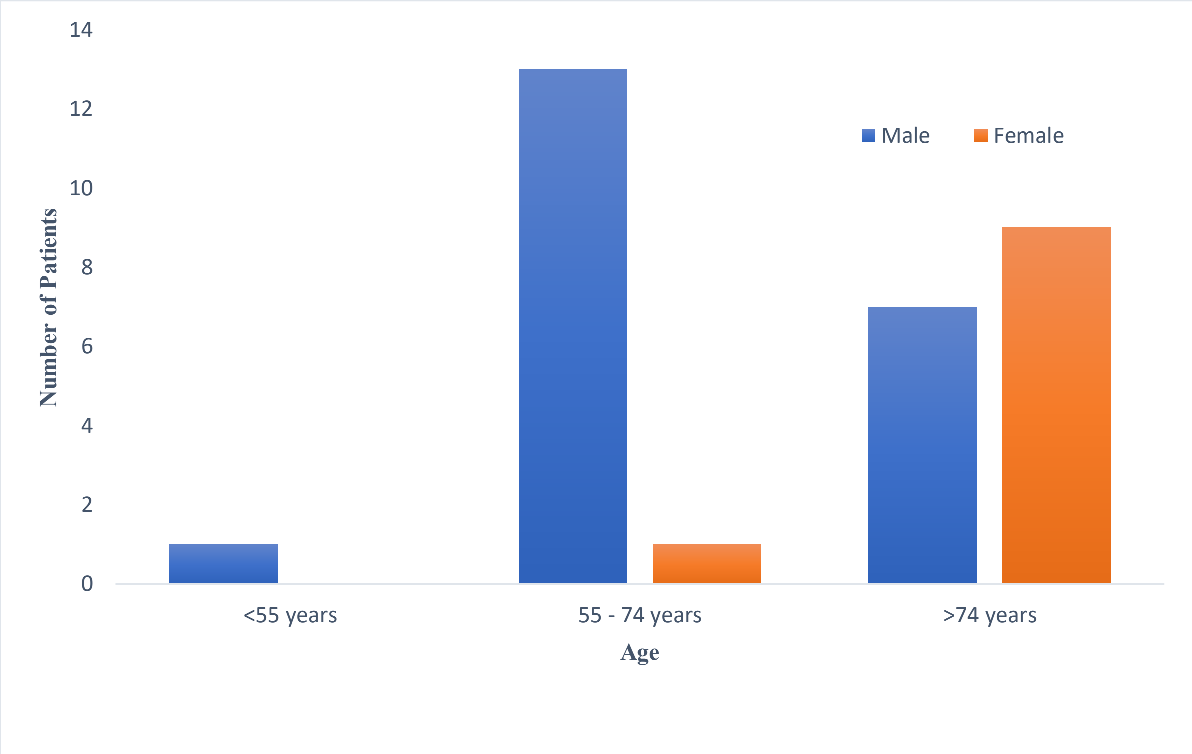

Figure 14. Demographics of patients diagnosed as BRVO by OSIs following referral to the EMAC service (n= 31).

Demographics of Ocular Conditions – AVMD

OSIs-diagnosed AVMD accounted for over 5% of all referrals to EMAC within the three-month period. Ten of 17 patients diagnosed with AVMD were male and the remaining seven were female. The mean age of diagnosed male patients was 76 years (SD= 14.3 years); the youngest diagnosed at 47 years and the oldest diagnosed at 92 years. The average age of diagnosed female patients was 74.3 years (SD= 15.8 years); the youngest diagnosed at 43 years and the oldest diagnosed at 87 years. A two-tailed unpaired t-test showed no statistical significance between the mean ages of both groups (p= 0.82). None of the patients developed CNV secondary to AVMD. Two other referred patients were provisionally diagnosed with macular dystrophy that was not AVMD; one patient diagnosed with retinitis pigmentosa (RP), and the other was diagnosed with Doyne honeycomb retinal dystrophy or familial dominant drusen. A summary of these findings is illustrated in figure 15.

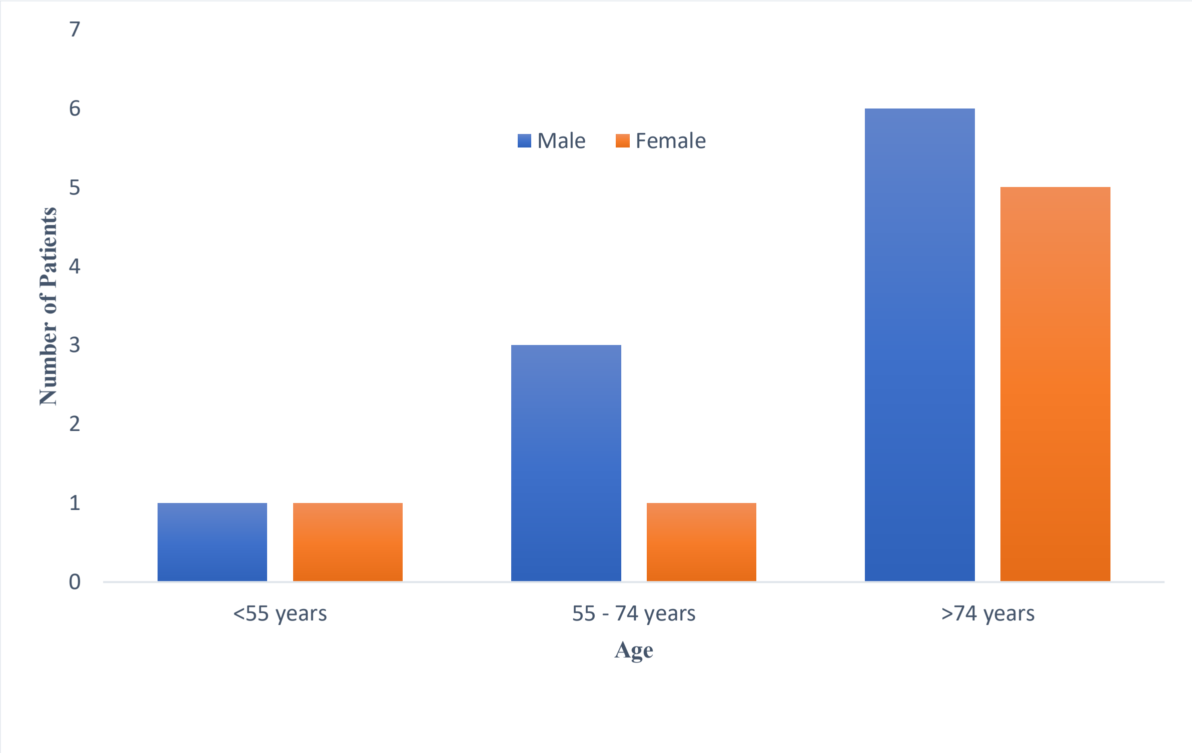

Figure 15. Demographics of patients diagnosed as AVMD by OSIs following referral to the EMAC service (n= 17).

Demographics of Ocular Conditions – Macular Hole

OSIs-diagnosed macular hole also accounted for over 5% of all referrals to EMAC within the three-month period. Eleven of 17 patients diagnosed with macular hole were female and the remaining six were male. The mean age of diagnosed female patients was 72.6 years (SD= 8.2 years); the youngest diagnosed at 61 years and the oldest diagnosed at 87 years. The average age of diagnosed male patients was 74.7 years (SD= 10.3 years); the youngest diagnosed at 57 years and the oldest diagnosed at 86 years. A two-tailed unpaired t-test showed no statistical significance between the mean ages of the two groups (p= 0.66). A summary of these findings is illustrated in figure 16.

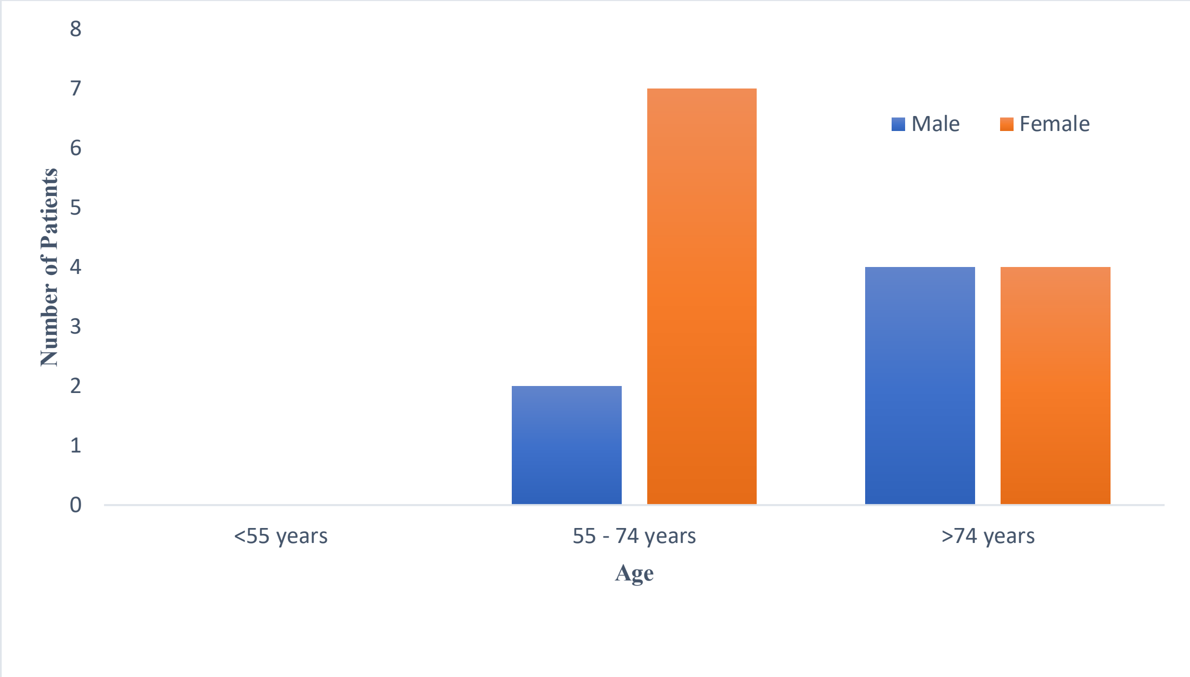

Figure 16. Demographics of patients diagnosed as macular hole by OSIs following referral to the EMAC service (n= 17).

Demographics of Ocular Conditions – CSR

OSIs-diagnosed CSR accounted for about 5% of all referrals to EMAC within the three-month period. Twelve of the 14 patients diagnosed with CSR were male and the other two were female. The average age of diagnosed male patients was 49.4 years (SD= 13.3 years); the youngest diagnosed at 27 years and the oldest diagnosed at 68 years. Only one patient, a 54-year-old male had CNV secondary to CSR requiring IVI treatment. A summary of these findings is illustrated in figure 17.

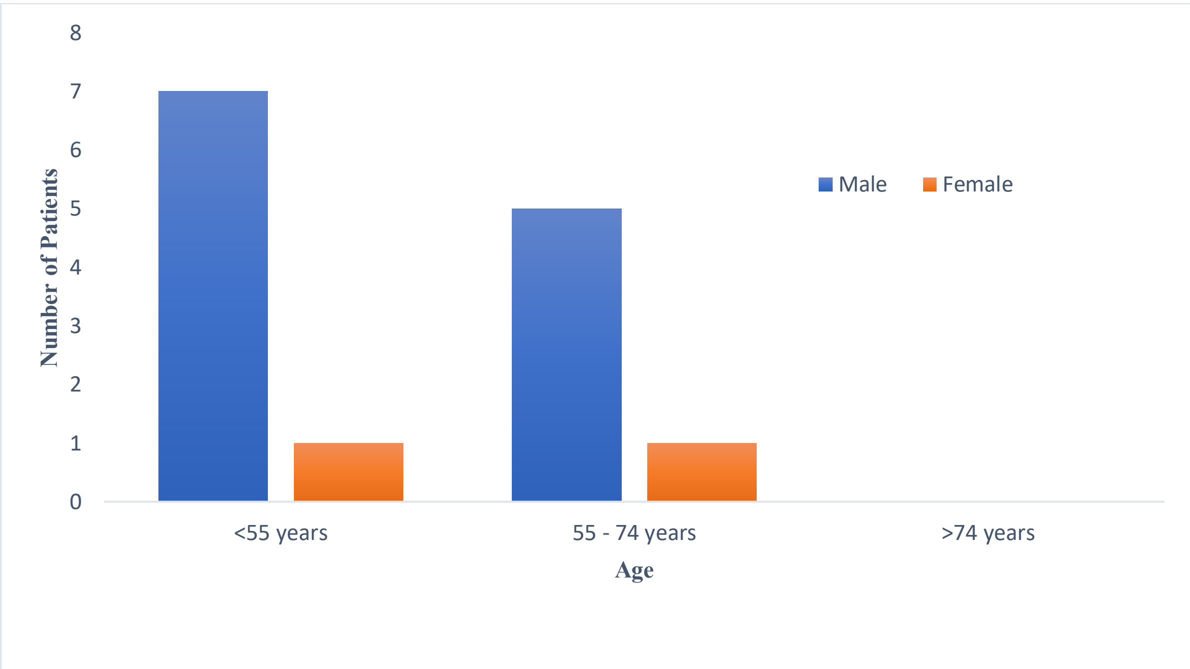

Figure 17. Demographics of patients diagnosed as CSR by OSIs following referral to the EMAC service (n= 14).

Demographics of Ocular Conditions – ERM

OSIs-diagnosed ERM accounted for over 4% of all referrals to EMAC within the three-month period. Six of 13 patients diagnosed with ERM were female and the remaining seven were male. The average age of diagnosed female patients was 74 years (SD= 16.1); the youngest diagnosed at 53 years and the oldest diagnosed at 93 years. The average age of diagnosed male patients was 65.3 years (SD= 12.7 years); the youngest diagnosed at 46 years and the oldest diagnosed at 85 years. A summary of these findings is illustrated in figure 18.

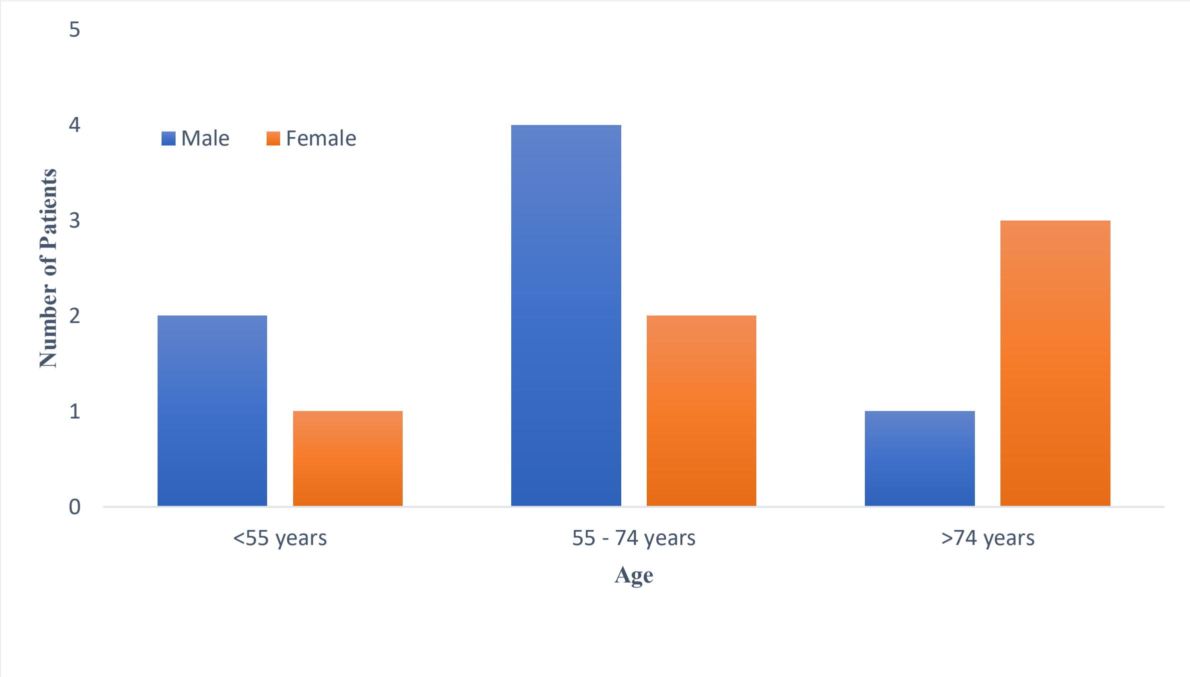

Figure 18. Demographics of patients diagnosed as ERM by OSIs following referral to EMAC (n= 13).

Demographics of Ocular Conditions – DR

OSIs-diagnosed DR accounted for 3.5% of all referrals to EMAC within the three-month period. Six of 11 patients diagnosed with DR were female and the remaining five were male. The average age of diagnosed female patients was 70 years (SD= 13.1); the youngest diagnosed at 55 years and the oldest diagnosed at 85 years. The average age of diagnosed male patients was 58 years (SD= 10.1 years); the youngest diagnosed at 49 years and the oldest diagnosed at 72 years. Only two patients, a 72-year-old male and a 65-year-old female had CSMO requiring IVI treatment. A summary of these findings is illustrated in figure 19.

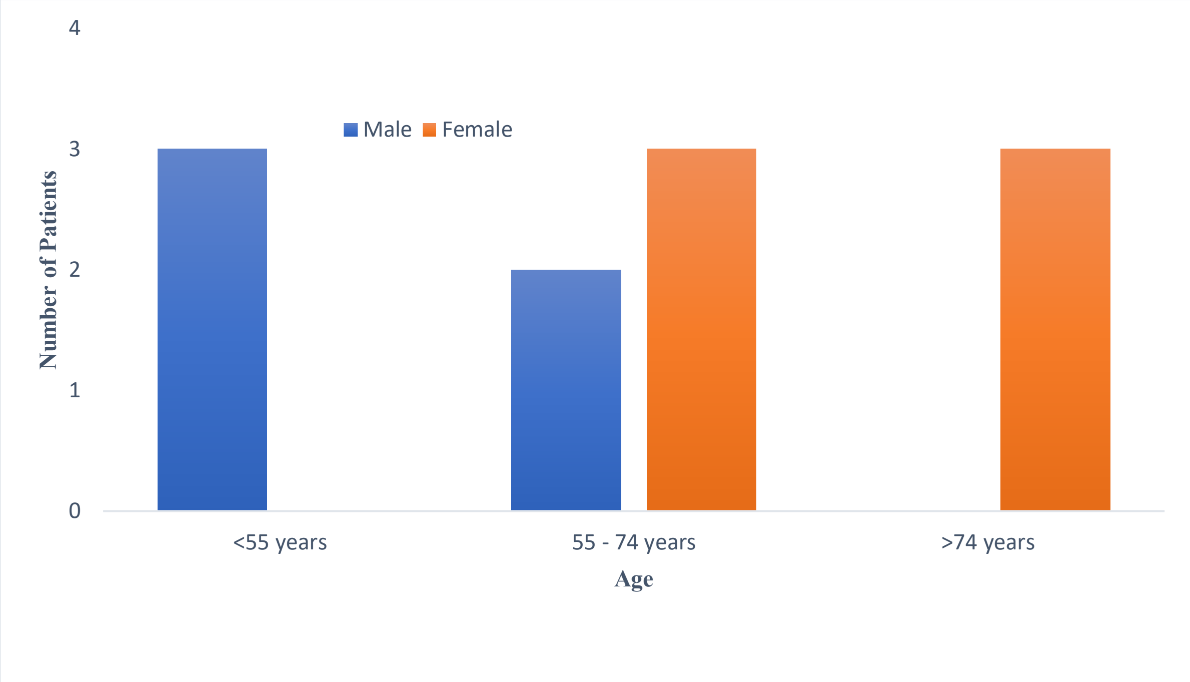

Figure 19. Demographics of patients diagnosed as DR by OSIs following referral to EMAC (n= 11).

Demographics of Ocular Conditions – CRVO

OSIs-diagnosed CRVO accounted for 2.2% of all referrals to EMAC within the three-month period. Four of seven patients diagnosed with CRVO were female and the other three were male. The age range of female patients was 41 to 68 years; only two patients had secondary CMO requiring IVI treatment. The age range of male patients was 69 to 74 years. Only one patient, a 72-year-old male had secondary CMO requiring IVI treatment.

Demographics of Other Ocular Conditions

Other notable ocular conditions referred to EMAC include MacTel, post-op CMO and myopic CNV. Five patients were provisionally diagnosed by OSIs as MacTel: two males and three females. Four patients were provisionally diagnosed with post-op CMO: two males and two females. Two patients were provisionally diagnosed with myopic CNV; one male and one female, both were 48 years of age, and both listed for IVI treatment.

Chapter Discussion

The chapter outlined referral patterns to EMAC from different sources and demographics of macular conditions referred to the service. Although the patient monthly attendance to EMAC in 2019 ranged between 100 to 110 patients, no statistically significant seasonal variation was observed for all conditions combined. This signifies a consistent resource demand throughout the year in terms of clinic staffing, EMAC appointment availability and treatment appointment availability for macular conditions requiring urgent intervention such as wet AMD, secondary CNVs, and RVOs with secondary CMO.

Seasonal variation in retinal conditions has only been studied for retinal detachment (RD), RVO, and CSR. Some studies showed the incidence of rhegmatogenous RD was significantly associated with seasonality and positively correlated to increases in environmental heat.[38-41] The incidence was highest during the summer months and lowest during the winter months. One study in Quebec, Canada showed elevated outdoor temperatures may be associated with an increased risk of tractional RD.[42] Conversely, more recent studies in Japan and Turkey did not show any significant seasonal variation for incidence of rhegmatogenous RD.[43,44] The reverse correlation has been found in RVOs, with several studies showing the incidence is highest during the winter months (January/February) and lowest during the summer months (July/August).[45-48] Conversely, two studies carried out in the 1990s in Armenia and Iowa, USA did not reveal any significant seasonal variation for incidence of RVOs.[49,50] Two studies carried out in the 1980s exploring the effect of seasonal variation on the incidence of CSR did not yield any statistically significant results.[51,52] However, one study showed an increased number of cases in the spring (March/April), whilst the other showed increased numbers in summer (June/July). Two more recent studies exploring this variation showed statistically significant differences.[53,54] Both studies showed prevalence of CSR was highest in the spring, although seasonal variation was statistically significant in one study.[53] The other study showed significant differences in monthly variation, with the highest prevalence recorded in April.[54]

In this study, nearly three quarters of all referrals to EMAC were from community optometrists and about 16% were from GPs, two predominant primary care groups referring to HES. This is analogous with studies showing the proportion of referrals from community optometrists to HES has been increasing (39% in 1988, 48% in 1999, and 72% in 2008).[55-57] Just a third of referrals from optometrists required urgent treatment, and only a sixth of referrals from GPs necessitated urgent treatment. This low percentage of appropriate referrals from optometrists is likely due to a combination of factors. This includes extent of clinical expertise, availability of technology (i.e., OCT and widefield imaging) in practice and ability to interpret the results, as well as appropriately managing patients through referral to the correct HES department in a suitable timeframe. These factors also likely contributed to a false positive (FP) rate of 5.2% for referrals from optometrists, where twelve patients referred to an emergency macular clinic were deemed as having no macular pathology by EMAC OSIs. A study assessing the value of OCT in diagnosing posterior segment disease in community optometry showed OCT improves optometrists' diagnostic performance and confidence compared to fundus imaging alone.[58] The average percentage of correct diagnoses using a combination of OCT and fundus imaging was 80%, an increase of 18% from using fundus imaging alone. The false negative rate reduced from 27% to 13% when OCT was used in combination with fundus imaging.

The much lower ratio of appropriate referrals from GPs is likely due to lack of specialist skills in this area and limited availability of suitable instrumentation required for diagnosing macular conditions, with substantial reliance on patient symptoms for diagnosis and referral. This is exacerbated by the growing strain on GP practices, with declining GP numbers looking after greater number of patients.[59] These factors likely contributed to the FP rate of 14%, where one in seven patients referred were deemed by OSIs as having no macular abnormalities. A study reviewing 1000 referrals to Walsall's HES showed approximately 57% of referrals were from optometrists, over 14% of referrals were from GPs, and the other 29% were from other sources.[60] The FP rate for optometrists' referrals was similar to this study's (6.2%) but was only 7.7% for GPs' referrals. Another study looking at referrals from GPs and optometrists to an ophthalmologist's practice in Belfast over a three-month period showed a similar FP rate of 6.5% and 7.4% for optometrists and GPs, respectively.[57] Whilst the FP rates of these studies were similar to that of this study's for optometrists' referrals, the FP rate for GPs' referrals in this study was nearly double, likely due to some of the aforementioned factors.

Three key messages arise from the low ratio of appropriate referrals from primary care (GPs and optometrists), as illustrated in figure 6. Firstly, unless definitively certain of the diagnosis, GPs should advise patients to see an optometrist for full assessment and diagnosis of a macular condition prior to referring to EMAC. Secondly, there is evidence optometrists would benefit from regular teaching and training in diagnosing and managing macular conditions. Finally, frequent and effective communication and feedback between HES and primary care is required to improve optometrists' diagnostic abilities and management of macular conditions.

Considering the primary reason for inception of the EMAC service and an ageing population, it is unsurprising about half the referrals were diagnosed as AMD by EMAC OSIs. The mean age for all patients presenting with dry and wet AMD was 77.8 and 82.1 years, respectively. This is in line with well-established literature that ageing is the most consistent non-modifiable environmental risk factor for AMD; prevalence of advanced forms of the disease increases with each decade of life, and highest after 75 years of age.[61-63] Gender and ethnicity have also been identified as significant non-modifiable risk factors, with several studies showing that Caucasian female individuals are more susceptible to develop severe, advanced forms of AMD.[64-66] These factors were found in this study, since 60% of patients diagnosed with AMD were female, and although statistically insignificant, female patients were on average 2.5 and 2.3 years older than their male counterparts for dry and wet AMD, respectively. Other risk factors associated with AMD include smoking, family history of AMD, cardiovascular disease, high body mass index, sedentary lifestyle, and high fat diet with limited antioxidant compounds.[64,67-75] Approximately 29% of referred patients diagnosed with AMD (45) reported smoking on the EMAC patient questionnaire. Over 13% of patients (20) described themselves as previous smokers, with the remaining 91 patients being non-smokers.

RVO was the second-most diagnosed condition by OSIs, accounting for 12.1% of all referrals. Although studies suggest RVO is the second most common retinal vascular disorder following DR, in this study, more patients with RVO were referred to EMAC than DR or diabetic-related conditions (e.g., CSMO).[76] This is due to EMAC guidelines that specify referrals of RVO with secondary CMO should be directed to EMAC, while DR and other related conditions should be referred to the MR subspeciality, which encompasses diabetic clinics. RVO, broadly classified as BRVO or CRVO, is a condition with a global prevalence of 28.06 million in 2015; a sixth of those affected have CRVO, while the rest diagnosed with BRVO.[77] Hypertension is the main risk factor for developing RVO, and though the prevalence increases with age, there are no significant inter-sex differences. The aforesaid factors were also found in this study, with a little over a sixth of patients diagnosed with CRVO, while the remaining patients diagnosed with BRVO. All but two patients diagnosed with RVO had pre-existing hypertension or were subsequently diagnosed with hypertension following blood testing carried out by the GP at the request of the EMAC OSI. Interestingly, BRVO-diagnosed female patients were on average thirteen years older than their male counterparts, while CRVO-diagnosed male patients were on average over fourteen years older than their female counterparts. Though these differences were individually statistically significant, there was no statistically significant age difference between both sexes for all RVOs combined, in line with existing literature.[77]

AVMD accounted for over 5% of referrals to EMAC. This is likely due to overlap of observed clinical and OCT signs between AVMD and AMD, which include drusen, SRF, and PED. Additionally, most symptomatic patients fall in the same age group as those with AMD and report similar visual symptoms such as metamorphopsia and reduced or loss of central vision. First described by Gass in 1974, it was known as 'peculiar foveomacular dystrophy', but later renamed adult-onset foveomacular vitelliform dystrophy and classified as a form of pattern dystrophy.[78] Its age of onset remains highly variable, but more recent studies suggest the mean age of diagnosis ranges between the 6th to 8th decade of life.[79,80] Patients remain asymptomatic till the 5th decade, and some may even remain asymptomatic throughout life.[81] Findings of this study aligned with existing literature, as only two patients were in their 5th decade, with all other referred patients in their 7th decade or older. The average age of AVMD patients in this study was 75.3 years, which was similar to two studies evaluating characteristics and management of AVMD.[82,83]

Similarly, macular hole accounted for over 5% of referrals to EMAC. This is likely due to the overlap of observed clinical and OCT signs between macular hole and AMD, which include a raised central lesion and IRF. Furthermore, most symptomatic patients fall in the same age group as those with AMD and report similar visual symptoms such as loss of central vision and metamorphopsia. It was first reported by Knapp in 1869 secondary to trauma,[84] however, the term 'hole in the macula' was used by Ogilvie in 1900.[85] The age of onset for macular hole is usually the 6^{th} or 7^{th} decade,[86] and it is three times more likely to occur in females than in males.[87] Results of this study generally aligned with existing literature, where all patients referred were in their 6^{th} decade or older, with an average age of 73.4 years and a range of 57 to 87 years. Moreover, nearly two-thirds of all patients later diagnosed by EMAC OSIs as having macular hole were female.

CSR accounted for about 4.5% of referrals to EMAC. This is likely due to overlap of observed clinical and OCT signs between CSR and AMD, which include SRF and PED. Furthermore, most symptomatic patients report comparable visual symptoms such as metamorphopsia and reduced central vision. First described by von Graefe in 1866, it was known as 'recurrent central retinitis' and characterised by recurrent serous detachment.[88] It was later renamed 'central serous retinopathy' by Bennet in 1955 and is now widely known as 'central serous chorioretinopathy' since the disease involves both the retina and choroid.[89] The age of onset for most CSR patients is between 28 to 68 years, with a mean age of 43 years.[90] Studies showed a higher prevalence of CSR among men, with 72% to 88% occurring in male patients,[91,92] and a 6-times higher incidence in men than in women.[93] However, CSR tends to occur at later ages in women.[93,94] Findings of this study aligned with existing literature, with an age of onset ranging between 27 to 68 years for referred patients, and a mean age of 49.8 years. With twelve males and two females referred, the 6-times higher incidence rate was also observed. The two affected females were 48 and 56 years of age, in line with literature suggesting a later age of onset in women.

In summary, it is evident that demographics of common macular conditions referred to EMAC over the three-month period generally aligns with current literature. It is therefore important for primary care practitioners, especially optometrists, to account for these characteristics and utilise them as an additional helpful tool to aid diagnosis and appropriately manage patients. Correctly diagnosing patients in primary care ensures patients are only referred to HES, when necessary, with referrals made to the correct department with an appropriate level of urgency. This can help relieve the overall burden on HES, and most importantly, ensure patients receive the appropriate management in a timely manner, thus, improving their visual outcomes.

Chapter IV – Management & Treatment Outcomes of Referred Macular Conditions

Chapter three highlighted referrals patterns to EMAC and demographics of macular conditions referred to the service. This chapter explores treatment outcomes of these macular conditions following referral to the service, with greater focus on wet AMD. This emphasises the impact of prompt urgent referral of certain macular conditions like wet AMD, RVOs with secondary CMO, and secondary CNVs to EMAC on better visual outcomes through early intervention. It also shows the importance of correctly referring other macular conditions to the appropriate department in HES, allowing for timely investigation and intervention.

Similar to the previous chapter, the analysis will encapsulate all data collected throughout the project between August 1st, 2019, and October 31st, 2019, for a total of 314 patients. Visual outcomes one-year post-treatment will be further analysed for various macular conditions.

Clinical Outcomes of EMAC referrals

A clinical outcome refers to management decisions of OSIs after subsequently reviewing notes of patients referred to the EMAC service. Nearly 59% (184) of all referrals to EMAC over the three-month period were subsequently triaged by OSIs to the MR clinic; over 31% (98) of patients were triaged to MTC to initiate or resume IVI treatment; over 8% (26) of patients were triaged to the VR clinic. For the remaining six patients, three were discharged, one referred to glaucoma clinic, one referred to a cataract centre, and one referred to primary care clinic (PCC). A summary of these findings is illustrated in figure 20.

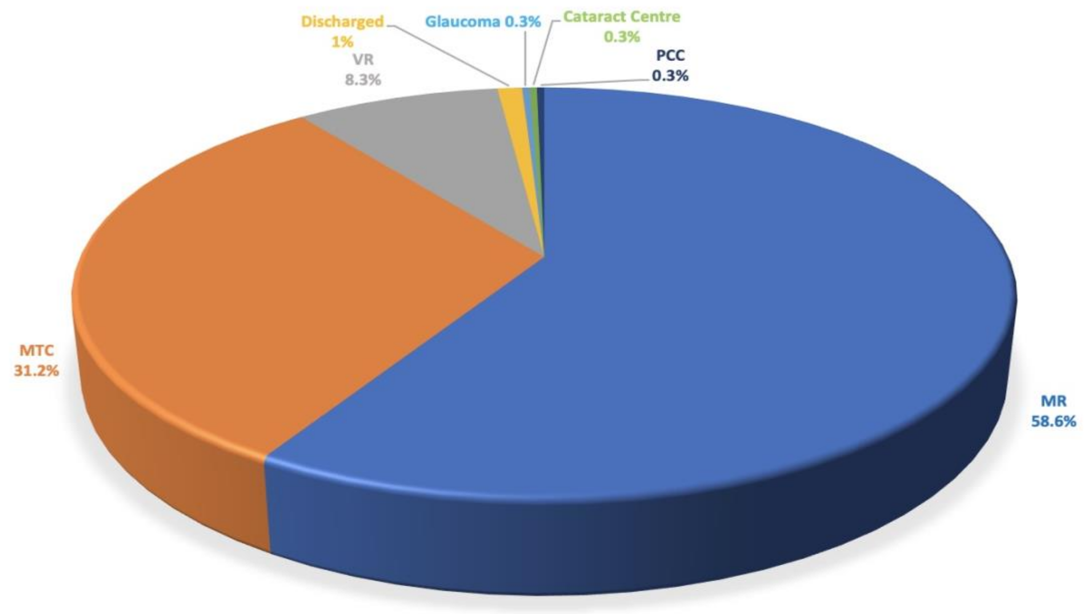

Figure 20. Clinical outcomes of EMAC referrals by OSIs (n= 314). Abbreviations: *MR* medical retina, *MTC* macular treatment centre, *VR* vitreoretinal, and *PCC* primary care clinic.

Management Outcomes for Wet AMD

As previously mentioned, 24.5% (77) of all referrals to EMAC within the three-month period were provisionally diagnosed as wet AMD. Whilst provisional diagnoses for all referrals are solely made by OSIs after subsequently reviewing the patient notes, wet AMD is an exception. As previously described, two advanced OSPs at MREH have been trained to identify features of wet AMD on OCT and OCT-A scans and refer patients to MTC for same-day IVI treatment. This is only applicable to typical wet AMD cases where classic features of the disease are seen on the OCT scan, and a choroidal neovascular membrane (CNVM) has been detected on the OCT-A scan. However, all other macular cases including suspect wet AMD cases that require additional specialist imaging were subsequently reviewed by OSIs. Of 77 referrals tentatively diagnosed as wet AMD, nearly 60% (46) of patients were diagnosed by OSPs and referred for same-day treatment, and the remaining 40% (31) of patients were diagnosed by OSIs.

Treatment Outcomes for Wet AMD

In line with the RCOphth guidelines for management of AMD,[95] treatment for wet AMD must be commenced without delay, preferably within two weeks of detection of a treatable lesion or initial presence of symptoms. For the purpose of this project, an analysis was carried out to determine whether patients with wet AMD were treated within two weeks from the referral date. Over the three-month period, 93.5% (72) of patients were treated within two weeks. Four of the other five patients were offered a treatment appointment within two weeks from referral. The five patients were treated outside that period for the following reasons:

1. One patient initially declined treatment on their first MTC visit, but proceeded with the treatment on their follow-up visit four weeks later.
2. One patient altered their initial appointment due to personal reasons; the new date fell outside the two-week period.
3. One patient had blepharitis and consequently, treatment was delayed till the infection resolved. Treatment was administered on their follow-up visit two weeks later.
4. One patient required an FFA to conclusively diagnose their condition, which was done two weeks following their initial appointment.
5. One patient was delayed due to a delay in their referral. The referral was received by the MREH's administrative team from the referring optometrist after 12 days. Whilst the patient was given an EMAC appointment 3 days from referral (in line with EMAC policy) and received same-day treatment, the two-week period was breached.

Five (6.5%) out of the 77 patients diagnosed with wet AMD presented with bilateral disease. A further eight patients who initially presented with unilateral disease developed wet AMD in the fellow eye within one year. Although a total of 90 eyes were available for further analysis regarding treatment and visual outcomes one-year post-treatment, only 66 patients (78 eyes) had a year's follow up data available and were included in the analysis. The remaining eleven patients (twelve eyes) were excluded from analysis due to the following reasons:

1. Eight patients passed away within first year of treatment.
2. One patient with bilateral disease declined treatment at initial visit and was discharged after failing to attend a further four appointments.
3. One patient had four IVIs before they were discharged after cancelling and failing to attend multiple appointments.
4. One patient provisionally diagnosed with wet AMD had an FFA, which revealed CSR as the formal diagnosis.

For patients included in the analysis, twelve (18.2%) developed bilateral disease. About 43% (23) of those presenting with unilateral disease (54) were affected in the left eye with the remaining 57% (31) affected in the right eye.

IVI Treatment & Visual Outcomes for Wet AMD

Aflibercept (known in literature as VEGF Trap-Eye; Regeneron, Tarrytown, New York, USA and Bayer Healthcare, Berlin, Germany) and ranibizumab (Genentech Incorporation, South San Francisco, California, USA and Novartis AG, Basel, Switzerland) were the only two IVI drugs approved by the national institute for health and care excellence (NICE) for treatment of wet AMD in MTC at the time of this study. In June 2022, NICE approved IVI Faricimab (Roche Holding AG, Basel, Switzerland) for treating wet AMD. A ranibizumab-biosimilar known as Ongavia (Teva Pharmaceuticals, Tel Aviv-Yafo, Israel) has also been approved in the UK for treatment of wet AMD, amongst other macular conditions. For the purpose of this text, aflibercept, ranibizumab, and faricimab will be referred to as Eylea, Lucentis and Vabysmo, respectively.

About 63% (49 eyes) were treated with Eylea with the remaining 29 eyes (37%) treated with Lucentis. For the 41 Eylea-treated patients, 22 were female and 19 were male, with an average age of 81.5 years (SD= 7.5 years). For the 25 Lucentis-treated patients, 16 were female and 9 were male, with a mean age of 81.7 years (SD= 8.0 years). A two-tailed unpaired t-test showed no statistical significance between the average ages of the two groups (p= 0.91). The average number of Eylea injections administered in the first year was 7 (SD= 2.2 injections). The least frequently treated patients received three Eylea injections (i.e., loading dose only) in the first year, whilst the most frequently treated patients received twelve Eylea injections in the same period (i.e., monthly injections). In contrast, the mean number of Lucentis injections given in the first year was 6.6 (SD= 2.7 injections). The least frequently treated patients received three Lucentis injections (i.e., loading dose) in the first year, whilst the most frequently treated patients received eleven injections in the same period. No statistical significance was noted between the average number of Eylea and Lucentis injections administered in the first year of treatment ($p = 0.50$).

The average baseline VA for patients treated with Eylea injections was 57.3 letters (SD= 13.7 letters). The average VA one-year post IVI-treatment was 65.8 letters (SD= 12.2 letters), with an average VA gain of 8.5 letters (SD= 9.2 letters). Visual gain was reported in approximately 84% (41) of eyes one-year post-treatment, ranging between 1 and 31 letters. Visual gain of up to 20 letters was noted in nearly 70% of eyes. Over 14% of eyes experienced visual gain of more than 20 letters. About 8% (4) of eyes had no gain or loss, and visual loss was reported in 8% (4) of eyes. No patients experienced a loss of five letters or more. A two-tailed paired t-test showed statistically significant visual gain one-year post Eylea treatment ($p < 0.001$).

The average baseline VA for patients treated with Lucentis injections was 58.5 letters (SD= 16.6 letters). The average VA one-year post IVI-treatment was 63.2 letters (SD= 14.7 letters), with an average VA gain of 4.7 letters (SD= 12.7 letters). Visual gain was reported in 62% (18) of eyes one-year post-treatment, ranging between 1 and 43 letters. Visual gain of up to 20 letters was noted in nearly 52% of eyes. Over 10% of eyes experienced visual gain of more than 20 letters. One patient had no visual gain or loss. Visual loss was reported in over one-third (10) of eyes; 90% ranged between 1 and 10 letters of loss with one patient losing 20 letters one-year post-treatment. A two-tailed paired t-test showed statistically insignificant visual gain one-year post Lucentis treatment ($p = 0.056$). Table 2 compares visual outcomes one-year post Eylea and Lucentis IVI treatments.

Table 2. Visual outcomes one-year post Eylea and Lucentis IVIs in wet AMD patients.

	Eylea (total n= 49)	**Lucentis** (total n= 29)
	Number of eyes, n (%)	Number of eyes, n (%)
Visual Gain (Letters)		
>40	0 (0%)	1 (3.45%)
>30 to ≤40	1 (2%)	0 (0%)
>20 to ≤30	6 (12.2%)	2 (6.9%)
>10 to ≤20	10 (20.4%)	5 (17.25%)
>0 to ≤10	24 (49%)	10 (34.5%)
No Visual Gain or Loss	4 (8.2%)	1 (3.45%)
Visual Loss (Letters)		
>0 to ≤10	4 (8.2%)	9 (31.0%)
>10 to ≤20	0 (0%)	1 (3.45%)

It is worth noting two patients (two eyes) initially treated with Lucentis and experienced visual loss one-year post-treatment were switched to Eylea and achieved visual gain. One patient lost seven letters despite having 7 Lucentis injections in the first year. They were later switched to Eylea and gained 14 letters from baseline VA in the year after. The other patient lost six letters despite having 9 Lucentis injections in the first year. They were later switched to Eylea and gained eight letters from baseline VA. Finally, no statistical significance was noted between the visual gains achieved one-year post-Eylea and Lucentis treatments (p= 0.137).

Wet AMD Classification

Treatment-naïve wet AMD patients were classified into four broad subtypes:

1. Type I – occult CNVM
2. Type II – classic CNVM
3. Type III – retinal angiomatous proliferation (RAP)
4. Polypoidal Choroidal Vasculopathy (PCV)

Unlike the preceding sections, all 89 eyes formally diagnosed as wet AMD will be used in this analysis, irrespective of whether they were treated. Thirteen eyes were classified as Type I CNVM and nearly a quarter of eyes (22) were deemed to have a RAP lesion. Over 57% of eyes (51) revealed signs consistent with a classic CNVM, and only three eyes were categorised as PCV. A breakdown of subtypes is summarised in figure 21.

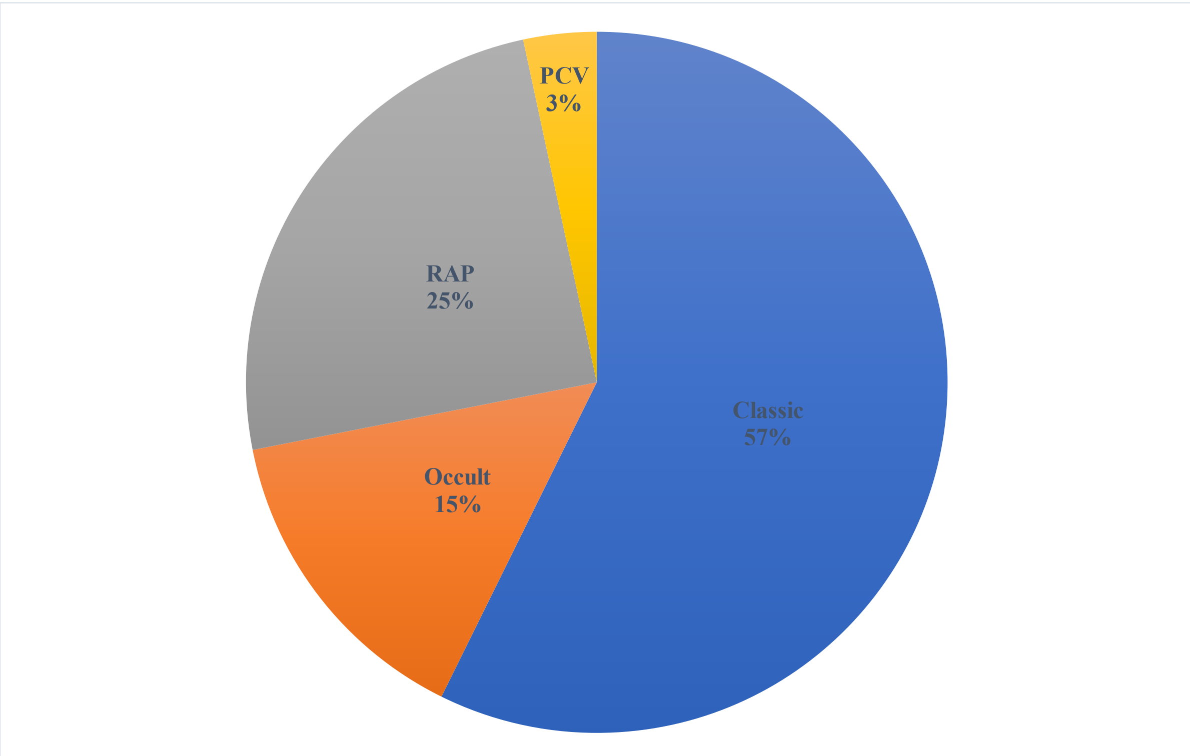

Figure 21. Subtypes of eyes diagnosed with wet AMD (n= 89). Abbreviations: *RAP* retinal angiomatous proliferation and *PCV* polypoidal choroidal vasculopathy.

OCT-A & Wet AMD

Furthermore, an assessment was carried out to establish the effectiveness of using of OCT-A to diagnose wet AMD in comparison to the gold standard FFA. Over 88% (68) of patients did not require an FFA as their diagnosis of wet AMD was evident through the OCT and OCT-A scans. The remaining nine patients all had an FFA for the following reasons:

1. OCT and OCT-A scans were inconclusive for seven patients, and an FFA was required to confirm the diagnosis prior to initiating treatment.
2. An FFA was required for a patient to rule out other differential diagnoses. The patient had mixed pathology and FFA was required to confirm presence of wet AMD.
3. Due to positioning difficulties, poor-quality OCT and OCT-A scans were obtained for a patient during their EMAC visit, and an FFA was required to confirm the diagnosis.

Eyes classified with Type II (classic) CNVM were further analysed. OCT-A scans were used to measure the CNVM size along its widest diameter. The analysis only included 48 out of 51 eyes; OCT-A scans were not performed for the other 3 eyes, all in patients who developed wet AMD in the fellow eye within one year and started on IVI treatment based on clinical findings and an OCT scan. The average CNVM size was 2.52 μm (SD= 0.84 μm) with a range of 0.43 μm to 3.74 μm. Six eyes had a CNVM smaller than 1.50 μm in size, with fifteen eyes having a CNVM larger than 3.00 μm in size. The remaining 27 eyes had a CNVM size between 1.50 μm and 3.00 μm in size. The findings are summarised in table 3.

Table 3. Type II (classic) CNVM sizes (n= 48). Abbreviations: *CNVM* choroidal neovascular membrane and *μm* micrometres.

CNVM Size (μm)	Number of Eyes, n (%)
<1.50	6 (12.5%)
1.50 to 3.00	27 (56.3%)
>3.00	15 (31.2%)

A linear regression analysis was carried out to establish whether the frequency of injections given over the first year of treatment was correlated to the size of the CNVM. Only 41 out of 48 eyes were used for this analysis; the other 7 eyes were excluded due to reasons explained earlier in this chapter. No statistically significant correlation was found between CNVM size, and the number of injections administered in the first year of treatment; r (39) = 0.07, p= 0.68. A weak positive correlation was observed, as illustrated in figure 22.

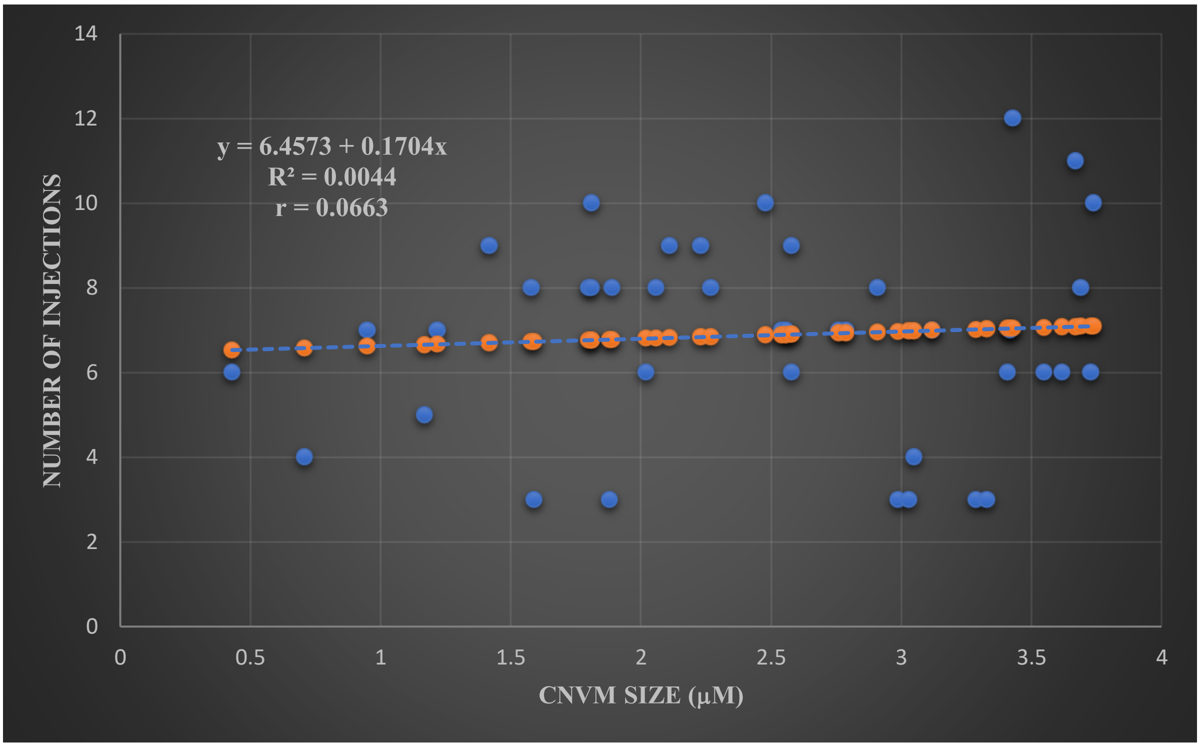

Figure 22. Correlation between CNVM size and the number of injections administered in first year of treatment.

Management & Treatment Outcomes for RVOs

The RCOphth does not specify particular timelines for treating other macular conditions (e.g., vascular conditions) with IVI agents in the manner specified with treating wet AMD. Urgency of treatment is dependent on detriment to visual prognosis, established through visual acuity at presentation, extent of ischaemia, and the patient's cardiovascular profile (with greater focus on blood pressure, blood sugar levels and lipid profile). However, a similar analysis was done to evaluate management and treatment outcomes of these conditions. In total, 38 patients were provisionally diagnosed with an RVO; 31 had a BRVO and 7 had a CRVO.

Out of 31 patients provisionally diagnosed with BRVO, two patients had a macular RVO, and two patients had an HRVO. Only 13 patients had secondary CMO that required IVI treatment. Over 92% of patients (12) were treated within two weeks from referral. The remaining patient was treated outside of that timeline due to a delay in their referral to MREH's administrative team. All 18 patients without secondary CMO were triaged to the MR clinic, and seen within six weeks from referral, in line with internal protocols. Out of 7 patients tentatively diagnosed with CRVO, three patients had secondary CMO that required IVI treatment, all treated within two weeks from referral. The other four patients were seen in the MR clinic within six weeks from referral, in line with internal protocols. These findings are summarised in table 4.

Table 4. Classification of provisionally diagnosed RVOs following referral to EMAC (n= 38). Abbreviations: *CMO* cystoid macular oedema, *RVO* retinal vein occlusion, *CRVO* central vein occlusion, *BRVO* branch retinal vein occlusion, and *HRVO* hemi-retinal vein occlusion.

	With Secondary CMO (n)	**Without Secondary CMO (n)**
BRVO	10	17
HRVO	2	0
Macular RVO	1	1
CRVO	3	4

IVI Treatment & Visual Outcomes for RVOs with CMO

As previously mentioned, 16 patients (13 BRVO; 3 CRVO) were provisionally diagnosed with CMO secondary to an RVO. All patients presented with unilateral disease. A total of 16 eyes were available for analysis regarding treatment and visual outcomes one-year post-treatment. However, one patient/eye was excluded from analysis as the patient declined further treatment after receiving four IVIs and was discharged five months from initial presentation. This small sample size poses several limitations such as increased likelihood of random sampling errors, increased vulnerability to outliers as well as increased risk of types I and II errors due to limited statistical power. Moreover, subgroup analysis such as assessment of the post-treatment visual outcomes of different IVIs is limited. All these factors combined can lead to overall reduced generalisability of the results and biases in conclusions.

All CRVO patients were treated with Eylea. The mean number of injections administered in the first year was 5.3 (SD= 2.1 injections). The least frequently treated patient received three injections (i.e., loading dose only) in the first year, whilst the most frequently treated patients received seven injections over the same period. The average baseline VA for CRVO patients was 45.7 letters (SD= 5.1 letters). The mean VA one-year post IVI-treatment was 63 letters (SD= 24.9 letters), with an average VA gain of 17.3 letters (SD= 24.8 letters). Visual gain was noted in two patients one-year post-treatment; one patient gained 28 letters, whilst the other gained 35 letters. However, the third patient had ischaemic CRVO, and lost 11 letters despite IVI and pan-retinal photocoagulation (PRP) treatment, as they developed an atrophic macula. Visual gain reported one-year post Eylea treatment was not statistically significant (p= 0.30).

Approximately 85% (11) of BRVO patients were treated with Eylea with the remaining two patients (15%) treated with Lucentis. The average number of Eylea injections administered in the first year was 7 (SD= 2.3 injections). The least frequently treated patient received four Eylea injections in the first year, whilst the most frequently treated patients received ten Eylea injections over the same period. In contrast, the average number of Lucentis injections given in the first year was 7.5 (SD= 0.7 injections). One patient received seven Lucentis injections in the first year, with the other patient receiving eight injections over the same period. No statistical significance was noted between the mean number of Eylea and Lucentis injections administered in the first year of treatment (p= 0.77).

The average baseline VA for patients treated with Eylea injections was 52.6 letters (SD= 14.4 letters). The average VA one-year post IVI-treatment was 67.2 letters (SD= 9.9 letters), with a mean VA gain of 14.6 letters (SD= 14.4 letters). Visual gain was reported in 80% (8) of eyes one-year post-treatment, ranging between 2 and 40 letters. Visual gain of up to 20 letters was noted in 60% of eyes, and two patients experienced visual gain of more than 35 letters. Visual loss was reported in two patients, however, neither experienced a loss of five letters or more. Visual gain reported one-year post Eylea treatment was statistically significant (p= 0.011).

The average baseline VA for the two patients treated with Lucentis injections was 69 letters (SD= 1.4 letters). The average one-year post IVI-treatment was 67.5 letters (SD= 9.2 letters), with a mean VA loss of 1.5 letters (SD= 10.6 letters). One patient gained six letters one-year post-treatment, while the other lost nine letters over the same period. The latter patient enjoyed a visual gain of 14 letters following the loading dose, but they were not regularly treated as the patient failed to attend or cancelled multiple appointments, lengthening the inter-treatment review intervals. Table 5 compares visual outcomes one-year post Eylea and Lucentis IVIs.

Table 5. Visual outcomes one-year post Eylea and Lucentis IVIs in BRVO patients.

	Eylea (total n= 10)	**Lucentis** (total n= 2)
	Number of eyes, n (%)	Number of eyes, n (%)
Visual Gain (Letters)		
>40	1 (10%)	0 (0%)
>30 to ≤40	1 (10%)	0 (0%)
>20 to ≤30	0 (0%)	0 (0%)
>10 to ≤20	5 (50%)	0 (0%)
>0 to ≤10	1 (10%)	1 (50%)
Visual Loss (Letters)		
>0 to ≤10	2 (20%)	1 (50%)

Management & Visual Outcomes for RVOs without CMO

As previously mentioned, 22 patients (18 BRVO; 4 CRVO) were provisionally diagnosed with an RVO without secondary CMO. Since all patients presented with unilateral disease, a total of 22 eyes were available for analysis regarding management (if any), and visual outcomes one-year post-presentation to EMAC. However, one patient with BRVO was excluded from analysis as they passed away prior to their first MR clinic review.

All four CRVO patients presented with pathology in the left eye. Three did not have any CMO during EMAC or the subsequent MR clinic review. However, one patient with mild off-centre oedema during EMAC developed centre-involving oedema six weeks later, noted at their MR clinic review. They were referred to MTC for IVI treatment and only required three Lucentis injections (i.e., loading dose) in the first year. A visual gain of two lines was attained following treatment. The average baseline VA for all CRVO patients was 64.3 letters (SD= 8.42 letters), with a range of 55 to 68 letters. All patients were regularly monitored in the MR clinic as per internal protocols and none required extra diagnostic testing such as FFA.

All 17 BRVO patients had no CMO or chronic CMO not amenable to treatment. None of the patients required any form of treatment and only one patient required further diagnostic testing (FFA). The average baseline VA for all BRVO patients was 67.7 letters (SD= 19.7 letters), with a range of ‘Hand Movements’ to 90 letters. About 59% (10) of patients were discharged one-year post-presentation to EMAC. Six of these patients had a longstanding RVO that did not require further monitoring, whilst the other four had complete resolution of the RVO and were discharged as a result. For the remaining seven patients, four were regularly monitored in F2F MR clinics, two were monitored in the virtual MR clinic (MRAC), and the final patient was referred to the corneal clinic due to reduced vision secondary to a corneal dystrophy. The management outcomes for BRVO patients are summarised in figure 23.

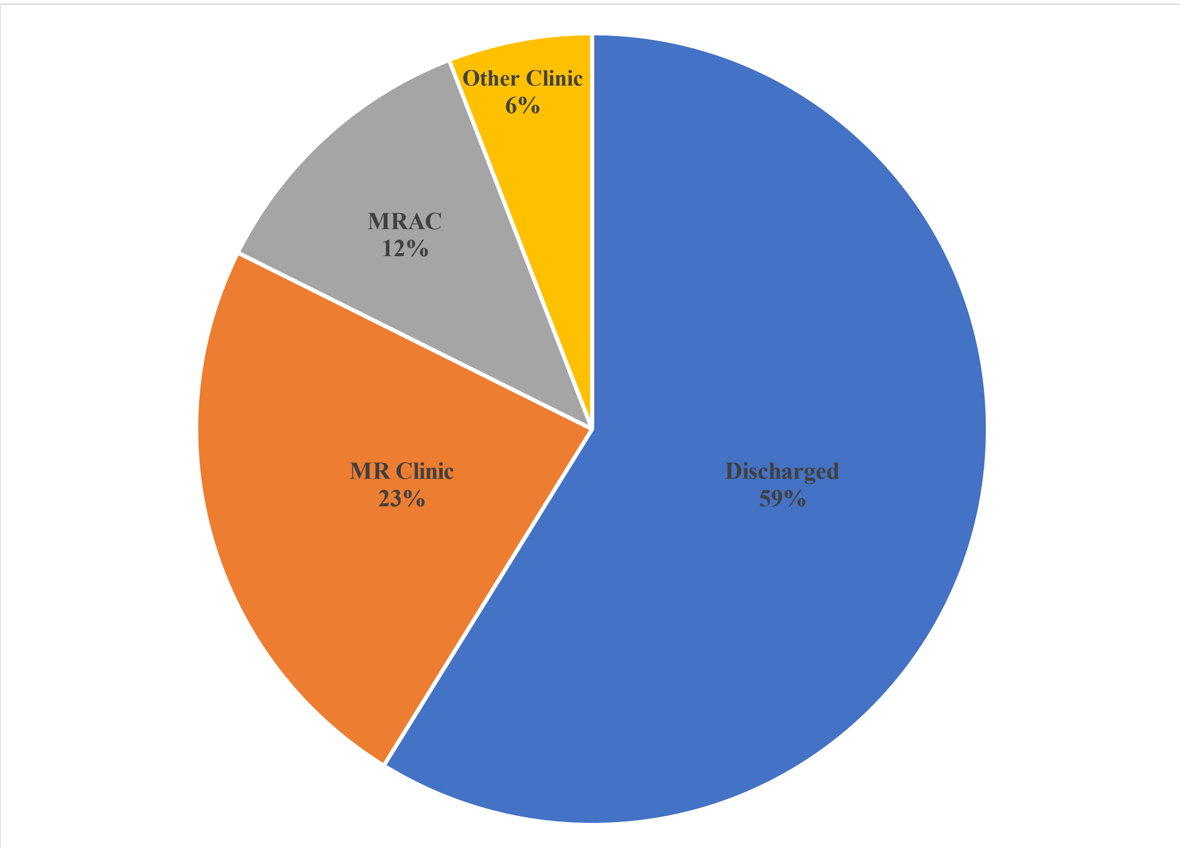

Figure 23. Clinical outcomes of patients with BRVO without CMO (n= 17). Abbreviations: *MR* medical retina, and *MRAC* medical retina assessment clinic.

Management & Treatment Outcomes for Myopic CNV

Only two patients were tentatively diagnosed with myopic CNV in EMAC and referred for IVI treatment in MTC. Both received an appointment within two weeks from referral. One patient received treatment, requiring one Lucentis injection in the first year. The OCT-A revealed a CNVM size of 1.17 mm. The baseline VA was 35 letters, and three letters were gained one-year post-treatment. The other patient had an FFA that showed an inactive CNVM. In the absence of patient symptoms and any change on OCT, monitoring without treatment was advised. The patient was discharged following three further reviews.

Management & Treatment Outcomes for DR & CSMO

Out of 11 patients tentatively diagnosed with DR and/or DMO, only two patients had centre involving DMO or CSMO that required IVI treatment. Both were offered an appointment for treatment within two weeks, but both altered their appointment due to personal reasons, and treatment was initiated outside that timeline. A total of 3 eyes were included in the analysis as one patient had bilateral disease. Both patients received Eylea injections. The average number of injections administered in the first year was 6.3 (SD= 2.3 injections). The patient with bilateral CSMO had five injections in the first year in each eye, while the other patient received nine injections over the same period. The mean baseline VA was 64.3 letters (SD= 3.2 letters). The mean VA one-year post IVI-treatment was 70.7 letters (SD= 2.9 letters), with a mean VA gain of 6.3 letters (SD= 5.0 letters). Visual gain was noted in all eyes one-year post-treatment, ranging between 1 and 11 letters. However, this was not statistically significant ($p= 0.064$).

An MR or diabetic clinic review was requested for the remaining nine patients with DR and/or DMO. Two patients were discharged after failing to attend multiple clinic appointments. The remaining seven patients were all Type 2 diabetics. The average duration of diabetes was 20.9 years (SD= 10.4 years), with a range of 10 to 40 years. Only two patients required treatment within first year post-presentation to EMAC. One patient (male with diabetes duration of 18 years) had bilateral PRP for proliferative diabetic retinopathy (PDR), while the other patient (female with diabetes duration of 25 years) had left eye macular laser for DMO. Three out of seven patients required an FFA within the first year. One patient was discharged to the DESP, with the other six patients regularly monitored in F2F diabetic clinics (three patients) and the virtual diabetic clinic, EDAC (three patients).

Management & Treatment Outcomes for CSR

One patient was provisionally diagnosed with CNV secondary to CSR in EMAC and referred for IVI treatment. He received an MTC appointment within two weeks from referral. He had treatment, requiring nine Eylea injections in the first year. He had a baseline VA of 33 letters and gained five letters one-year post-treatment. The OCT-A revealed CNVM size of 3.43 mm.

The remaining 13 patients provisionally diagnosed with CSR without a secondary CNV were reviewed in the MR clinic within six weeks, in line with internal protocols. Three patients had bilateral disease with the remaining ten patients only affected unilaterally. The mean baseline VA was 79.6 letters (SD= 6.5 letters), and no patients required any form of treatment. Though, one patient had additional specialist imaging: FFA and ICG angiography. Three patients were discharged in the first year; one patient failed to attend multiple MR clinic appointments, while the other two had complete resolution of the condition and an excellent VA of 85 letters. Seven out of the ten remaining patients were monitored in MRAC, while the other three were monitored in a F2F MR clinic.

Management & Treatment Outcomes for Macular Hole

All 17 patients provisionally diagnosed with a macular hole presented with unilateral disease and were seen in the VR clinic. Six patients had a lamellar macular hole (LMH) with the remaining eleven patients presenting with a full-thickness macular hole (FTMH). Four out of six patients with LMH were reviewed in VR clinic, and discharged following their first clinic review, as surgical intervention was not indicated. One patient failed to attend their appointment and was discharged, whilst the other patient passed away prior to their first VR clinic review. The average VA for patients with LMH was 71.8 letters (SD= 5.9 letters).

All eleven patients with FTMH attended their VR clinic appointment and were subsequently listed for combined phacoemulsification and vitrectomy surgery. The average hole size was 469µm (SD= 123.2µm), with a range of 300µm to 670µm. Only ten patients underwent surgery, with the final patient failing to attend their surgery appointment and was subsequently discharged. Only patients who underwent surgery were included in the analysis for assessing post-surgical visual outcomes. The average baseline (pre-surgical) VA for these ten patients was 48 letters (SD= 8.6 letters). The average post-surgical VA was 55.2 letters (SD= 12.6 letters), for a mean visual gain of 7.2 letters (SD= 11.5 letters). Visual gain was achieved in 70% of cases, ranging from 1 to 32 letters. One patient achieved no gain or loss, and visual loss was reported in two patients. Post-treatment visual gain was not statistically significant ($p = 0.079$). Table 6 summarises aforesaid post-surgical visual outcomes. As previously noted, the small sample size poses numerous limitations including increased likelihood of random sampling errors, increased vulnerability to outliers, and increased risk of types I and II errors due to limited statistical power. This can lead to overall reduced generalisability of results and biases in conclusions.

Table 6. Post-surgical visual outcomes for patients with FTMH (n= 10).

	Number of eyes, n (%)
Visual Gain (Letters)	
>30 to ≤40	1 (10%)
>20 to ≤30	0 (0%)
>10 to ≤20	2 (20%)
>0 to ≤10	4 (40%)
No Visual Gain or Loss	1 (10%)
Visual Loss (Letters)	
>0 to ≤5	2 (20%)

Management & Treatment Outcomes for ERM

Thirteen patients were provisionally diagnosed with ERM. All but two patients presented with unilateral disease. A total of 15 eyes were available for analysis regarding treatment and visual outcomes post-surgical intervention. The average baseline vision for all affected eyes was 74.7 letters (SD= 11.1 letters). No patients with a VA equal to or better than 70 letters had surgical intervention. Three patients/eyes had VA worse than 70 letters, and the clinical outcomes were as the following:

1. One patient (baseline VA of 47 letters) was offered surgery, but she declined, and was later discharged, as per her preference.
2. One patient (baseline VA of 64 letters) was listed for cataract surgery, since she had a mild ERM with cataract being the visually limiting factor.
3. One patient (baseline VA of 59 letters) underwent ERM surgery (phacoemulsification, vitrectomy and ERM peel) resulting in a visual gain of 20 letters.

For the other ten patients, eight were discharged following their first VR clinic appointment, whilst the other two patients were given further clinic reviews in three months' time. The latter two patients/eyes had VA of 75 letters or better.

Management Outcomes of Patients without Macular Pathology

Twenty-one patient records reviewed in EMAC were deemed as having no obvious macular abnormalities based on their OCT and OCT-A scans. Fifteen patients were referred for suspect unilateral disease, with the remaining six patients referred for suspect bilateral pathology. A total of 27 eyes were available for analysis. Reduced VA was the most common chief reason for referral, followed by distortion. Other less common reasons for referral included macular changes, exudates, hyperopic shift, CMO, and peripapillary oedema. Findings are summarised in figure 24.

An MR clinic appointment was requested for 71.4% (15) of the aforementioned patients, while three patients were directly discharged from EMAC. One patient was seen in PCC, one in the glaucoma clinic, and one at the cataract centre. These results are summarised in figure 25. Two patients failed to attend their MR clinic review and were subsequently discharged. The average baseline VA for all eyes was 64.9 letters (SD= 18.9 letters). Only six patients (seven eyes) required treatment. Four patients/eyes had cataract surgery, and two patients (three eyes) had yttrium-aluminium-garnet (YAG) laser capsulotomy for posterior capsular opacification (PCO). All patients achieved visual improvement following treatment, with an average visual gain of 14.9 letters (SD= 6.3). Apart from one patient undergoing electrodiagnostic testing, no other patients had any additional specialist testing or imaging carried out.

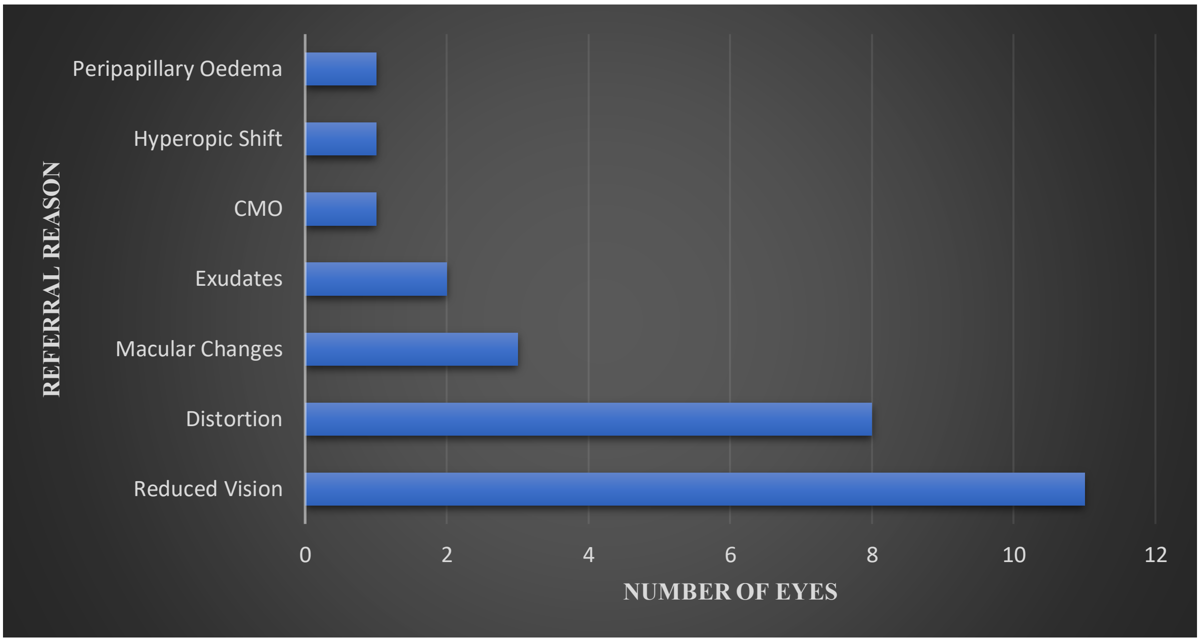

Figure 24. Primary reason of referral to EMAC for patients provisionally diagnosed as having no discernible macular abnormalities (n= 27). Abbreviation: *CMO* cystoid macular oedema.

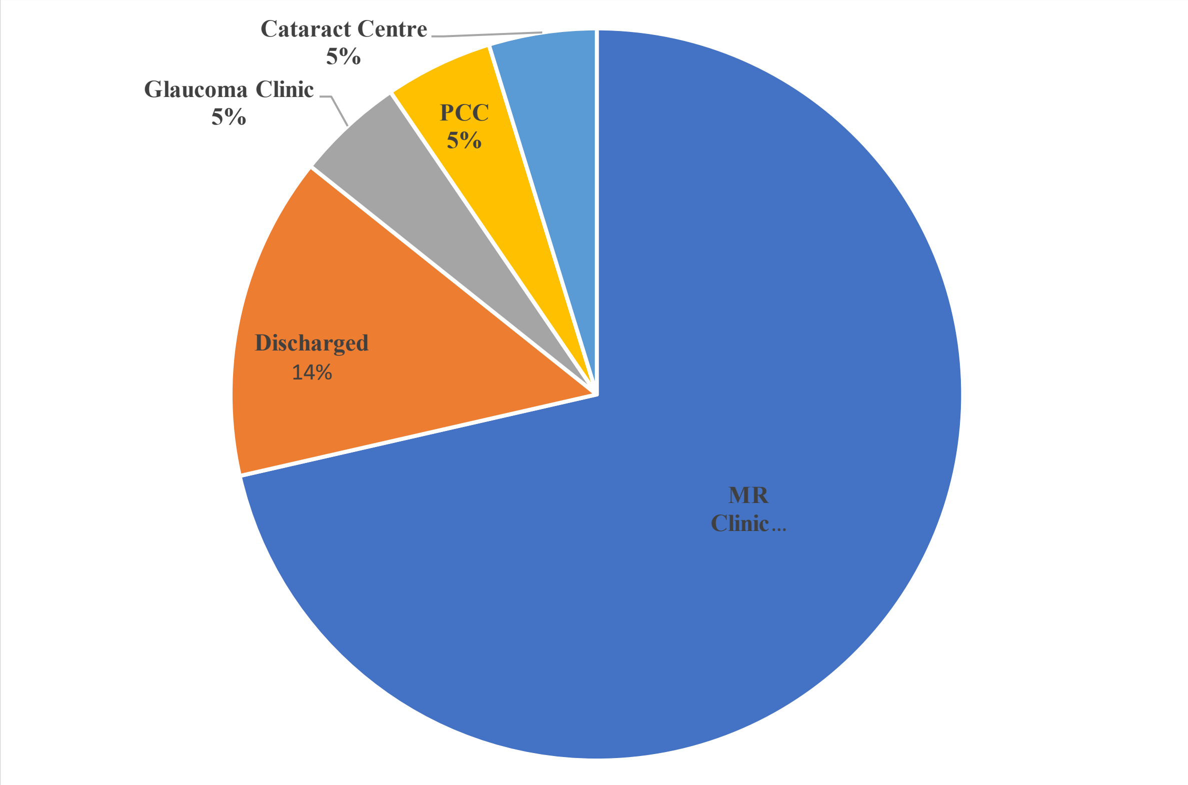

Figure 25. Clinical outcomes for patients tentatively diagnosed as having no evident macular abnormalities (n= 21). Abbreviations: *MR* medical retina, and *PCC* primary care clinic.

Further investigation was carried out to establish the aforesaid patients' clinical diagnosis and whether it aligns with the primary reason for referral. A formal clinical diagnosis is one made by an ophthalmologist once the patient is reviewed in a specialist clinic following triage in the EMAC service. The findings are detailed out in table 7.

Table 7. Formal clinical diagnosis for patients provisionally diagnosed as having no evident macular abnormalities in EMAC (n= 21). Abbreviations: *CMO* cystoid macular oedema, *RE* right eye, *LE* left eye, *PCO* posterior capsular opacification, *RPE* retinal pigment epithelium, and *MR* medical retina.

Patient #	Laterality	Reason for Referral	Formal Clinical Diagnosis
2	Right	Reduced vision	RE PCO
11	Right	Distortion	Nil; discharged from EMAC
86	Right	Reduced vision	Presbyopia
92	Right	Reduced vision	Did not attend MR clinic & discharged
116	Right	Reduced vision	RE pterygium
140	Right	CMO	Bilateral glaucoma suspect
141	Left	Hyperopic shift	Nil; discharged from EMAC
142	Right	Macular changes	RE Optic neuropathy & cataract
155	Left	Reduced vision	LE PCO
163	Right	Distortion	No macular abnormalities

171	Right	Distortion	RE visually significant cataract
175	Bilateral	Reduced vision	RE non-organic visual loss & cataract
184	Bilateral	Macular changes	Subtle RPE changes secondary to Pentosan Polysulfate Sodium (PPS)
214	Left	Reduced vision	Nil; discharged from EMAC
244	Bilateral	Distortion	Functional visual loss
255	Right	Distortion	Longstanding cerebral aneurysm
269	Bilateral	Reduced vision	Bilateral PCO
272	Right	Reduced vision	RE Cataract
296	Bilateral	Distortion	Bilateral nutritional optic neuropathy
297	Bilateral	Exudates	Bilateral retinal deposits
312	Right	Peripapillary oedema	Did not attend MR clinic & discharged

It is evident from the table above that 90% of patients (19) did not have any macular anomalies. One patient had bilateral retinal deposits, which were only visible clinically. The other patient had subtle retinal pigment epithelium (RPE) changes secondary to PPS that were only apparent on fundus autofluorescence (FAF). Twelve out of 15 patients (80%) referred to MR clinic from EMAC were discharged. Two were discharged after failing to attend their initial MR clinic review, whilst the other ten patients were discharged after their first clinic appointment or following listing for a surgical procedure. For the three patients who were not discharged, two are reviewed regularly in MR clinics, with the final patient referred to neuro-ophthalmology for further investigations. The two patients who attended PCC and the cataract centre were discharged after undergoing laser capsulotomy and cataract surgery, respectively. The final patient, referred to glaucoma clinic continues to be monitored as a glaucoma suspect, and no treatment was indicated.

Chapter Discussion

The chapter highlighted management outcomes of macular conditions referred to EMAC with particular emphasis on wet AMD. All but five patients provisionally diagnosed with wet AMD were treated within two weeks from referral, in line with RCOphth guidelines for management of AMD.[95] Although this makes for a respectable ratio of 93.5%, it can be argued four out of the five remaining patients would have also been treated within that timeline once patient and administrative factors are disregarded, elevating that ratio to 98.7%. Patient factors such as having an ocular infection, declining treatment, or altering their initial appointment, as well as significant delays in receiving a referral should not be ascribed as a delay of treatment on the hospital's account. For the last patient, it can be argued they would have been treated within two weeks had the EMAC OSI requested FFA to be carried out on the same day as the patient's initial MTC appointment. However, the patient was identified as needing an FFA on the MTC clinic visit rather than the EMAC appointment. About 6.5% of wet AMD patients had bilateral disease at presentation, and over 11% of patients initially presenting with unilateral disease developed the condition in the fellow eye within the first year. This is just under compared to existing literature showing a yearly rate of fellow-eye involvement between 13% to 20%.[96-99]

Although Lucentis was the first IVI approved by NICE in 2008 for treatment of wet AMD,[100] Eylea is generally used as first-line therapy for treatment of wet AMD and other macular conditions in MREH. Eylea has a greater binding affinity to VEGF isoform A (VEGF-A) than Lucentis.[101,102] Furthermore, it has a high binding affinity for other VEGF isoforms including VEGF-B, as well as placental growth factor, additional factors in neovascularisation.[103] This higher binding affinity and in effect longer duration of action allowing for extended treatment intervals are the primary reasons behind the 63% to 37% split towards Eylea for treatment of wet AMD patient eyes in this study. Despite this, the average number of injections in the first year was similar for both Eylea and Lucentis, as seen in some recent studies.[104,105] For eyes treated with Eylea, there was a statistically significant visual gain of 8.5 letters one-year post treatment. This was comparable to the VIEW 1 and VIEW 2 trials that compared the efficacy of monthly and bi-monthly Eylea injections with monthly Lucentis injections. Visual gains in those similarly designed phase 3 randomised controlled trials (RCTs) were 7.9 and 8.9 letters, respectively.[106] In this study, about 27% of eyes had VA gains of ≥15 letters and about 8% had visual loss, comparable to the VIEW trials of 31% and 5%, respectively.

For eyes treated with Lucentis, surprisingly, there was a statistically insignificant visual gain of 4.9 letters one-year post treatment. This gain was more modest compared to visual gains in trials looking at treatment of wet AMD using Lucentis such as ANCHOR and MARINA. The gains in the two phase 3 RCTs were 11.3 and 7.2 letters, respectively.[107,108] Similarly, in this study, about 14% of eyes had VA gains of ≥15 letters, considerably inferior compared to the ANCHOR (40.3%) and MARINA (33.8%) trials. Visual loss was noted in over 34% of eyes, considerably higher compared to the ANCHOR (4.6%) and MARINA (5.4%) trials. The results observed are likely due to a combination of factors. In two eyes, there was visual loss of twenty and ten letters, secondary to an RPE tear and atrophy, respectively. This would have skewed the overall visual gains given that only 29 eyes were treated with Lucentis. Similarly, only four eyes treated with Eylea had visual loss, all with a loss of four letters. However, ten eyes treated with Lucentis had visual loss ranging from two to twenty letters, and a median of six letters. At MREH, Lucentis is generally used in eyes with smaller CNVMs that may require a smaller number of injections (i.e., loading dose only), or in eyes with significant anatomical damage and poor baseline vision (≤40 letters) where long-term visual potential may be limited. Moreover, there is variability in VA measurements in AMD patients, particularly at advanced stages of the disease, and unlike clinical trials, patients do not routinely have refraction at their treatment (MTC) visits. These factors likely led to the results observed for Lucentis, despite a similar baseline VA for eyes treated with Eylea and Lucentis. The statistical insignificance reported for the visual gains between both drugs one-year post treatment was mirrored in some of the aforementioned trials and other studies.[104,106]

Although two eyes initially treated with Lucentis and had visual loss later achieved visual gain when switched to Eylea, the literature remains split over the benefit of switching patients from one drug to another.[109] The landscape of wet AMD treatment with IVIs is likely to change after approval of Vabysmo by NICE for management of wet AMD and DMO. In the phase 2 RCT STAIRWAY that compared 4-weekly Lucentis to 12- and 16-weekly Vabysmo, visual gains from baseline at 52 weeks were 9.6, 10.1, and 11.4 letters, respectively.[110] Moreover, at week 24, almost two-thirds of Vabysmo-treated patients had no disease activity. In the identical phase 3 RCTs TENAYA and LUCERNE that compared 8-weekly Eylea to protocol-compliant Vabysmo (treated up to 16 weeks) showed minimal to no visual gain from baseline between both drugs.[111] However, approximately 80% of Vabysmo-treated patients were on extended fixed-dosing intervals of ≥12 weeks and about 45% of patients were on fixed-dosing interval of 16 weeks. These RCTs provide evidence that a larger proportion of patients can be treated at longer intervals with Vabysmo without compromising visual gains observed in pre-existing approved IVIs. As such, moving forward, it would be unsurprising to see a shift from Eylea and Lucentis to Vabysmo for treatment-naïve wet AMD patients and pre-existing patients treated at less than 8-week intervals.

In recent times, there has been a shift in HES from using the gold standard FFA to OCT-A for diagnosis of wet AMD. Although FFA provides dynamic information about the presence and pattern of leakage to diagnose and classify wet AMD, it is an invasive procedure, which can induce discomfort, nausea, and rarely, anaphylaxis.[112,113] OCT-A is a non-invasive, quick, novel imaging technique that bypasses some of these limitations while allowing direct in-vivo visualisation of the retinal and choroidal vasculature. Through high-frequency and dense volumetric scanning, blood flow is detected by analysing signal decorrelation between scans; in essence, comparing movement of erythrocytes within blood vessels to stationery areas of the retina.[114] In this study, 88% of wet AMD patients were solely diagnosed with OCT and OCT-A, while 12% (nine patients) required an FFA. This is comparable with results published in a recent meta-analysis evaluating the diagnostic accuracy of OCT-A in wet AMD and its concordance with FFA.[115] Looking at seven studies, it showed a cumulative sensitivity of

85.9% and specificity of 89%. OCT-A has its limitations including presence of image artefacts and inability to detect CNVM in presence of large haemorrhages, serous leakage or large PEDs.[116] Furthermore, it has poorer diagnostic ability for identification of type I CNV.[117,118] These limitations were evident in this study where OCT-A was inconclusive for seven patients in presence of a large PED with minimal overlying fluid activity and for patients ultimately diagnosed with type I CNV (OCT-A showing fibrovascular or serous PED and minimal to no overlying fluid activity). Its diagnostic ability was also limited in a patient with mixed macular pathology, which is not uncommon in patients seen in macular and MR clinics. Although the above shows the increasing value of OCT-A as a first-line diagnostic tool for diagnosis of wet AMD, its limitations present a barrier from displacing FFA as the gold standard test.

In this study, there was no significant correlation found between CNVM size and the number of injections administered in the first year. This is likely due to the fact CNVM size only gives one piece of the puzzle in a complex disease entity such as wet AMD. CNVM size reflects the extent of RPE and choroidal dysfunction, but treatment frequency may be also influenced by the impact of the IVI drug on other pertinent factors such as vascular stability and permeability and endothelial proliferation. Inhibition of the VEGF pathway, which can be done by all three NICE-approved IVIs impedes endothelial proliferation, reduces vascular permeability, and suppresses neovascularisation.[111] However, Vabysmo can also inhibit the Angiopoietin-2 pathway, thus desensitising vessels to actions of VEGF and improving vascular stability.[111] The regulation of these pathways may prove more important than CNVM size in considering frequency and interval of treatment. A review of the literature did not show any studies looking at frequency of injections and CNVM sizes. One study however looked at CNV structure (type I and II only) in wet AMD patients before and after a Lucentis loading dose (three injections). CNV structure was unchanged in 78% of patients, reduced in thickness in 18%, and was larger in 4%.[119] Despite this, a completely dry retinal structure was seen in 59% of cases, 27% showed reduced fluid activity, and 14% showed unchanged activity. This further reinforces that although CNVM size may be a visualisable sign on OCT-A, it is not the main indicator for the expected frequency of injections for treatment of wet AMD.

Looking at patients with CMO secondary to RVO, although BRVO makes up about five-sixths of patients affected, the disease process is generally considered less severe compared to CRVO and unsurprisingly, the former had better baseline VA, in line with existing literature.[77] Similar to wet AMD, although Lucentis was the first IVI approved for treatment of CMO due to RVO,[120] in this study, Eylea was used to treat about 88% of all RVO cases. This is due to previously described reasons about Eylea’s mode of action. For CRVO patients treated with Eylea, there was a visual gain of 17.3 letters one-year post treatment. This was comparable to the 16.3 letter visual gain from baseline at 52 weeks in the phase 3 RCT COPERNICUS.[121] For BRVO patients treated with Eylea, there was a statistically significant visual gain of 14.6 letters one-year post treatment. This was comparable to the VIBRANT trial that compared the efficacy of Eylea IVIs against macular grid laser photocoagulation. Visual gain from baseline at 24 weeks in that phase 3 RCT was 17 letters.[122] Half of the BRVO patients had VA gains of ≥15 letters, comparable to the VIBRANT trial's ratio of 52.7%.

In total, fourteen patients were referred to EMAC, subsequently diagnosed with CSR. Only a single patient required IVI treatment for a secondary CNVM. The other thirteen patients had a very good baseline vision of 80 letters and none of them required treatment. These findings are consistent with existing literature that suggests acute CSR usually self-resolves within the first three months and there is good visual prognosis in 90 to 95% of cases.[123] However, it may recur in about a third of patients within the first year.[124] Persistent CSR lasting over six months is classified as chronic, which can lead to irreversible retinal pigmentary damage and a secondary CNVM, as seen in one patient in this study. Given the above, it can be argued patients with acute CSR and very good VA can be monitored in primary care with appropriate advice issued and management of associated risk factors, if present. In the event of persisting signs and symptoms after three months, a referral should be made directly to the MR clinic. A referral to EMAC is only indicated if a secondary CNVM is suspected.

Looking at VR conditions, and starting with macular holes, none of the patients with a lamellar macular hole had surgery and were subsequently discharged after their initial VR appointment; they had an average baseline VA of 72 letters. This is in line with a recently published review that concluded surgery is recommended if the patient reports significant metamorphopsia or if there is evidence of progressive visual loss.[125] All eleven patients with FTMH were listed for surgery: ten patients underwent surgery, and one patient was discharged after missing their appointment. Apart from two patients who lost less than five letters post-surgery, all patients experienced stable or improved vision. Existing literature shows greatly improved surgical outcomes for macular holes, with a closure rate as high as 90 to 100%.[126] Duration of symptoms and stage of macular hole have been identified as significant factors for higher anatomical and visual success rate.[127-129] Early surgical intervention is recommended, and all patients should be offered surgery within one year of onset. None of the patients with an ERM and VA ≥70 letters were listed for surgery, and most were subsequently discharged after their initial VR appointment. This is generally consistent with clinical practice, where surgery is not usually recommended to asymptomatic patients or those with good VA (≥70 letters). Differing opinions remain about the timing of surgical intervention for ERM, as some studies suggest earlier intervention for select patients with early symptomatic ERM may be beneficial in preserving excellent vision, despite modest post-operative visual gains.[130,131]

Twenty-one patients were judged to having no obvious macular anomalies by EMAC OSIs. Macular abnormalities were found in two of these patients through clinical examination and FAF imaging on their subsequent MR clinic review. These findings were subtle, insignificant and did not require any treatment. Only three patients were directly discharged from EMAC, and three patients were referred to other outpatient clinics. However, following changes to the EMAC protocols in late 2020, most of these twenty-one patients would have been directly discharged from EMAC to the referrer for reassessment and re-referral to the appropriate HES department. Patients who would be directly discharged include those with very good VA (≥75 letters) and no obvious macular anomalies, those with reduced vision unrelated to the macula, and those with unchanged pre-existing macular conditions previously seen and discharged by MREH. These changes have been implemented to reduce the rate of inappropriate referrals to the EMAC service and avoid its misuse as a shortcut for earlier triage and review of patients than referral through the appropriate pathway.

In summary, prompt urgent referral of patients with wet AMD, CMO secondary to RVOs, and CNVM secondary to other macular conditions to EMAC is crucial for earlier intervention and better visual outcomes. Other macular conditions such as RVO without secondary CMO, CSR, and DR should be directly referred to the MR department, with a referral to the GP also done to address pertinent risk factors, where appropriate. VR conditions likely to require surgical intervention should be directly referred to the VR department. Accurately referring patients to the correct service reduces the overall burden on HES through eliminating repeat appointments and streamlining services such as EMAC. More importantly, it enhances the patient experience through reducing the number of hospital visits and maximising their visual outcomes through timely management and intervention.

Chapter V – Agreement Levels between Optometrists with Specialist Interest and Medical Retina Ophthalmologists in Diagnosing Macular Conditions

Chapter four illustrated how specially trained optometrists (or OSIs) managed referrals sent to EMAC. This chapter highlights agreement levels between these OSIs and MR consultant ophthalmologists for diagnosis and management of referrals to EMAC, with a particular focus on AMD. This is important in reinforcing the high standard of training delivered to EMAC OSIs, allowing for effective diagnosis, management, and triaging of EMAC referrals to a level comparable to consultant ophthalmologists. It also aims to pinpoint any gaps in training, which can be addressed to further optimise the aforementioned element of the service.

Agreement is established based on the provisional diagnosis made by an OSI during EMAC and the formal diagnosis made by an ophthalmologist during the patient's subsequent visit to a subspecialist clinic (e.g., MR clinic). The OSI's provisional diagnosis was checked against the gold-standard ophthalmologist formal diagnosis, attained by a well-established, published set of diagnostic criteria associated with each macular condition. Agreement was calculated using Cohen's kappa statistic, with the formula included in Appendix 1. Greater significance will be placed on macular conditions requiring urgent treatment such as wet AMD but will also aim to discuss other macular and retinal conditions. Similar to earlier chapters, the analysis aimed to include all data collected for the project between August 1st, 2019, and October 31st, 2019, for a total of 314 patients. However, upon further review of the data, agreement levels could not be established for about 11% of patients (34), and thus, were excluded from said analysis due to the following reasons:

1. Five patients passed away prior to their first MR clinic appointment, therefore, a formal diagnosis was not made by an ophthalmologist.
2. Three patients were discharged directly from EMAC without the need for further clinic review, thus, no formal diagnosis was made/required by an ophthalmologist.
3. Sixteen patients were discharged after failing to attend multiple clinic appointments; therefore, no formal diagnosis was made by an ophthalmologist.
4. Ten patient cases were discussed by the OSI with an ophthalmologist, and thus, could not be included in the analysis.

It is worth noting OSIs only discussed ten cases (3.7%) out of a total 268 cases reviewed over that three-month span. The remaining 46 cases were reviewed by two advanced OSPs.

Agreement Levels between OSIs and Ophthalmologists for AMD

In total, 156 patients referred to EMAC were provisionally diagnosed with AMD, of which 77 were wet AMD, and 79 were dry AMD. All 77 patients with wet AMD were included in the analysis. However, as previously mentioned, 46 of these cases were detected by two advanced

OSPs trained to identify wet AMD on OCT and OCT-A scans and refer patients to MTC for same-day IVI treatment. This was only applicable to cases where classic features of wet AMD were observed on the OCT scan and CNVM was detected on the OCT-A scan. Only 83.5% of dry AMD cases (66) were included in the analysis. The remaining 13 cases were excluded for the following reasons:

1. Seven patients were discharged after failing to attend multiple appointments.
2. Two patients passed away prior to their MR clinic appointment.
3. Four patient cases were discussed with an ophthalmologist:
    a. Two patients had end-stage wet AMD and confirmation was sought regarding their unsuitability for IVI treatment.
    b. One patient had suspicious features of wet AMD, and an FFA was required to definitively make a diagnosis. The FFA only showed signs consistent with dry AMD.
    c. One patient had CNVM on OCT-A, but no signs of active disease on OCT or the fundus image. Advice was sought regarding need for IVI treatment. Close monitoring in MR clinic without active intervention was advised.

Considering a total of 97 patients (66 dry AMD and 31 wet AMD), OSIs and ophthalmologists had a near perfect agreement (Cohen's kappa, κ= 0.98) for diagnosing AMD; standard error (SE) of 0.024 and 95% confidence intervals (CI) from 0.93 to 1.00. Both groups agreed on all but one case, where the OSI provisionally diagnosed it as wet AMD, while the ophthalmologist formally diagnosed it as dry AMD with additional element of CSR, following an FFA carried out during the patient's MTC visit. No formally diagnosed wet AMD cases were incorrectly diagnosed as dry AMD by OSIs during the EMAC visit. As such, the false positive rate was 1.5%, and the false negative rate was 0%. Since OSIs and the two advanced OSPs perform a similar role for triaging wet AMD, the above analysis was repeated combining all wet AMD cases (77) seen by both groups, in addition to 66 dry AMD patients seen by OSIs, for a total of 143 patients. The repeat analysis also showed a near perfect agreement (Cohen's kappa, κ= 0.99) between OSIs and ophthalmologists for diagnosing AMD, with SE of 0.014 and 95% CI from 0.96 to 1.00.

Agreement Levels between OSIs and Ophthalmologists for other Macular Conditions

For the remaining 158 patients referred to EMAC provisionally diagnosed with other macular conditions, only 86.7% (137) of cases were included in the analysis. The remaining 21 cases were excluded for the following reasons:

1. Three patients were directly discharged following their EMAC appointment.
2. Nine patients were discharged after failing to attend multiple appointments.

3. Three patients passed away prior to their MR clinic appointment.
4. Six patient cases were discussed with an ophthalmologist:
    a. One patient had retinal pigmentary changes and advice was sought on whether further review was required. An MR appointment was advised.
    b. One patient had a VMT, and confirmation was sought on whether they require an MR or VR appointment. A VR appointment was advised.
    c. One patient had CSR and advice was sought about whether the patient required specialist imaging (FFA & ICG) at their first MR clinic review.
    d. One patient had DMO, and confirmation was sought from the ophthalmologist.
    e. Two patients had unusual presentation that required further discussion with the consultant. One patient was tentatively diagnosed with chorioretinitis, and the other provisionally diagnosed with a haemangioma.

Table 8 summarises agreement levels between OSIs and ophthalmologists for other macular conditions referred to EMAC.

Table 8. Agreement levels between OSIs and ophthalmologists for other macular conditions (n= 137). Abbreviations: *AVMD* adult-onset vitelliform macular dystrophy, *BRAO* branch retinal artery occlusion, *BRVO* branch retinal vein occlusion, *CAR* cancer-associated retinopathy, *CRVO* central retinal vein occlusion, *CSMO* clinically-significant macular oedema, *CSR* central serous retinopathy, *DR* diabetic retinopathy, *ERM* epiretinal membrane, *HRVO* hemi-retinal vein occlusion, *MacTel* macular telangiectasia, *CNV* choroidal neovascularisation, *Post-Op CMO* post-operative cystoid macular oedema, and *VMT* vitreo-macular traction.

Condition	Frequency, n	Agreement Levels, n (%)
AVMD	15	13 (86.7%)
BRAO	1	1 (100%)
BRVO	27	25 (92.6%)
CAR	1	1 (100%)
Chorioretinal Scar	1	1 (100%)
CRVO	7	6 (85.7%)
CSMO	2	2 (100%)
CSR	11	11 (100%)
DR	7	6 (85.7%)
Eccentric Lesion	1	1 (100%)
ERM	12	11 (91.7%)
HRVO	1	1 (100%)
MacTel	5	5 (100%)
Macular Dystrophy	2	2 (100%)

Macular Hole	15	15 (100%)
Myopic CNV	2	2 (100%)
No Macular Pathology	16	14 (87.5%)
Pigmentary Changes	2	2 (100%)
Post-Op CMO	4	4 (100%)
Vascular Changes	1	1 (100%)
VMT	4	3 (75%)
Total	**137**	**127 (92.7%)**

As illustrated above, there was agreement between provisional diagnoses made by OSIs and formal diagnoses made by ophthalmologists in about 93% of cases, ranging between 75% and 100%. In dissecting the ten cases of disagreements, they are as the following:

1. Two patients were provisionally diagnosed with AVMD. However, at their MR clinic review, one was formally diagnosed with inactive PCV, whilst the other was formally diagnosed as having a PED. Neither patient required treatment.
2. Two patients were provisionally diagnosed with BRVO. However, at their MR clinic review, one was found to have isolated retinal haemorrhages that were resolving, with the other having a deep inner retinal haemorrhage, which was also resolving. Neither patient required further testing or treatment.
3. One patient was provisionally diagnosed with CRVO without centre involving CMO. However, at their MR clinic review six weeks later, the off-centre CMO worsened and distorted the foveal profile. As such, they were formally diagnosed with CRVO with secondary CMO, and referred to MTC for IVI treatment.
4. One patient was provisionally diagnosed with DR. However, at their MR clinic review, they were formally diagnosed with having a solitary microaneurysm (MA) that is not related to diabetes. No treatment was indicated.
5. One patient was provisionally diagnosed with ERM. However, during their MR clinic review, they were formally diagnosed with VMT. No treatment was indicated.
6. Two patients were provisionally diagnosed as having no macular pathology. However, at their MR clinic review, one was formally diagnosed with retinal deposits, which was only noted on clinical examination. The other was formally diagnosed with subtle RPE changes secondary to PPS, which was only noted using FAF. Neither required further testing or treatment.

7. One patient was provisionally diagnosed with VMT. However, during their VR clinic appointment, they were formally diagnosed with vitreomacular adhesion (VMA). No treatment was indicated.

It is evident that despite disagreement between OSIs and ophthalmologists, this did not have a detriment on visual outcomes and the overall management plan in all but one patient. It can be argued there is no 'true' disagreement for the patient with CMO secondary to CRVO, since the correct clinical decision was made by the OSI based on the presentation during EMAC.

Out of 234 cases eligible for agreement analysis and reviewed by OSIs, disagreement between OSIs and ophthalmologists was noted in 11 cases (4.7%) for all macular conditions. This level of disagreement drops to 3.9% if the 46 wet AMD cases reviewed by OSPs are included in the cases eligible for agreement analysis by OSIs, for a total of 280 cases. This was done under the assumption all 46 cases identified by OSPs as wet AMD would have also been identified as such by OSIs had they reviewed the patient notes.

Chapter Discussion

The chapter highlighted agreement levels between OSIs and MR consultant ophthalmologists for management of referrals to the EMAC service. This is the first study of its kind looking at agreement levels between both these groups within the MR subspeciality. Apart from one case, there was unanimous agreement between the two groups for management of all AMD patients referred to the service. The FP rate was 1.5%, where a single case was provisionally diagnosed as wet AMD by the OSI, but subsequently diagnosed as dry AMD with an element of CSR by the consultant. However, it is worth noting the consultant had the advantage of an additional specialist imaging test, FFA, to aid formal diagnosis. The FN rate was 0%, which is reassuring no cases of wet AMD have been missed. These findings reinforce the notion that at the time of referral, appropriately and specially trained experienced optometrists (OSIs) can diagnose and manage AMD patients as effectively as consultant ophthalmologists. This is particularly important for a condition such as wet AMD, where misdiagnosis can lead to delayed treatment and irreversible loss of vision.

Looking at all other macular conditions presenting to the service, OSIs had an agreement level of about 93% compared to ophthalmologists. As previously discussed, for nine out of the ten cases of disagreement, there was no impact on the visual outcome or management plan. Once again, it is worth stating consultants had the added benefits of clinically assessing the patient and additional specialist imaging available, while OSIs only had OCT and OCT-A scans for making a provisional diagnosis. This likely played a role in five cases of disagreement; in two cases, diagnosis was made after clinical examination and use of FAF imaging, and in the other three cases, examining of the peripheral retina would have ruled out vascular conditions (RVO and DR) provisionally diagnosed by OSIs. For the one case requiring treatment (CRVO with secondary CMO), the OSI correctly requested an MR clinic appointment within six weeks, as the CMO was off-centre, but had the potential to become centre-involving. Although the CMO worsened and was foveal involving, thus requiring IVI treatment, this does not reflect a 'true' disagreement between both groups as the patient was correctly managed at initial presentation. With an inter-group disagreement level of less than 5%, and an opinion sought by OSIs from ophthalmologists in less than 4% of reviewed cases, it underpins the level of competence and autonomy possessed by specially trained OSIs working in the EMAC service. These findings add further value to pre-existing agreement studies, which have shown specially trained OSIs can be effective in extended roles across various subspecialities including diabetes, glaucoma, cataract, and minor as well as acute eye condition services.

At MREH, a study evaluated agreement levels between independent prescribing optometrists and consultant ophthalmologists for diagnosis and management of patients presenting to EED.[132] In this prospective study, a total of 321 participants presented with 423 diagnoses. There was 'almost perfect' agreement for diagnosis and onward management, consistent with results found in this study. Additionally, 'substantial' agreement was noted for prescribing decisions. Another study at MREH evaluated agreement levels between specially trained and accredited optometrists and glaucoma specialist consultant ophthalmologists.[133] In this prospective study with a total of 96 patients, similar results were also noted, with 'substantial' agreement reported between both groups for glaucoma-related management outcomes. Both groups were in complete agreement about treatment of 97% of right eyes and 96% of left eyes. Similar results were also reported in a study carried out at Moorfields Eye Hospital evaluating agreement between optometrists and ophthalmologists.[134] Fifty patients were reviewed by three medical clinicians and four optometrists, with findings independently and retrospectively by two consultant ophthalmologists. Agreement between optometrists and ophthalmologists was 79% for medical management and 72 to 98% for other aspects of patient management. It was lowest at 55% for evaluation of visual field status. Although this text primarily focuses on agreement between ophthalmologists and trained HES OSIs, similar results were also found in community-based glaucoma shared schemes.[135-138]

Looking at other subspecialities, there was only one agreement study looking at screening for diabetic retinopathy.[139] For a total of 474 diabetic eyes, there was agreement for about 77% of eyes between an optometrist and an ophthalmologist. The optometrist would have correctly referred about 77% of eyes with moderate or severe maculopathy and about 92% of eyes with moderate or severe retinopathy. Another study looking at an optometrist working in a PCC at

Moorfields hospital showed agreement with an ophthalmologist in about 80% of 152 patient cases.[140] There was partial agreement in about 17% of cases and disagreement for 3% of cases. No agreement studies were done for other subspecialities, however, two studies looking at cataract shared schemes showed that comparable post-surgical eyecare can be provided by accredited community optometrists, therefore, reducing the frequency of HES visits.[141,142] This reduced frequency of HES visits along with clinical effectiveness and increased patient satisfaction were also reported in a study evaluating a minor eye conditions scheme managed by accredited community optometrists in Lambeth and Lewisham.[143]

In summary, appropriately trained EMAC OSIs can diagnose, manage, and triage patients as effectively as consultant ophthalmologists. This adds to supporting evidence looking at ocular conditions across different subspecialities. It also illustrates the optometrist's evolving role in shared schemes within community optometry and in specialist clinics within the HES. Having an optometrist led EMAC service proficiently run by trained OSIs to a level equivalent to that of consultant ophthalmologists has several positive implications. Firstly, it allows for smooth and self-sufficient running of a key triaging hospital service with minimal disruption to other clinical services. Secondly, it releases ophthalmologists to carry out other clinical duties that cannot otherwise be done by other healthcare professionals (i.e., ocular surgery). Finally, and most crucially, it ensures patients continue to receive uncompromised high-degree quality of care, thus, optimising their visual prognosis and outcomes.

Chapter VI – Referral Patterns Across Greater Manchester

Chapter three described general referral patterns to EMAC and demographics of these referred macular conditions. This chapter evaluates the effect of deprivation and socioeconomic factors on these referral patterns across Greater Manchester (GM), as well as onset of presentation of these macular conditions. This is critical for identifying the extent of the existing gap of access to eyecare as a result of these factors and its impact on visual outcomes. Through this, it aims to inform changes to public eye health campaigns and encourage further interventions required to reduce health inequalities relating to macular disease.

As of 2020, GM's population is approximately 2.85 million.[144] GM comprises of ten boroughs: Bolton, Bury, Manchester, Oldham, Rochdale, Salford, Stockport, Tameside, Trafford, and Wigan. Bury makes up the lowest proportion of GM's population (6.7%), whilst Manchester makes up about a fifth of GM's total population.[144] Figure 26 illustrates the proportion of GM's population for all boroughs.

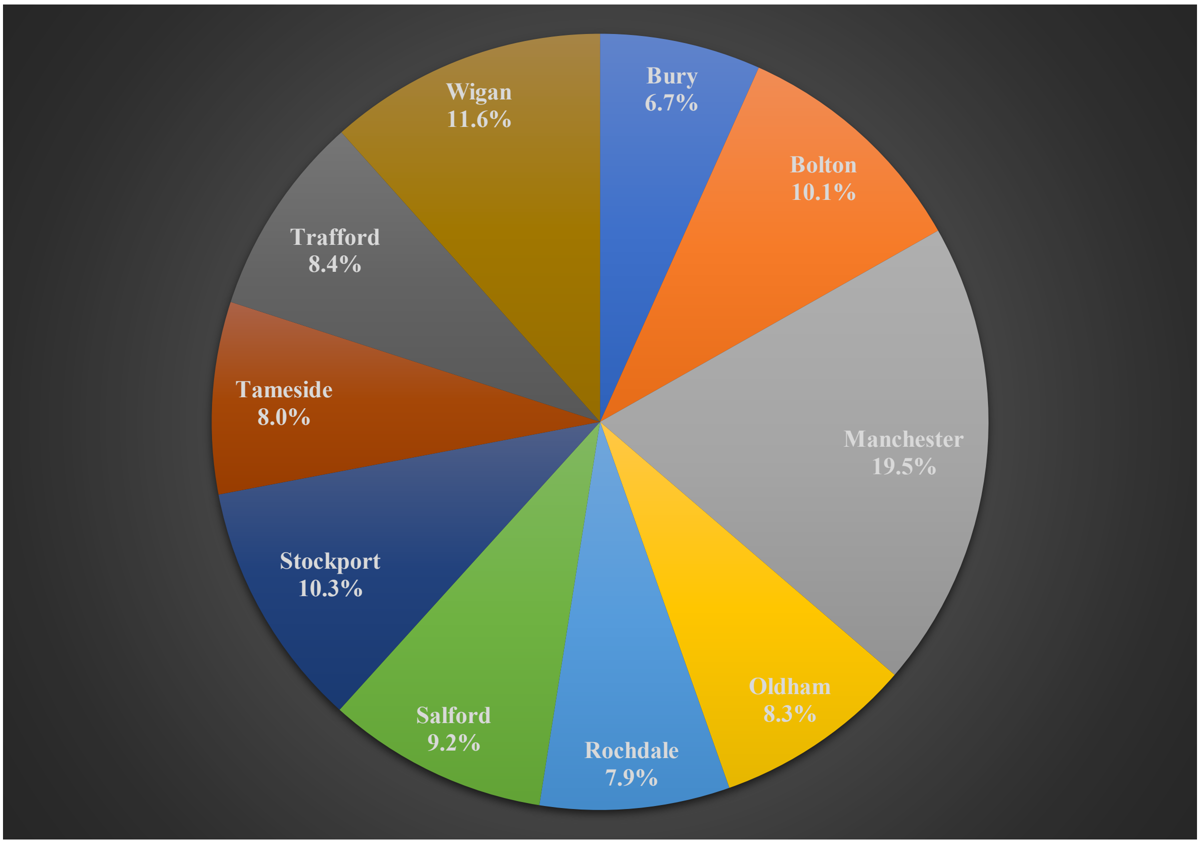

Figure 26. Proportion of GM's population (2.85 million) by borough (n= 10).

The null hypothesis of this chapter is deprivation and socioeconomic factors have no impact on access to eyecare across GM or onset of macular disease presentation to HES. Like earlier chapters, the analysis aimed to include all data gathered for the project between August 1st, 2019, and October 31st, 2019, for a total of 314 patients. However, upon further review of the data, eight patients (2.5%) were excluded as their residential postcode did not fall under one of the ten aforementioned local authority districts in the GM area. Of those eight patients, four were from High Peak, two were from East Cheshire, one was from Warrington, and the final patient was from Leeds. Complex patient cases necessitating additional specialist opinion and management (e.g., PDT for CSR) is a common reason for patients living outside of GM getting referred to MREH. Dissatisfaction with the quality of care offered by the local eye service is another common reason for referrals to MREH from local authorities outside of GM. Referrals from GM's different boroughs to EMAC over the three-month period did not correlate with the population percentages shown in figure 26. No patients were referred from Rochdale, and a small number of patients referred from Bolton, Oldham, and Wigan. Patients living in Manchester made up about 36% (110) of referrals, with Trafford making up over 28% (86) of referrals. Table 9 summarises referral numbers from all boroughs within GM.

Table 9. Referrals from boroughs in GM to EMAC over a three-month period (n= 306). Abbreviation: *GM* Greater Manchester.

Borough	Proportion of GM Population (%)	Number of Referrals, % (n)
Bolton	10.1%	1.0% (3)
Bury	6.7%	4.6% (14)
Manchester	19.5%	36.0% (110)
Oldham	8.3%	1.6% (5)
Rochdale	7.9%	0% (0)
Salford	9.2%	15.0% (46)
Stockport	10.3%	4.9% (15)
Tameside	8.0%	8.5% (26)
Trafford	8.4%	28.1% (86)
Wigan	11.6%	0.3% (1)

Despite presence of ten boroughs in GM, there were no referrals to EMAC from Rochdale and less than 3% of total referrals were made from Bolton, Oldham, and Wigan. This is likely due to presence of local eye units where referrals are directly made. Moreover, referrals from Bury and Stockport are not seen in MREH but directed to eye services in Bolton and Stepping Hill hospital, respectively. The combined total of 29 referrals from these two boroughs does not reflect the true number of referrals and arises due to patient preference, amongst other reasons. Considering the above, it is more appropriate the aforementioned evaluation is repeated after excluding the 38 referrals and the population size (approximately 1.57 million) associated with these six boroughs. In total, 268 referrals and a population size of roughly 1.28 million for the remaining four boroughs were available for further analysis. The total population of these four boroughs will be referred to as GM4. Referrals from these four boroughs to EMAC over the three-month period had better correlation to population numbers compared to that seen in table 9. Patients living in Manchester made up 41% of referrals, largely comparable to its population proportion of GM4. Tameside made up about a tenth of referrals, the least of all four boroughs, and lower than its population proportion of GM4. Patients residing in Trafford made up over 32% of referrals, higher than its population proportion of GM4. Table 10 summarises referral numbers from these specific four boroughs within GM.

Table 10. Referrals from four boroughs in GM to EMAC over a three-month period (n= 268). Abbreviation: *GM* Greater Manchester.

Borough	Proportion of GM4 (%)	Number of Referrals, % (n)
Manchester	43.3%	41.0% (110)
Salford	20.5%	17.2% (46)
Tameside	17.7%	9.7% (26)
Trafford	18.5%	32.1% (86)

The Index of Multiple Deprivation

The Index of Multiple Deprivation (IMD) is an overall official measure of relative deprivation across England, constructed by combining data from seven domains of deprivation according to their respective weights.[145] The seven domains of deprivation (weighting indicated in brackets) are summarised as the following:

1. Income (22.5%) – measures proportion of population experiencing deprivation relating to low income. There are 2 further supplementary indices:
    a. Income deprivation affection children index (IDACI) – measures proportion of all children aged 0 to 15 years living in income-deprived families.
    b. Income deprivation affecting older people index (IDAOPI) – measures proportion of individuals aged 60+ years experiencing income deprivation.
2. Employment (22.5%) – measures proportion of working age population involuntarily excluded from the labour market.
3. Education (13.5%) – measures lack of skills and attainment in the local population.
4. Health (13.5%) – measures risk of premature death and impairment of quality of life due to poor physical or mental health.
5. Crime (9.3%) – measures risk of personal and material victimisation at a local level.
6. Barriers to housing & services (9.3%) – measures physical and financial accessibility of housing and other local services.

7. Living environment (9.3%) – measures quality of both ‘indoor’ and ‘outdoor’ local environment.

The IMD is used to relatively rank each small area in England from the most deprived to the least deprived. There are 32,844 small areas known as lower-layer super output areas (LSOAs) that are designed to be of a similar population size; an approximate average population of 1500 or 650 households.[145] LSOAs are produced by the Office for National Statistics (ONS) for the reporting of small area statistics. LSOAs are ranked from 1 (most deprived) to 32,844 (least deprived). LSOAs are also assigned a decile ranging from 1 (most deprived 10%) to 10 (least deprived 10%). There are 326 local authorities in England. For the purpose of this text, IMD data from 2019 will be used, the latest data available from the Ministry of Housing, Communities & Local Government.[35]

Deprivation in Manchester Local Authority & Greater Manchester

Greater Manchester is made up of ten boroughs, as previously discussed. This section will first outline deprivation figures in the Manchester local authority, followed by deprivation data in Greater Manchester. There are 282 LSOAs in Manchester. Using the IMD, Manchester is the 6th most deprived local authority in England.[146] Over 43% (122) of Manchester’s 282 LSOAs are in the most deprived decile in England, and there are no LSOAs in Manchester in the least deprived decile. Manchester is only second to Liverpool for having the highest proportion of LSOAs in the most deprived decile in England. Manchester has the highest proportion of LSOAs in the most deprived 30% in England.

There are 1673 LSOAs in GM.[147] Within GM, Manchester has the highest proportion of LSOAs (43%) in the most deprived 10% in England, whilst Trafford has the lowest proportion (5%) in the most deprived 10% in England. About 30% of LSOAs in Salford, Oldham, and Rochdale are in the most deprived decile nationally, and no LSOAs are in the least deprived decile in England for the latter two boroughs. Figure 27 illustrates the LSOA decile distribution within the GM districts using the IMD.

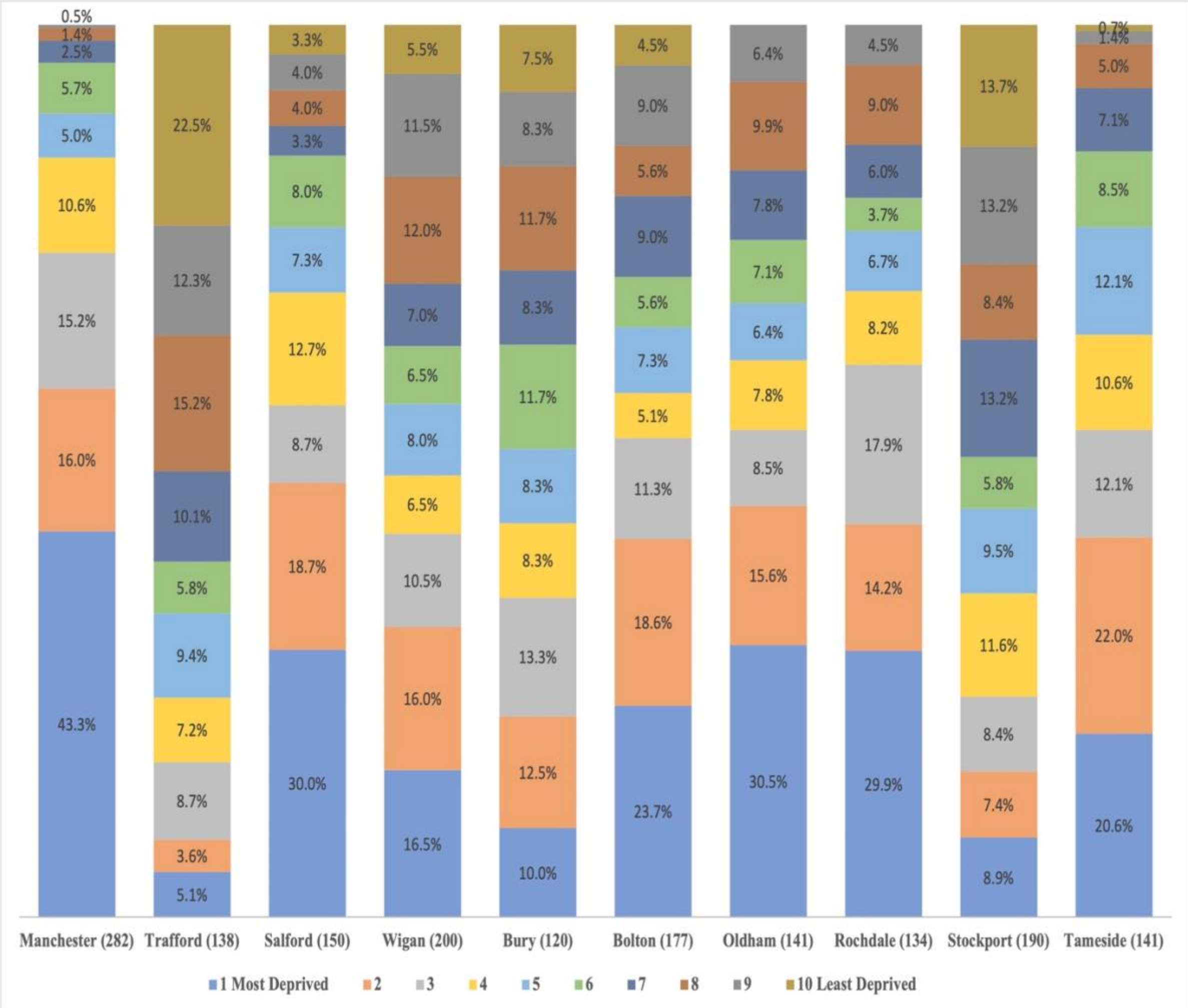

Figure 27. LSOA decile distribution within GM boroughs using IMD. LSOA number in each borough is outlined in brackets.

Health Deprivation & Disability in Manchester Local Authority & Greater Manchester

Whilst IMD proves useful in providing a comprehensive idea of deprivation, LSOA ranking and deprivation scores may be influenced or skewed by scores of individual domains. As such, and given the context of this text, it is more appropriate to specifically look at data from the Health Deprivation and Disability domain. For the purpose of this text, it will be referred to as the IHDD (Index of Health Deprivation and Disability). Using this domain, Manchester is ranked the 5th most deprived local authority in England.[146] Over 52% (147) of Manchester's 282 LSOAs are in the most deprived decile in England, with none of the borough's LSOAs in the least three deprived deciles. Manchester is ranked the most health-deprived GM borough. Within GM, Manchester has the highest proportion of LSOAs (52%) in the most deprived 10% in England, whilst Trafford has the lowest proportion (5%) in the most deprived 10% in England.[147] Except for Trafford, there are no LSOAs in any of the GM boroughs in the least deprived decile. Furthermore, except for Trafford, at least a fifth of LSOAs in every GM borough are in the 20% most deprived areas nationally. Figure 28 illustrates the LSOA decile distribution within the GM districts for the Health Deprivation and Disability domain.

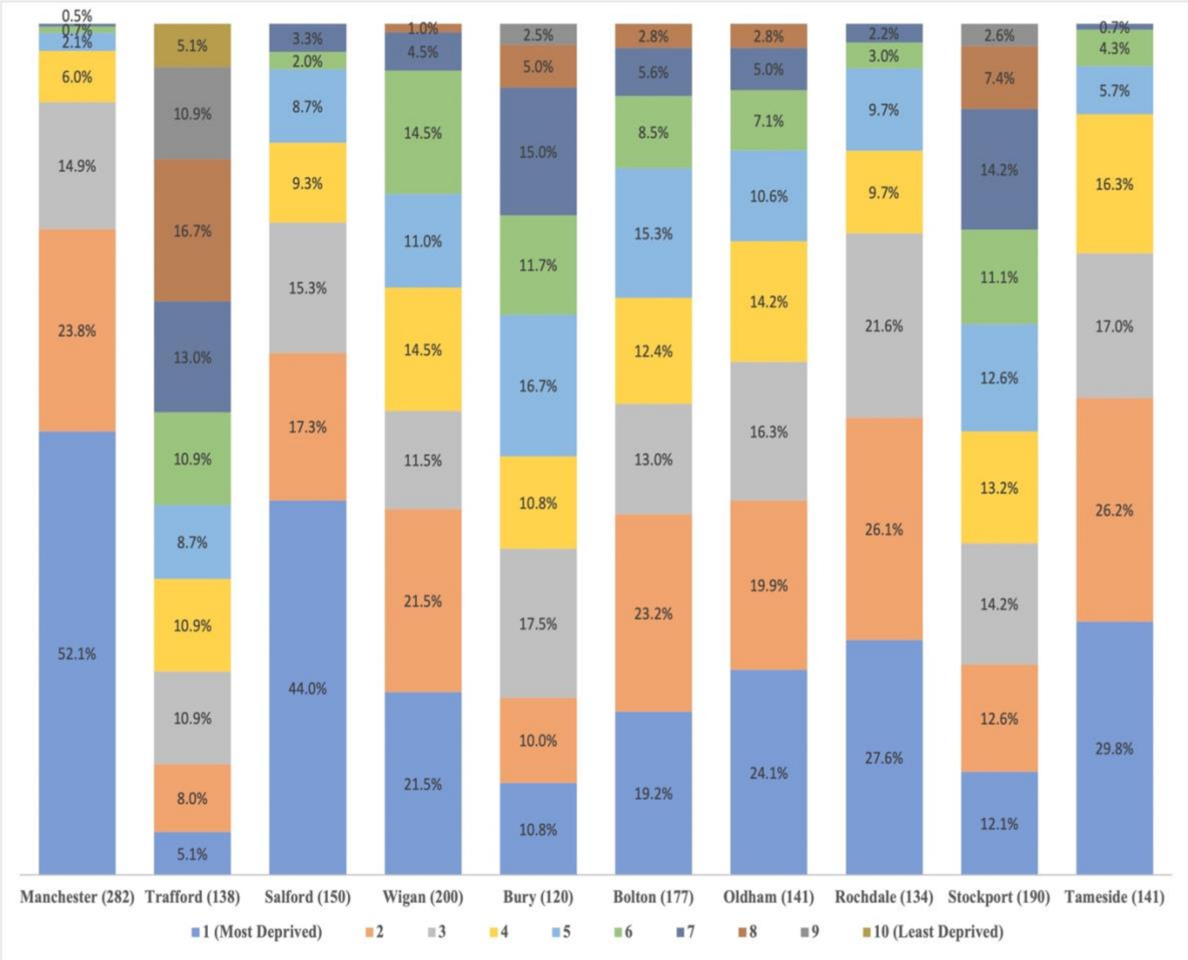

Figure 28. LSOA decile distribution within GM boroughs for Health Deprivation & Disability domain. LSOA number in each district is outlined in brackets.

Geographic Referral Patterns in Greater Manchester to the EMAC Service

This section aims to describe geographic patterns of referrals to the EMAC service within GM between August 1st, 2019, and October 31st, 2019, and determine if they are linked to socio-economic features of the region. As previously mentioned, only 306 out of 314 patients will be included in the analysis, as eight patients did not reside within GM. Whilst deprivation data assigns LSOAs to deciles, for the purpose of this text, patient data will be grouped in quintiles. On one end of the scale, deciles 1 and 2 will be grouped in quintile 1, labelled as 'most deprived', while deciles 9 and 10 will be grouped in quintile 5, labelled as 'least deprived'. The patient's residential postcode was used to identify their IMD and IHDD scores and assigned to the appropriate quintile accordingly.

One of the main objectives of this chapter is to ascertain whether deprivation affects access to eyecare. To investigate this, the ratio of referrals to EMAC from each deprivation quintile was compared to the ratio of GM's LSOA deprivation quintiles using the IMD. The null hypothesis being that no significant differences should exist between the two ratios. As previously stated, there are 1673 LSOAs in GM. Referral ratios and ratios of GM's LSOAs for each deprivation quintile using the IMD, as well as the difference between both are summarised in table 11. The trend suggests evidence of less than expected referrals from the most deprived quintile, which was also true of the two least deprived quintiles, though to a much lesser extent. More than expected referrals were observed in quintiles two and three.

Table 11. Ratios of referrals to EMAC and GM's LSOAs for deprivation quintiles using IMD. Abbreviations: *GM* Greater Manchester, *LSOAs* lower-layer super output areas, and *EMAC* emergency macular assessment clinic.

Deprivation Quintile	EMAC Referrals (%)	GM LSOAs (%)	Change (%)
1 (Most Deprived)	32.0%	37.9%	-5.9%
2	23.5%	20.6%	+2.9%
3	19.0%	14.4%	+4.6%
4	14.1%	14.8%	-0.7%
5 (Least Deprived)	11.4%	12.3%	-0.9%

A chi-square test showed there was no statistically significant difference between the observed referrals to EMAC and the expected ratio of referrals for each deprivation quintile, X^2 (4, N= 306) = 2.9, p= 0.58. However, as previously mentioned, IMD scores may be swayed by scores of individual domains, and since the focus of this text is on access to eyecare, the analysis was repeated with IHDD scores. Ratios of referrals and GM's LSOAs for each deprivation quintile using the IHDD, as well as the difference between both are summarised in table 12. Similar to the aforementioned analysis, there were less than expected referrals from the most deprived quintile and increased observed referrals in quintile two. However, unlike the above analysis, quintile three revealed less observed referrals, whilst higher than expected referrals were seen for the two least deprived quintiles.

Table 12. Ratios of referrals to EMAC and GM's LSOAs for deprivation quintiles using the IHDD. Abbreviations: *GM* Greater Manchester, *LSOAs* lower-layer super output areas, and *EMAC* emergency macular assessment clinic.

Deprivation Quintile	EMAC Referrals (%)	GM LSOAs (%)	Change (%)
1 (Most Deprived)	39.8%	46.0%	-6.2%
2	32.6%	26.4%	+6.2%
3	10.5%	16.7%	-6.2%
4	12.8%	9.1%	+3.7%
5 (Least Deprived)	4.3%	1.8%	+2.5%

A chi-square test showed statistically significant difference between the observed referrals to EMAC and the expected ratio of referrals for each deprivation quintile, X^2 (4, N= 306) = 9.6, p= 0.048. In this instance, it is evident there is unequal access to the EMAC service based on the deprivation level. As previously mentioned, despite presence of ten boroughs in GM, there were no referrals to EMAC from one borough (Rochdale) and combined total of nine referrals were made from three other boroughs (Bolton, Oldham, and Wigan), accounting for less than 3% of total referrals. However, these four boroughs accounted for 652 LSOAs in the GM area. Furthermore, referrals from Bury and Stockport should not be seen in MREH and should be directed to eye services in Bolton and Stepping Hill hospital, respectively. The combined total of 29 referrals from these two boroughs does not reflect the true number of referrals and arises due to patient preference, amongst other reasons that will be discussed later. However, these two boroughs accounted for 310 LSOAs in the GM area. Considering all the above, it is more appropriate the aforesaid analyses are repeated after excluding the 38 referrals and 962 LSOAs associated with these six boroughs. In total, 268 referrals and 711 LSOAs were available for further analysis.

Ratios of referrals and GM's (remaining four boroughs) LSOAs for each deprivation quintile using the IMD, as well as the difference between both are summarised in table 13. Different patterns can be observed when compared to IMD data for all boroughs and data from table 11. Although there were less than expected referrals from quintile one as seen in previous analysis, there were more than expected referrals from all other quintiles, more evident in quintiles three and five.

Table 13. Ratios of referrals to EMAC and GM's LSOAs (four boroughs only) for deprivation quintiles using IMD. Abbreviations: *GM* Greater Manchester, *LSOAs* lower-layer super output areas, and *EMAC* emergency macular assessment clinic.

Deprivation Quintile	EMAC Referrals (%)	GM LSOAs (%)	Change (%)
1 (Most Deprived)	34.7%	43.9%	-9.2%
2	23.1%	22.3%	+0.8%
3	19.8%	14.5%	+5.3%
4	10.5%	10.4%	+0.1%
5 (Least Deprived)	11.9%	8.9%	+3.0%

A chi-square test showed there was no statistically significant difference between the observed referrals to EMAC and the expected ratio of referrals for each deprivation quintile, X^2 (4, N= 268) = 4.9, p= 0.30. This analysis was also repeated with IHDD scores. Ratios of referrals and GM's (remaining four boroughs) LSOAs for each deprivation quintile using IHDD, as well as the difference between both are summarised in table 14. Similar patterns can be observed when compared to IHDD data for all boroughs and data from table 12. There were less than expected referrals from quintile one and more than expected referrals from quintiles two, four and five. The ratio of observed referrals from quintile three was roughly similar to what was expected.

Table 14. Ratios of referrals to EMAC and GM's LSOAs (four boroughs only) for deprivation quintiles using the IHDD. Abbreviations: *GM* Greater Manchester, *LSOAs* lower-layer super output areas, and *EMAC* emergency macular assessment clinic.

Deprivation Quintile	EMAC Referrals (%)	GM LSOAs (%)	Change (%)
1 (Most Deprived)	43.3%	56.7%	-13.4%
2	31.3%	24.3%	+7.0%
3	9.0%	9.1%	-0.1%
4	11.9%	6.8%	+5.1%
5 (Least Deprived)	4.5%	3.1%	+1.4%

A chi-square test showed statistically significant difference between the observed referrals to EMAC and the expected ratio of referrals for each deprivation quintile, X^2 (4, N= 268) = 9.6, p= 0.047. In this instance, it is evident there is unequal access to the EMAC service based on the deprivation level. This is similar to previous analysis done that included all GM's boroughs using IHDD scores.

Deprivation in Greater Manchester and Onset of Disease Presentation to the EMAC Service

This section will explore whether the level of deprivation affects the onset of macular disease presentation to the EMAC service. This will be assessed using IMD and IHDD scores, as well as the ACORN Index. ACORN is a segmentation tool produced by CACI, which categorises the UK population's socioeconomic status.[36] The index uses various data sources including open data, government data, commercial data, and CACI's propriety data to detail social and economic characteristics of the population, with a resolution for each postcode of about 15 residences. ACORN categorises households into six different groups, each with subclassifications, and types within each subclassification. The groups are recapped as the following, with the number of types for each subclassification included in brackets:

1. *Affluent Achievers:* three subclassifications including lavish lifestyles (3), executive wealth (6), and mature money (4).
2. *Rising Prosperity:* two subclassifications including city sophisticates (4) and career climbers (3).
3. *Comfortable Communities:* five subclassifications including countryside communities (3), successful suburbs (3), steady neighbourhoods (3), comfortable seniors (2), and starting out (2).
4. *Financially Stretched:* four subclassifications including student life (3), modest means (4), striving families (4), and poorer pensioners (4).
5. *Urban Adversity:* three subclassifications including young hardship (3), struggling estates (5), and difficult circumstances (3).

6. *Not Private Households:* one subclassification including not private households (3). This includes active communal population such as care homes and business addresses without residential population.

In total, there are six categories, eighteen subclassifications or groups, and 62 types. For the purpose of this text, ACORN index data from 2015 will be used, as this is the most recent data available for research purposes. For analysis purposes, the aforesaid categories will be labelled groups one to six in the order they were summarised (i.e., group 1 refers to 'affluent achievers', whilst group 6 refers to 'not private households'). Table 15 compares the ratio of EMAC referrals to the proportion of the UK population in each ACORN group. Only patients with a GM postcode (306) were used for this tabulation. There were more than expected referrals in group five, as well as groups one, four, and six, but to a lesser extent. There were less than expected referrals seen in groups two and three. A chi-square test showed there was no statistically significant difference between the observed referrals to EMAC and the expected ratio of referrals for each ACORN group, X^2 (5, N= 306) = 7.7, p= 0.17.

Table 15. Proportion of patients referred to EMAC compared to proportion of UK population in each ACORN group. Abbreviations: *EMAC* emergency macular assessment clinic, and *UK* United Kingdom.

ACORN Group	EMAC Referrals (%)	ACORN UK (%)	Change (%)
1; Affluent Achievers	24.2%	22.5%	+1.7%
2; Rising Prosperity	3.0%	9.3%	-6.3%
3; Comfortable Communities	23.2%	27.0%	-3.8%
4; Financially Stretched	24.8%	23.2%	+1.6%
5; Urban Adversity	23.2%	17.0%	+6.2%
6; Not Private Households	1.6%	1.0%	+0.6%

Baseline vision of the affected eye measured at the EMAC appointment will be used to assess whether extent of deprivation or socioeconomic status affects the onset of disease presentation to the service. As per EMAC protocol, vision was measured and recorded in number of letters, ranging between 1 (1.68 LogMAR) and 100 (-0.30 LogMAR). Each line on the LogMAR chart has five letters. For the purpose of this text, vision measured as 'hand movements (HM)', 'perception of light (PL)', or 'no perception of light (NPL)' was assigned a letter score of 0. A conversion chart between letter, LogMAR, and Snellen visual acuity scores is included in the Appendix. Only patients with a GM postcode (306) were used for this analysis, with the analysis carried out using IMD, IHDD, and ACORN index. In line with previous analysis, patients will be divided into quintiles for tabulations using IMD and IHDD; quintile 1 includes the 'most deprived', whilst quintile 5 encapsulates the 'least deprived'. Patients will be divided into six groups for tabulations using the ACORN index. Starting with the IMD analysis, table 16 summarises the number of patients in each deprivation quintile, as well as the average baseline vision at presentation to EMAC. The mean baseline vision for all patients presenting to EMAC is 64 letters (SD= 14.4 letters). Patients in the most deprived quintile presented with the worst mean baseline vision, measuring at 60 letters, while patients in the least two deprived quintiles presented with about two lines better, an average baseline vision of 69 letters. Patients in quintiles two and three had a mean baseline vision of 63 and 65 letters, respectively.

Table 16. Number of patients and average baseline vision at EMAC for deprivation quintiles using IMD (total n= 306). Abbreviation: *SD* standard deviation.

Deprivation Quintile	Number of Patients, n (%)	Mean Baseline Vision, letters (SD, letters)
1 (Most Deprived)	98 (32%)	60 (13.6)
2	72 (23.5%)	63 (14.1)
3	58 (19%)	65 (15.5)
4	43 (14.1%)	69 (13.2)
5 (Least Deprived)	35 (11.4%)	69 (14.1)

A one-way ANOVA was performed to assess the effect of deprivation on onset of presentation to EMAC using baseline vision. A statistically significant difference was observed in baseline vision between at least two groups (F (4, 301) = [4.62], p= 0.001). Tukey's HSD test for multiple comparisons showed the average baseline vision was significantly different between the most deprived and least deprived quintiles (p= 0.011, 95% confidence intervals (CI)= 1.44, 16.69). Similarly, the average baseline vision was statistically different between quintiles one and four (p= 0.005, 95% CI= 1.95, 16.12). There was no statistically significant difference in average baseline vision between the remaining groups. The analysis was further repeated with IHDD scores to solely assess how health deprivation affects onset of disease presentation to the EMAC service. Table 17 summarises the number of patients in each deprivation quintile, as well as the average baseline vision at presentation to EMAC using IHDD. Patients in the most deprived quintile presented with the worst mean baseline vision, measuring at about 61 letters, whilst patients in the least deprived quintile presented with nearly twelve letters better, measuring at 72.5 letters. Patients in quintiles three and four had similar mean baseline vision, while patients in quintile two presented with a mean baseline vision of just under 65 letters.

Table 17. Number of patients and average baseline vision at EMAC for deprivation quintiles using IHDD (total n= 306). Abbreviation: *SD* standard deviation.

Deprivation Quintile	Number of Patients, n (%)	Mean Baseline Vision, letters (SD, letters)
1 (Most Deprived)	122 (39.9%)	60.7 (14.0)
2	100 (32.7%)	64.5 (13.4)
3	32 (10.5%)	67.1 (18.1)
4	39 (12.7%)	67.1 (14.1)
5 (Least Deprived)	13 (4.2%)	72.5 (11.0)

A one-way ANOVA was performed to assess the effect of health deprivation and disability on onset of presentation to EMAC using baseline vision. A statistically significant difference was observed in baseline average vision between at least two groups (F (4, 301) = [3.64], p= 0.007). Tukey's HSD test for multiple comparisons showed the mean baseline vision was significantly different between the most deprived and least deprived quintiles (p= 0.039, 95% CI= 0.35, 23.08). There was no statistically significant difference in average baseline vision between the remaining groups. The analysis was further repeated with the ACORN index to solely assess how socioeconomic factors affect onset of disease presentation to the EMAC service. Table 18 summarises the number of patients in each category, as well as the average baseline vision at presentation to EMAC using the ACORN index. Patients in group two presented with the best average baseline vision of 78 letters, followed by patients in group one, reading just over 67 letters. Patients in group six presented with the worst mean baseline vision of 52 letters. Patients in groups three to five had similar mean baseline visions of about 62 to 63 letters.

Table 18. Number of patients and average baseline vision at EMAC for socioeconomic groups using the ACORN index (total n= 306). Abbreviation: *SD* standard deviation.

ACORN Group	Patient Numbers, n (%)	Mean Baseline Vision, letters (SD, letters)
1; Affluent Achievers	74 (24.2%)	67.4 (14.6)
2; Rising Prosperity	9 (3.0%)	78 (6.7)
3; Comfortable Communities	71 (23.2%)	63.3 (15.8)
4; Financially Stretched	76 (24.8%)	62.5 (12.2)
5; Urban Adversity	71 (23.2%)	61.6 (14.1)
6; Not Private Households	5 (1.6%)	52 (18.2)

A one-way ANOVA was performed to assess the effect of socioeconomic factors on onset of presentation to EMAC using average baseline vision. A statistically significant difference was observed in baseline average vision between at least two groups (F (5, 300) = [4.00], p= 0.002).

Tukey's HSD test for multiple comparisons showed the mean baseline vision was significantly different between groups two and three (p= 0.04, 95% CI= 0.40, 29.02), groups two and four (p= 0.024, 95% CI= 1.24, 14.26), groups two and five (p= 0.014, 95% CI= 2.06, 30.68), as well as groups two and six (p= 0.013, 95% CI= 3.44, 48.56). There was no statistically significant difference for the average baseline vision between the remaining groups.

Deprivation in Greater Manchester and False-Positive Referrals to EMAC

This section will evaluate whether deprivation and socioeconomic factors impact the rate of false-positive referrals to EMAC. In chapter three, the proportion of referrals requiring urgent treatment by referral source was reviewed. Moreover, diagnosis and management of patients deemed to have no macular pathology after referral to EMAC was reviewed in chapter four. This section will revisit these two aspects with a particular focus on deprivation levels as well as socioeconomic factors. This will be assessed using IMD and IHDD scores, as well as the ACORN Index for all (306) patients with a GM postcode. For the purpose of this report, urgent treatment includes both intravitreal anti-VEGF injections, and topical treatment for conditions such as Post-Op CMO. False-positive refers to patients incorrectly sent to EMAC and should have been directly referred to the appropriate department in MREH.

Figure 29 shows the proportion of referrals requiring urgent treatment for each deprivation quintile using IMD scores. About a third (100) of all referrals to EMAC required urgent treatment. Just over 37% of referrals from the least deprived quintile required urgent treatment, the highest of all quintiles. About 28% of referrals from the second least deprived quintile required urgent treatment, the lowest of all quintiles. A third of referrals from quintile two required urgent treatment and 31% of referrals from the most deprived quintile required urgent treatment. Over 36% of referrals from quintile three required urgent treatment. Apart from quintile four, as deprivation level increased, there was a lower proportion of referrals requiring urgent treatment to the EMAC service. These calculations were repeated with IHDD scores to solely assess the impact of health and disability deprivation on referrals to the service. Figure 30 demonstrates the proportion of referrals requiring urgent treatment for each deprivation quintile using IHDD scores. Similar patterns were noted when IMD scores were used. Over 38% of referrals from the two least deprived quintile required urgent treatment, the highest of all quintiles. Only a quarter of referrals from quintile three required urgent referrals, the lowest of all quintiles. Over 31% of referrals from quintile one required urgent treatment, and 34% of referrals from quintile two also required urgent treatment.

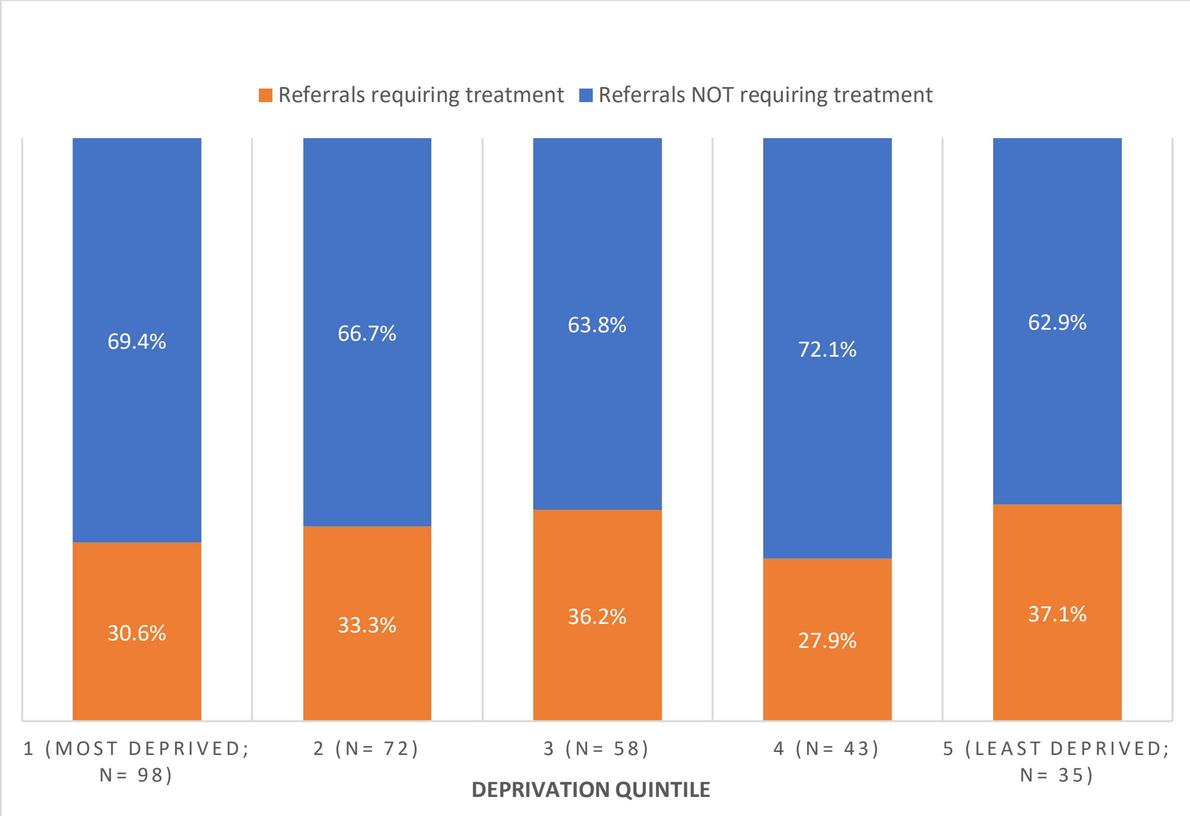

Figure 29. Ratio of referrals requiring urgent treatment for each deprivation quintile using IMD scores (total n= 306).

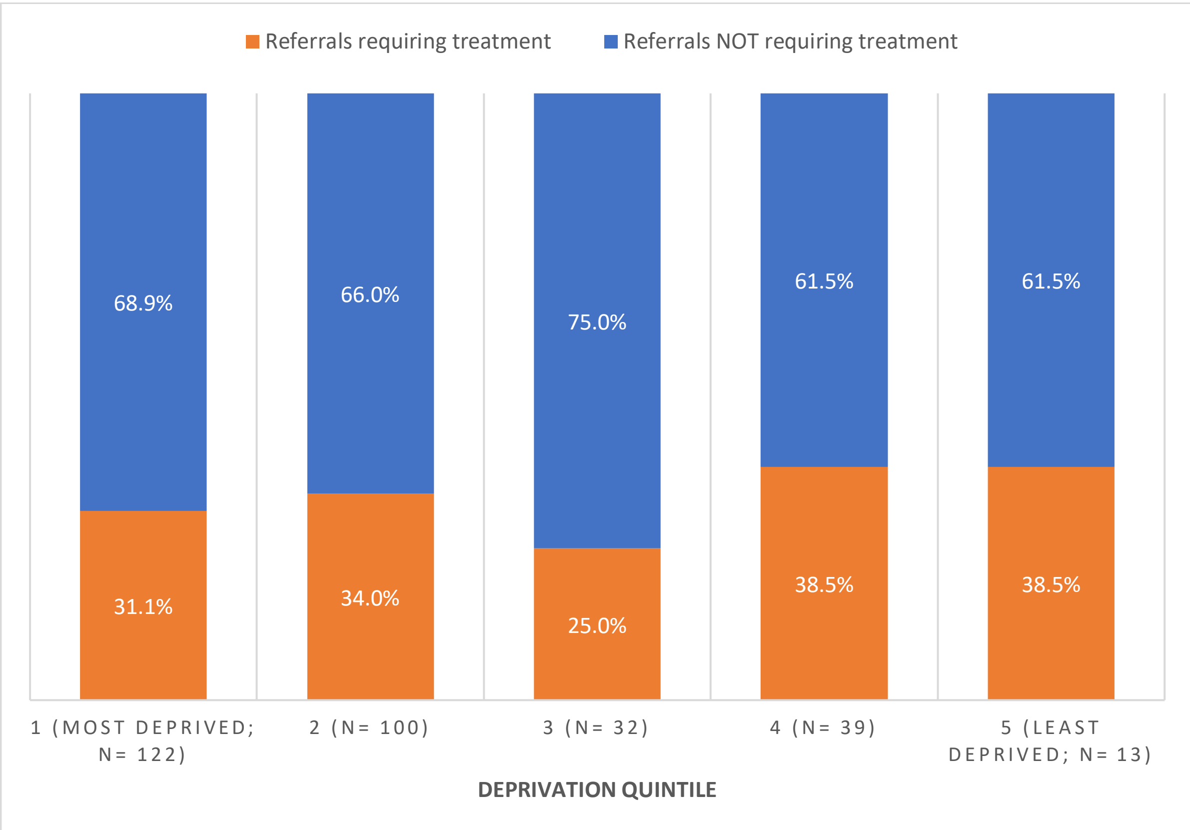

Figure 30. Ratio of referrals requiring urgent treatment for each deprivation quintile using IHDD scores (total n= 306).

The calculations were repeated with the ACORN index to assess the impact of socioeconomic factors on referrals to EMAC. Figure 31 illustrates the proportion of referrals requiring urgent treatment for every ACORN category. Though only five referrals were from category six, 60% of them required urgent treatment. Only 22% of referrals from category two required urgent treatment, the lowest ratio of all categories. About 30% of referrals from categories four and five required urgent treatment, slightly lower than the ratio from category one (31.1%). About 40% of referrals from category three required urgent treatment.

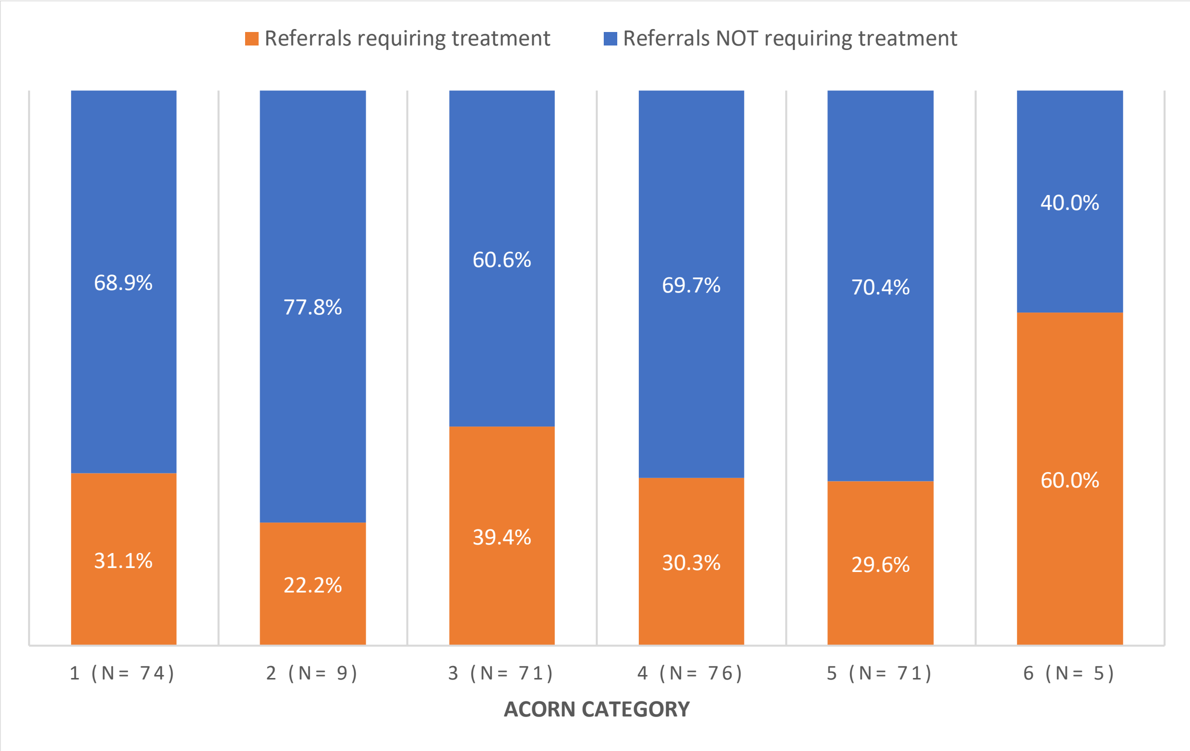

Figure 31. Ratio of referrals requiring urgent treatment for each ACORN category using the ACORN index (total n= 306). Abbreviation: *ACORN* A Classification of Residential Neighbourhoods.

As previously reported in chapter four, 21 patients referred to EMAC were deemed to having no macular pathology. However, through F2F fundal examination and additional imaging, two patients were found to have subtle macular changes at their MR appointment. Table 19 shows number of patients in each deprivation quintile for the remaining 19 patients without macular pathology using IMD and IHDD scores. In both scoring systems, over 68% of referred patients with no macular pathology were from the two most deprived quintiles. Using IMD, one patient each was referred from quintiles three and four, with the remaining four patients referred from the least deprived quintile. Using IHDD, two patients each were referred from quintiles three, four, and five. Given the small sample size, no formal statistical analysis was done. However, interestingly, the average baseline vision of the four patients from the least deprived quintile, measuring 80.8 letters (SD= 4.6 letters) was nearly four lines better than the average baseline vision of the seven patients in the most deprived quintile, measuring 61.3 letters (SD= 12.1 letters), and the six patients in the second most deprived quintile, measuring 61.8 letters (SD= 15.8 letters). Similar patterns were noted to IMD when patients were reclassified according to the ACORN index, as seen in figure 32. Over 63% of patients of referred patients were from categories four, five and six. No patients were referred from category two (rising prosperity); two patients were referred from category three (comfortable communities), with the remaining five patients referred from the highest socioeconomic status, category one (affluent achievers).

Table 19. Number of patients with no macular pathology in each deprivation quintile using IMD and IHDD scores (total n= 19). Abbreviations: *IMD* index of multiple deprivation, and *IHDD* index of health deprivation and disability.

Deprivation Quintile	Number of Patients, n (%) - IMD	Number of Patients, n (%) - IHDD
1 (Most Deprived)	7 (36.8%)	9 (47.4%)
2	6 (31.5%)	4 (21.1%)
3	1 (5.3%)	2 (10.5%)
4	1 (5.3%)	2 (10.5%)
5 (Least Deprived)	4 (21.1%)	2 (10.5%)

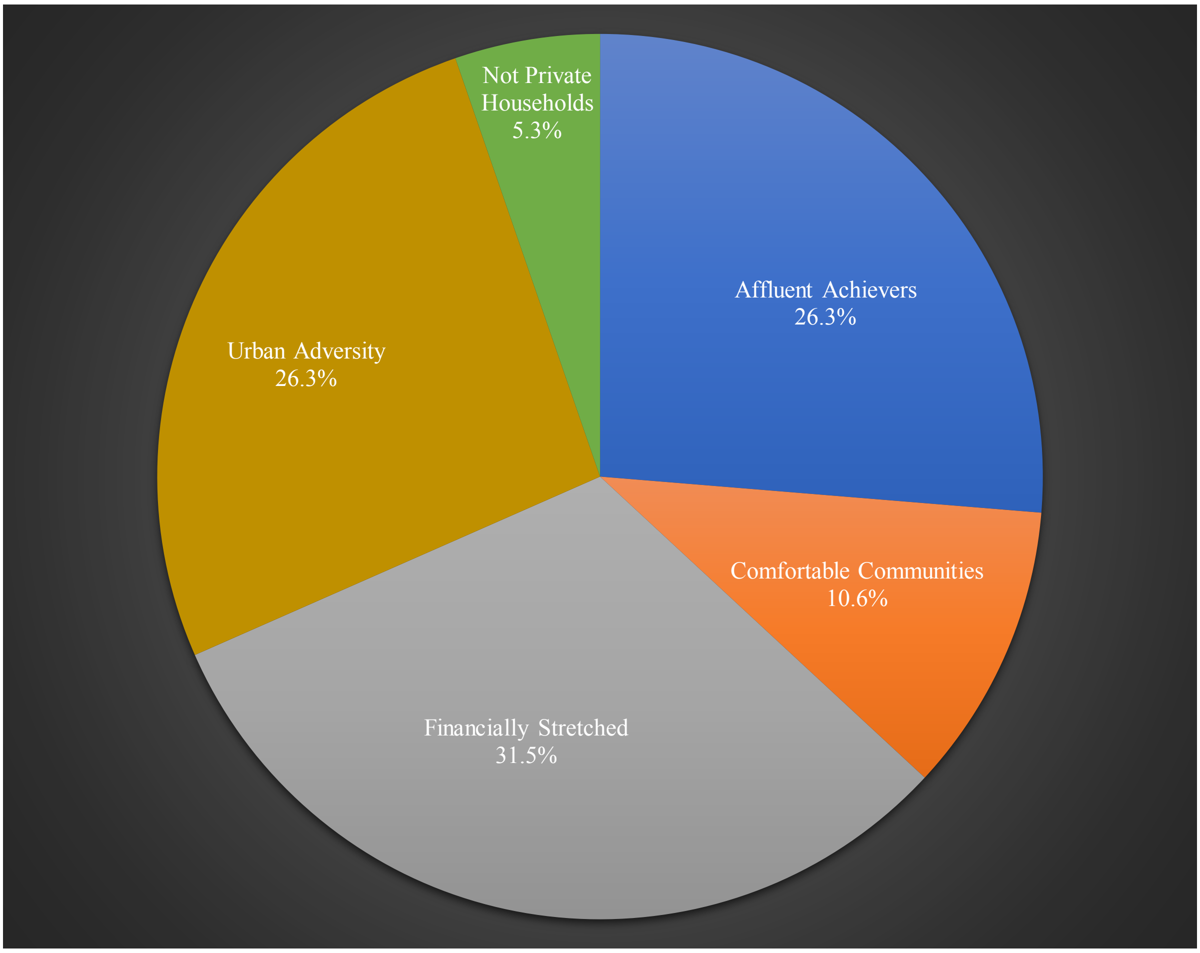

Figure 32. Percentage of patients with no macular pathology in each ACORN group (n= 19).

Once again, given the small sample size, no formal statistical analysis was done. However, interestingly, the average baseline vision of the five patients from the highest socioeconomic group (affluent achievers), measuring 82.6 letters (SD= 5.7 letters) was over 21 letters better than the mean baseline vision of the six patients in group four (financially stretched) measuring 61.3 letters (SD= 14.4 letters). It was also over 15 letters better than the mean baseline vision of the five patients in group five (urban adversity), measuring 67.4 letters (SD= 7.2 letters). The following two sections will explore whether deprivation affects the onset of presentation of both wet and dry AMD to the EMAC service. The analysis was not carried out for all other macular conditions due to insufficient sample size.

Deprivation in Greater Manchester and Onset of Disease Presentation – Wet AMD

Only patients with a GM postcode formally diagnosed with wet AMD (74) were used for this analysis, with the analysis carried out using IMD, IHDD, and the ACORN index. Starting with IMD analysis, table 20 summarises the number of patients with wet AMD in each deprivation quintile, as well as the average baseline vision at presentation to EMAC. The average baseline vision for all patients was 57.5 letters (SD= 13.3 letters). Patients in the least deprived quintile presented with the worst average baseline vision, measuring at 53.9 letters, whilst patients in the second least deprived quintile presented with the highest average baseline vision of 64 letters. Patients in quintiles one to three had similar mean baseline visions ranging from 55 to 58 letters.

Table 20. Number of wet AMD patients and average baseline vision at EMAC for deprivation quintiles using IMD (total n= 74). Abbreviation: *SD* standard deviation.

Deprivation Quintile	Number of Patients, n (%)	Mean Baseline Vision, letters (SD, letters)
1 (Most Deprived)	22 (29.7%)	58 (12.0)
2	15 (20.3%)	54.9 (13.0)
3	16 (21.6%)	57 (13.3)
4	11 (14.9%)	64 (13.1)
5 (Least Deprived)	10 (13.5%)	53.9 (16.3)

A one-way ANOVA was performed to assess the effect of deprivation on onset of presentation of wet AMD to EMAC using baseline vision. No statistically significant difference was noted in baseline vision between at least two groups (F (4, 69) = [1.00], p= 0.41). The analysis was further repeated with IHDD scores to solely assess how health deprivation affects onset of wet AMD presentation to the EMAC service. Table 21 summarises the number of patients in each deprivation quintile, as well as the mean baseline vision at presentation to EMAC using IHDD. Patients in the least deprived quintile presented with the highest mean baseline vision of 64.8

letters, whilst patients in the second least deprived quintile presented with the worst mean baseline vision of 53.6 letters. Patients in quintiles one and two had similar average baseline visions about 57 to 58 letters. Patients in quintile three had a baseline vision of 62.3 letters.

Table 21. Number of wet AMD patients and average baseline vision at EMAC for deprivation quintiles using IHDD (total n= 74). Abbreviation: *SD* standard deviation.

Deprivation Quintile	Number of Patients, n (%)	Mean Baseline Vision, letters (SD, letters)
1 (Most Deprived)	28 (37.8%)	56.8 (12.4)
2	23 (31.1%)	58 (12.9)
3	6 (8.1%)	62.3 (14.4)
4	13 (17.6%)	53.6 (15.5)
5 (Least Deprived)	4 (5.4%)	64.8 (13.7)

A one-way ANOVA was performed to assess the effect of health deprivation and disability on onset of presentation of wet AMD to EMAC using baseline vision. No statistically significant difference was noted in average baseline vision between at least two groups ($F (4, 69) = [0.79]$, $p= 0.53$). The analysis was repeated once again with the ACORN index to solely assess how socioeconomic factors affect onset of wet AMD presentation to the EMAC service. Table 22 summarises the number of patients in each category, as well as the average baseline vision at presentation to EMAC using the ACORN index. Patients in group two had the highest mean baseline vision of 69.5 letters, but there were only two patients in this group. Patients in group one had the worst average baseline vision of 54.1 letters. Patients in groups three and six had a similar average baseline visions of approximately 55 letters. Patients in groups four and five also presented with similar average baseline visions of about 60 letters.

Table 22. Wet AMD patient numbers and mean baseline vision at EMAC for socioeconomic groups using the ACORN index (total n= 74). Abbreviation: *SD* standard deviation.

ACORN Group	Patient Numbers, n (%)	Mean Baseline Vision, letters (SD, letters)
1; Affluent Achievers	20 (27%)	54.1 (16.1)
2; Rising Prosperity	2 (2.7%)	69.5 (3.5)
3; Comfortable Communities	18 (24.3%)	55.6 (11.3)
4; Financially Stretched	18 (24.3%)	60.9 (11.9)
5; Urban Adversity	13 (17.6%)	59.2 (11.2)
6; Not Private Households	3 (4.1%)	55 (21.7)

A one-way ANOVA was performed to assess the effect of socioeconomic factors on onset of wet AMD presentation to EMAC using baseline vision. Given the exceptionally small sample size of groups two and six, the analysis was carried out after their exclusion. No statistically significant difference was noted in the average baseline vision between at least two groups for the remaining four groups (F (3, 65) = [1.08], p= 0.36).

Deprivation in Greater Manchester and Onset of Disease Presentation – Dry AMD

Only patients with a GM postcode formally diagnosed with dry AMD (78) were used for this analysis, with the analysis carried out using IMD, IHDD, and the ACORN index. Starting with IMD analysis, table 23 summarises the number of patients with dry AMD in each deprivation quintile, as well as the average baseline vision at presentation to EMAC. The average baseline vision for all patients was 67.6 letters (SD= 11.9 letters). Patients in the most deprived quintile presented with the worst mean baseline vision, measuring at 61.6 letters, whilst patients in the second least deprived quintile presented with the highest average baseline vision of about 75 letters. The mean baseline vision of patients in quintiles three and five were only a few letters worse than quintile four's, measuring 70.8 and 72.9 letters, respectively. Mean baseline vision of patients in quintile two was about a line better than quintile one's, measuring 66.4 letters.

Table 23. Number of dry AMD patients and average baseline vision at EMAC for deprivation quintiles using IMD (total n= 78). Abbreviation: *SD* standard deviation.

Deprivation Quintile	Number of Patients, n (%)	Mean Baseline Vision, letters (SD, letters)
1 (Most Deprived)	22 (29.7%)	61.6 (15.6)
2	23 (20.3%)	66.4 (10.4)
3	15 (21.6%)	70.8 (6.4)
4	10 (14.9%)	74.7 (9.5)
5 (Least Deprived)	8 (13.5%)	72.9 (7.5)

The Kruskal-Wallis *H* test was performed to evaluate the effect of deprivation on the onset of dry AMD presentation to EMAC using baseline vision. Statistically significant difference was noted in the mean baseline vision between at least two groups (*H*(4) = [13.03], p= 0.011), with a mean rank score of 29.5 for quintile one, 35.3 for quintile two, 44 for quintile three, 57 for quintile four, and 48.9 for quintile five. Post-Hoc Dunn's test using a Bonferroni-corrected alpha of 0.005 for multiple comparisons revealed the average baseline vision was significantly different between quintiles one and four (p= 0.001). There was no statistically significant difference in the mean baseline vision between the remaining groups. The analysis was further repeated with IHDD scores to solely assess how health deprivation and disability affects onset of dry AMD presentation to the EMAC service. Table 24 summarises the number of patients in each deprivation quintile, as well as average baseline vision at presentation to EMAC using IHDD. Patients in the most deprived quintile presented with the worst average baseline vision, measuring 62.4 letters, whilst patients in the second least deprived quintile presented with the highest mean baseline vision of 74.3 letters. The average baseline vision of patients in quintiles three and five was largely similar to quintile four's, measuring 73.5 letters and 72 letters, respectively. Average baseline vision of patients in quintile two was over a line better than quintile one's, measuring at 68.3 letters.

Table 24. Number of dry AMD patients and average baseline vision at EMAC for deprivation quintiles using IHDD (total n= 78). Abbreviation: *SD* standard deviation.

Deprivation Quintile	Number of Patients, n (%)	Mean Baseline Vision, letters (SD, letters)
1 (Most Deprived)	27 (34.6%)	62.4 (14.4)
2	31 (39.7%)	68.3 (9.8)
3	10 (12.8%)	73.5 (9.6)
4	8 (10.3%)	74.3 (3.4)
5 (Least Deprived)	2 (2.6%)	72 (17.0)

The Kruskal-Wallis *H* test was used to evaluate the effect of health deprivation and disability on the onset of dry AMD presentation to EMAC using baseline vision. Given quintile five's extremely small sample size, it was excluded from the analysis. The test revealed a statistically significant difference in mean baseline vision between at least two groups for the remaining four groups ($H(3) = [11.4]$, p= 0.01), with a mean rank score of 30.0 for quintile one, 37.7 for quintile two, 51.4 for quintile three, and 54.0 for quintile four. Post-Hoc Dunn's test using a Bonferroni-adjusted alpha of 0.0083 for multiple comparisons showed the mean baseline vision was significantly different between groups one and four (p= 0.006). There was no statistically significant difference in mean baseline vision between the remaining groups. The analysis was further repeated with the ACORN index to solely assess how socioeconomic factors affect onset of dry AMD presentation to EMAC. Table 25 summarises the number of patients in each category, as well as the average baseline vision at presentation to EMAC using the ACORN index. There was a single patient in each of groups two and six, with a baseline vision of 82 letters and 60 letters, respectively. Considering the remaining four groups, group one patients presented with the highest mean baseline vision, measuring 72 letters, while group four patients had the worst average baseline vision of 63.5 letters. Patients in group three had a mean baseline vision of 70 letters, which was a line better compared to mean baseline vision for patients in group five.

Table 25. Dry AMD patient numbers and mean baseline vision at EMAC for socioeconomic groups using the ACORN index (total n= 78). Abbreviation: *SD* standard deviation.

ACORN Group	Patient Numbers, n (%)	Mean Baseline Vision, letters (SD, letters)
1; Affluent Achievers	18 (23.1%)	72 (9.0)
2; Rising Prosperity	1 (1.3%)	82
3; Comfortable Communities	22 (28.2%)	69.5 (9.6)
4; Financially Stretched	21 (26.9%)	63.5 (10.0)
5; Urban Adversity	15 (19.2%)	64.9 (18.0)
6; Not Private Households	1 (1.3%)	60

The Kruskal-Wallis *H* test was performed to assess the effect of socioeconomic factors on the onset of dry AMD presentation to EMAC using baseline vision. Given the exceptionally small sample size of groups two and six, the analysis was carried out after their exclusion. The test showed statistically significant difference in mean baseline vision between at least two groups for the remaining four groups ($H(3) = [7.85]$, p= 0.049), with an average rank score of 46.9 for group one, 41.3 for group three, 27.9 for group four, and 39.3 for group five. Post-Hoc Dunn's test using a Bonferroni-adjusted alpha of 0.0083 for multiple comparisons showed the mean baseline vision was significantly different between groups one and four (p= 0.006). There was no statistically significant difference in mean baseline vision between the remaining groups.

Chapter Discussion

The chapter outlined the impact of deprivation and socioeconomic factors on referral patterns to the EMAC service within GM. Referral numbers from the ten boroughs in GM did not align with their respective proportion of GM's population. Despite making up nearly 38% of GM's population, there was a combined total of nine referrals from Bolton, Oldham, Rochdale, and Wigan, accounting for 2.9% of referrals. This is due to the presence of local eye units in these areas where referrals from primary care are directed. Despite this, and as previously described, referrals from these four boroughs (as well as those from local authorities outside GM) can be directed to MREH for more complex clinical cases requiring additional specialist opinion and management. Patient preference for referral to MREH instead of the local eye unit is another common reason, particularly if the patient is dissatisfied with quality of care provided locally. Manchester, located in the North-West region is one of the most deprived local authorities in England; it is the 6th most deprived local authority using IMD and the 5th most deprived local authority using IHDD. This is in line with the well-established and longstanding North-South health divide and regional inequalities in health across England.[148] This divide arises since the three Northern regions 'North-West', 'North-East', and 'Yorkshire and Humber' are more deprived than other regions in England.[148,149]

Analyses were carried out in this study to assess whether deprivation affects access to eyecare. There was no statistically significant difference between ratios of EMAC referrals and GM's LSOAs for all five deprivation quintiles using IMD when considering all ten boroughs or the four boroughs making up 87.6% of all referrals. This is likely due to deprivation scores being skewed by scores of individual domains that can mask or dilute the effect of health deprivation. However, there was 5.9% and 9.2% less than expected referrals from the most deprived quintile for all ten boroughs and four boroughs, respectively. However, unequal access due to deprivation was noted when considering IHDD scores, which showed statistically significant difference between the ratios of EMAC referrals and GM's LSOAs for all ten boroughs. There was 6.2% less than expected referrals from the most deprived quintile and 6.2% more than expected referrals from the two least deprived quintiles. This was also statistically significant when considering only four boroughs, with 13.4% less than expected referrals from the most deprived quintile and 6.5% more than expected referrals from the two least deprived quintiles. The common factor for all the aforementioned analyses was the less than expected referrals from the most deprived quintile despite it making a large proportion of GM's LSOAs, ranging from 37.9% to 56.7%. These patterns are consistent with research showing health inequality in eyecare access, which can be ascribed to the scarcity of optometry practices and limited access to optometric services in more deprived regions.[150] The lack of public awareness about health benefits of eye examinations within more deprived regions, combined with negative perceptions of optometry around spectacle sales play an additional role in affecting service access.[151,152]

Analysis was also carried out in this report to evaluate whether socioeconomic factors affect access to eyecare. There was no statistically significant difference between the ratios of EMAC referrals and national population for each ACORN group. However, surprisingly, unlike the patterns seen for IMD and IHDD, there was 1.6% and 6.2% more than expected referrals for groups four (financially stretched) and five (urban adversity), respectively. Conversely, there was 6.4% and 3.8% less than expected referrals from groups two (rising prosperity) and three (comfortable communities), respectively. Two reasons may account for these findings. Firstly, ACORN index data from 2015 was used in this study, most recent data accessible for research purposes. Considering the dynamic nature of consumer behaviour, which in turn can affect socioeconomic factors and ACORN group classification, more up-to-date index data may have provided a different picture more consistent to patterns seen using IMD and IHDD. Secondly, and most importantly, IMD and IHDD analyses compared ratios of EMAC referrals and GM's

LSOAs for each deprivation quintile, which was not possible for the ACORN analysis. There was no data specific to the proportion of GM's population in each ACORN group, therefore, the ratio of EMAC referrals was compared to that of the UK's population for all groups. Given that socioeconomic health inequalities are larger in the North of England than in the South,[153] with these regional inequalities considered amongst the largest in Europe,[154] using national figures likely reflected a misconstrued picture to that of GM's for all groups. As such, it likely showed inaccurate referral patterns where more than expected referrals were sent from lower socioeconomic groups and less than expected referrals from higher socioeconomic groups. It is evident results of this study did not align with pre-existing research that shows health inequality and limited access to care is linked to lower socioeconomic status.[155]

Analysis was carried out in this report to assess the impact of deprivation and socioeconomic factors on onset of disease presentation. Patients in the most deprived quintile presented with the lowest average baseline vision, whilst patients in the least deprived quintile presented with the highest mean baseline vision. There was a statistically significant difference of about two lines (ten letters on the LogMAR chart), evident for both IMD and IHDD. Results were largely similar using the ACORN index. These patterns likely arose to aforesaid factors including limited access to optometric services for patients living in more deprived areas, combined with these patients' negative perceptions about optometry overshadowing health benefits of eye examinations. This can lead to reduced frequency of attendance or non-attendance, which can in turn result in delayed diagnosis and overall poorer visual outcomes. This is line with existing literature showing ocular disease and resultant visual impairment are prevalent amongst individuals living in greater deprivation in countries including the UK.[156-160] Moreover, those living in more deprived regions are more likely to present with late-stage ocular disease[161-164] and have low vision.[165] Individuals living in more deprived regions are more likely to develop diabetes and DR,[166] and are less likely to attend screening appointments, all combining to increased risks of visual loss secondary to DR.[167]

Generally, higher FP rates for referrals to EMAC were observed in the more deprived quintiles and lower socioeconomic groups. For the purpose of this text, FP refers to patients incorrectly referred to the service, who should have been directly referred to the appropriate department in MREH. This pattern likely arose to a combination of factors including scarcity of services, availability of supplementary imaging services (i.e., OCT and widefield fundus photography), and affordability of these services to patients. With less optometry practices present in more deprived areas, and additional associated costs with diagnostic techniques such as OCT, it can be argued patients living in these areas are less likely to have access to these diagnostics and less likely to afford them. As such, clinicians examining patients in more deprived areas may need to primarily rely on clinical examination for diagnosis and management, thus, resulting in a higher FP rate of referrals to EMAC.

Income has been shown as a major determinant for social inequalities associated with visual impairment and blindness.[168] Manchester is one of several major UK cities with household income among the lowest in the country.[169] It had an annual disposable household income of about £15,000 per person, which is about 30% lower than the UK average. This notion is also supported when assessing referred patients judged as having no macular pathology. Though over two-thirds of these referrals were from the two most deprived quintiles, those requiring treatment had ocular media abnormalities. An OCT scan would have likely confirmed absence of macular abnormalities as a cause for the reduced vision, with patients appropriately referred for management of their ocular media opacity. Furthermore, patients referred from the least deprived quintile had a near-excellent mean baseline vision of over 81 letters, about four lines better than the average baseline vision for patients in the most deprived quintile. This suggests patients from affluent areas are likely referred to EMAC out of overcaution and/or clinician's inability to correctly manage patients based on clinical findings, as opposed to inability to rule out macular pathology, which likely happened in less affluent areas. This likely contributed to the overall observed FP rate patterns.

Investigating the impact of deprivation and socioeconomic factors on onset of presentation of wet AMD patients to EMAC revealed no statistical difference in average baseline vision using IMD, IHDD or ACORN index. While this is reassuring, a large majority of these patients were in the most deprived quintiles and lowest socioeconomic groups, ranging from 46% to 69% using ACORN index and IHDD, respectively. Literature on the subject is limited and mixed. One study revealed wet AMD patients from more deprived areas were found to have worse baseline vision than patients in less deprived areas.[162] Similarly, another study suggested patients residing in more deprived areas had severe visual outcomes in AMD.[163] However, one study revealed no association between baseline vision and socioeconomic factors.[170]

Exploring the impact of those factors on onset of presentation of dry AMD patients to EMAC revealed statistically significant difference in mean baseline vision as a result of affluence and socioeconomic status. Patients from high affluence or socioeconomic areas are presenting with approximately two lines better vision than those from low affluence or socioeconomic areas. This is likely due to a myriad of reasons such as readily available access to optometric services in more affluent areas encouraging patients to have regular eye examinations, availability of additional diagnostic testing in practice, and affordability of these services, which affects the willingness of patients to access them. All these reasons likely combine to play a role in earlier diagnosis of dry AMD patients from high affluence or socioeconomic areas and their referral to HES. A study showed that living in less deprived areas exerted a protective effect on AMD; those living in the most affluent 5% of areas had nearly half the odds of AMD than those living in relatively more deprived areas, after adjusting for all other factors.[157]

In summary, there is evidence deprivation and socioeconomic factors impact referral patterns to the EMAC service, as well as presentation onset of macular conditions. This is in line with existing literature carried out across different subspecialities. Findings can inform changes to public eye health campaigns, stressing the importance of regular eye examinations for earlier detection of eye disease. They also serve as a steppingstone for further investigations into the potential interventions required to reduce health inequalities relating to ocular disease. There are negative clinical implications due to this disparity. Delayed diagnosis in primary care and late presentation to HES can lead to missed opportunities for early intervention and treatment, resulting in overall worse visual prognosis and outcomes. Similarly, effectiveness of potential treatments may be reduced for advanced forms of macular disease. Moreover, individuals with limited resources may struggle to follow treatment regimens or attend regular follow-up HES appointments, thus, compromising the effectiveness of their treatment. This may contribute to overall health inequities, affecting quality of life and mortality levels.

Chapter VII – EMAC & OCT Workshop as CPD for Optometrists

Chapter three revealed only a third of referrals from primary care optometrists met the EMAC referral criteria, however, chapter five illustrated almost perfect agreement between OSIs and ophthalmologists for management of referred macular conditions to EMAC. This chapter will evaluate the effectiveness of further education and training on optometrists' confidence levels in diagnosing macular conditions using OCT and making appropriate referrals to the EMAC service. This is crucial as improving optometrists' confidence levels and understanding of the EMAC criteria can improve their diagnostic performance and quality of referrals, which in turn, results in a more streamlined EMAC service. Moreover, this will help identify any gaps in training that can be addressed through regular delivery of interactive educational workshops to primary care optometrists by experienced EMAC optometrists at MREH.

As previously described, an educational event consisting of a 90-minute workshop was set up and delivered to optometrists across GM. The workshop covered several topics including the EMAC service, OCT technology and its uses, and signs of macular disease on OCT. Clinical case scenarios of the most common macular conditions were presented along with up-to-date referral guidelines for each condition. Subclassification of wet AMD was also discussed in-depth with provided examples. Optometrists were asked to complete an identical survey both before and after the workshop.

Developing the survey started with a discussion between the main supervisor and myself (both optometrists) about its objectives. Questions were created that ensured the research objectives could be achieved. The objectives comprised of assessing optometrists' levels of confidence, understanding of the EMAC referral criteria, and how these aspects are affected by the primary setting of practice, level of optometric experience, and the availability of OCT technology. A rough draft of questions was developed to address these elements, which were later discussed, optimised, and finalised after collaboration with the supervisor and two work colleagues. This is reflected in questions two to six. This first draft was reviewed and amended by the associate supervisor (ophthalmologist). This version was then put to a focus group of one optometrist, two ophthalmologists, and one clinical manager and a final version was devised.

Another primary objective of the survey was to assess its efficacy and educational value. After a similar collaborative process as explained above, questions seven and eight were included. Additionally, five clinical case records of macular conditions (questions nine to thirteen) were included to evaluate the optometrists' diagnostic and management performance. Clinical cases were selected to include conditions that required referral to EMAC (wet AMD and RVO with secondary CMO), referral to other outpatient clinics (AVMD and FTMH) or no referral at all (asymptomatic ERM). An identical survey was used before and after the workshop to illustrate its outcomes on all the aforementioned objectives.

In total, there were 251 registrants for the event, but the attendance rate was 69% (173). The pre-workshop survey was filled out by 192 registrants, whilst the post-workshop survey was filled out by 151 registrants. To assess the effectiveness of this educational event, analysis was only considered for those 151 participants that completed all three elements of the event. Upon further review of the data, only 147 participants were included in the analysis, with the remaining four participants excluded for the following reasons:

1. Three participants were not optometrists: one doctor, one nurse, and one OSP.
2. One participant was an international optometrist who was not registered in the UK.

Demographics of Optometrists & Availability of OCT Technology

In the surveys, optometrists were asked about their primary mode of practice, availability of OCT technology in said practice, and their total level of optometric experience in years. About 86% (126) of participants worked in primary care while nearly 13% (19) worked in secondary care. The remaining two participants worked in Academia. Over 82% of optometrists (124) indicated presence of an OCT in their practice, whereas the remaining 27 optometrists were without one. There was a large range in the level of experience across optometrists, between one year and 44 years, with a median of 14 years of experience. The total average years of experience was 17.3 years (SD= 12.5 years). Two optometrists were at pre-registration level.

Optometrists' Confidence Levels in Assessing Macular OCT Scans

In the surveys, optometrists were asked to assess their confidence level in assessing macular OCT scans using a five-point categorical scale, ranging from 'very confident' to 'not confident at all'. Pre-workshop survey results revealed over 31% of optometrists felt 'confident' or 'very confident' in assessing macular OCT scans, whilst a quarter of optometrists answered, 'not confident' or 'not confident at all'. The remaining optometrists reported 'somewhat confident' in assessing macular OCTs. Post-workshop survey results revealed a largely similar number of optometrists felt 'somewhat confident' in assessing OCTs. Eleven optometrists answered 'very confident' in assessing OCTs, an increase of 37.5%. An increase of 50% was observed in optometrists feeling 'confident' in assessing scans. On the other end of the scale, there was a reduction of 62% and 75% in optometrists feeling 'not confident' and 'not confident at all' in assessing OCTs, respectively. A summary of results is illustrated in figure 33.

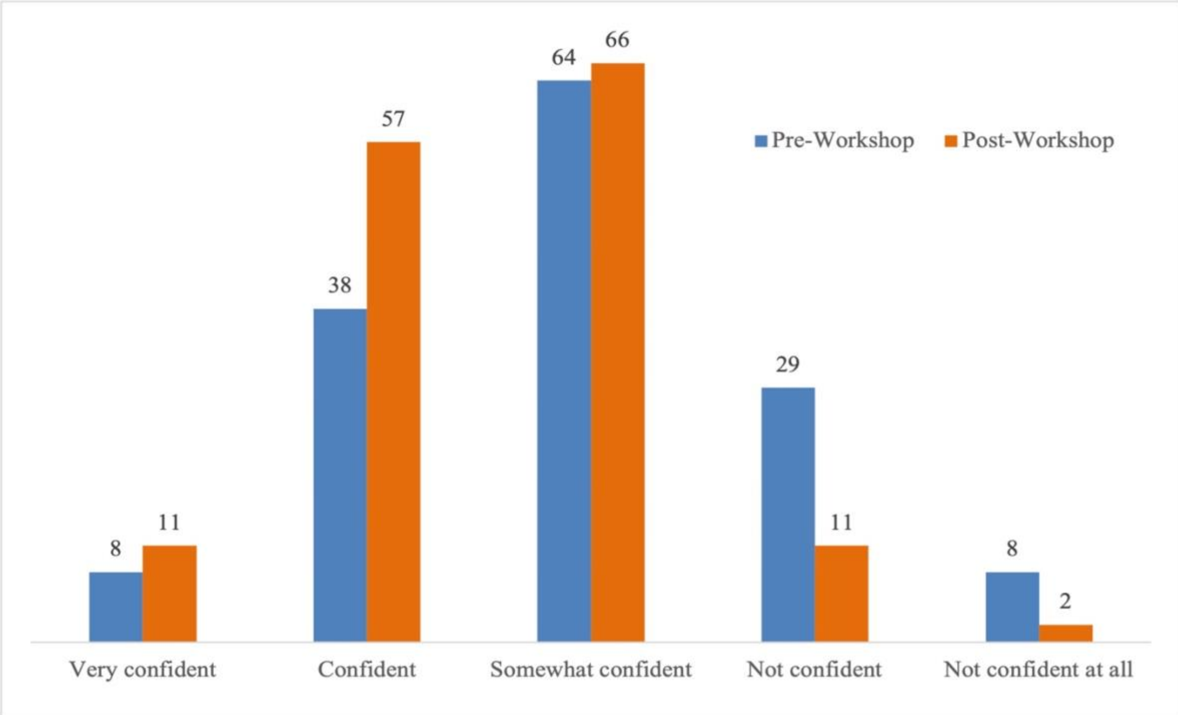

Figure 33. Optometrists' pre- and post-workshop confidence levels in assessing macular OCT scans (n= 147). Abbreviation: *OCT* optical coherence tomography.

A two-tailed Wilcoxon signed-rank test was carried out to evaluate the effect of the workshop on optometrists' confidence levels in assessing macular OCT scans. The test showed statistically significant improvement in confidence levels following the workshop ($p < 0.001$). Confidence levels were compared between primary care and secondary care optometrists. The mean total years of experience for optometrists working in primary care was 17.7 years (SD= 12.7 years), which was four years longer than those working in secondary care (13.7 years; SD= 10.6 years). This difference was not statistically significant ($p = 0.21$). Pre-workshop confidence levels showed optometrists working in secondary care setting had a higher average confidence score compared to those working in primary care. A two-tailed Mann-Whitney U-test showed this difference was statistically significant ($p = 0.02$). Similarly, post-workshop confidence levels showed optometrists working in secondary care setting had a higher average confidence score compared to those working in primary care. However, a two-tailed Mann-Whitney U-test showed this difference was not statistically significant ($p = 0.17$). Although the mean confidence score for optometrists working in secondary care was higher post-workshop compared to pre-workshop, a two-tailed Wilcoxon signed-rank test revealed this was not statistically significant ($p = 0.39$). A two-tailed Wilcoxon signed-rank test showed statistically significant higher average confidence score for optometrists working in primary care post-workshop compared to pre-workshop ($p < 0.001$).

Optometrists' confidence levels were further gauged through evaluating the number of correct answers achieved for the five clinical case scenarios in accordance with their pre-workshop self-perceived confidence levels in assessing OCT scans. Four optometrists answered all cases incorrectly, of which two reported 'somewhat confident' and two reported 'not confident'. For the eight optometrists reporting 'very confident', they all answered a minimum of three cases correctly, with two answering all cases correctly. For the eight optometrists reporting 'not confident at all', no optometrist achieved a perfect score, but interestingly, half of them answered four cases correctly. For the 38 optometrists reporting 'confident', although 21% achieved a perfect score, nearly a quarter of them only got two or less correct answers. For the 29 optometrists reporting 'not confident', only one optometrist achieved a perfect score, but nearly half of the optometrists only got two or less correct answers. For the 64 optometrists reporting 'somewhat confident', only four optometrists achieved a perfect score and a third of optometrists got two or less correct answers. A summary of results is illustrated in figure 34.

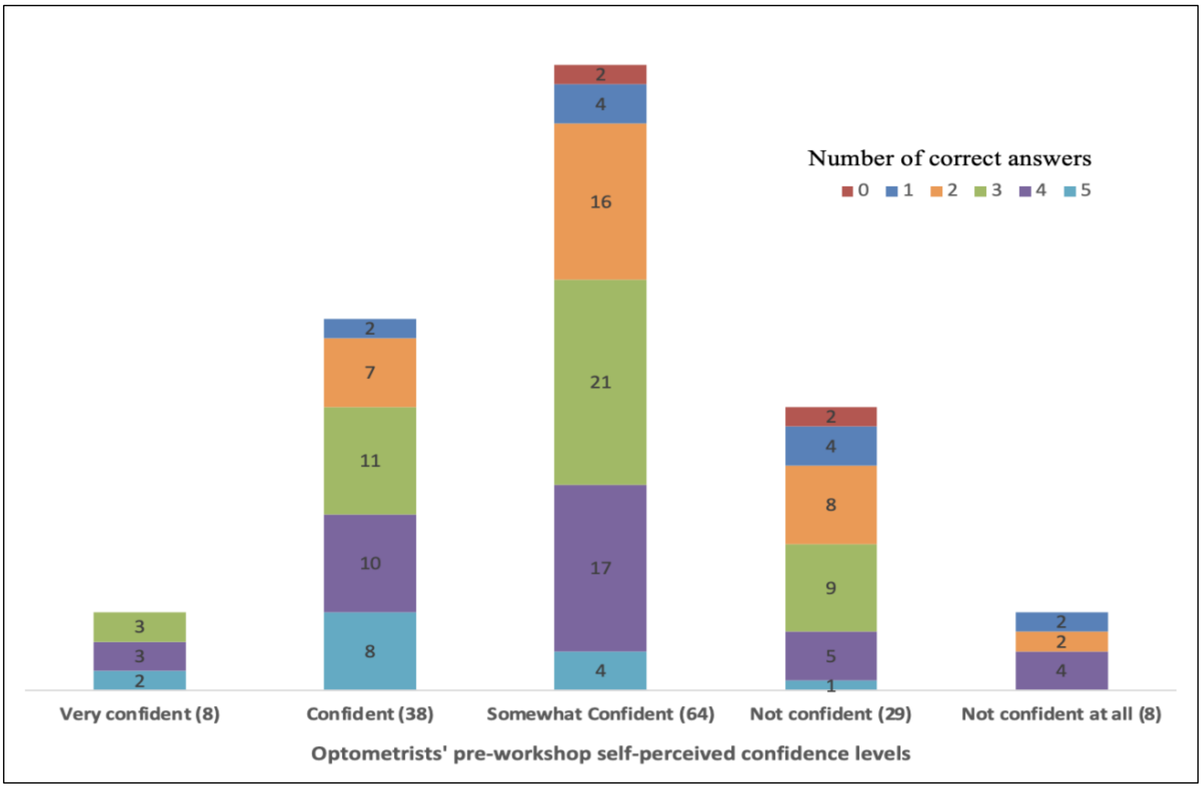

Figure 34. Number of correct answers achieved for five clinical case records compared to the optometrists' pre-workshop self-perceived confidence levels in assessing OCTs (n= 147).

About a tenth of optometrists achieved a perfect score, with all of them reporting presence of OCT technology in their practice. The average years of experience for this group was 17.1 years (SD= 13.7 years), with a range of one to 42 years. About 27% of optometrists answered four cases correctly, with 82% of them reporting presence of OCT in their practice. The mean years of experience for this group was 17.5 years (SD= 11.3 years), with a range of one to 40 years. About 30% of optometrists correctly answered three cases, and 84% of them reported use of OCT in their practice. The mean years of experience for this group was 18.4 years (SD= 13.9 years), with a range of one to 43 years. Over 22% of optometrists correctly answered two cases, with 79% of them reporting presence of OCT in their practice. The average years of experience for this group was 14.8 years (SD= 11.8 years), with a range of one to 43 years. Twelve optometrists only achieved a score of one out of five, with two-thirds of them reporting presence of OCT in their practice. The mean years of experience for this group was 17.5 years (SD= 11.8 years), with a range of one to 44 years. The final four optometrists achieved a score of zero, with only half of them reporting presence of OCT in their practice. The average years of experience for this group is 21.3 years (SD= 14.2 years), with a range of ten to 42 years. The Kruskal-Wallis *H* test was performed to evaluate differences in years of experience between groups. The test showed no statistical significance between the different groups ($H(5) = [2.19]$, $p = 0.82$), with a mean rank score of 71.6 for group '5 correct answers', 76.4 for group '4 correct answers', 76.2 for group '3 correct answers', 66.0 for group '2 correct answers', 77.3 for group '1 correct answer', and 91.4 for '0 correct answers'.

A linear regression analysis was carried out to establish whether the number of correct answers achieved for clinical cases in the pre-workshop survey correlated to years of experience. No statistically significant correlation was found between years of experience and number of cases correctly answered, $r(145) = 0.014$, $p = 0.86$. A very weak positive correlation was observed, as illustrated in figure 35. Further linear regression analysis was carried out to assess whether pre-workshop self-perceived confidence in assessing macular OCT scans correlated to years of experience. No statistically significant correlation was found between both factors, $r(145) = -0.087$, $p = 0.29$. A very weak inverse correlation was observed, as illustrated in figure 36.

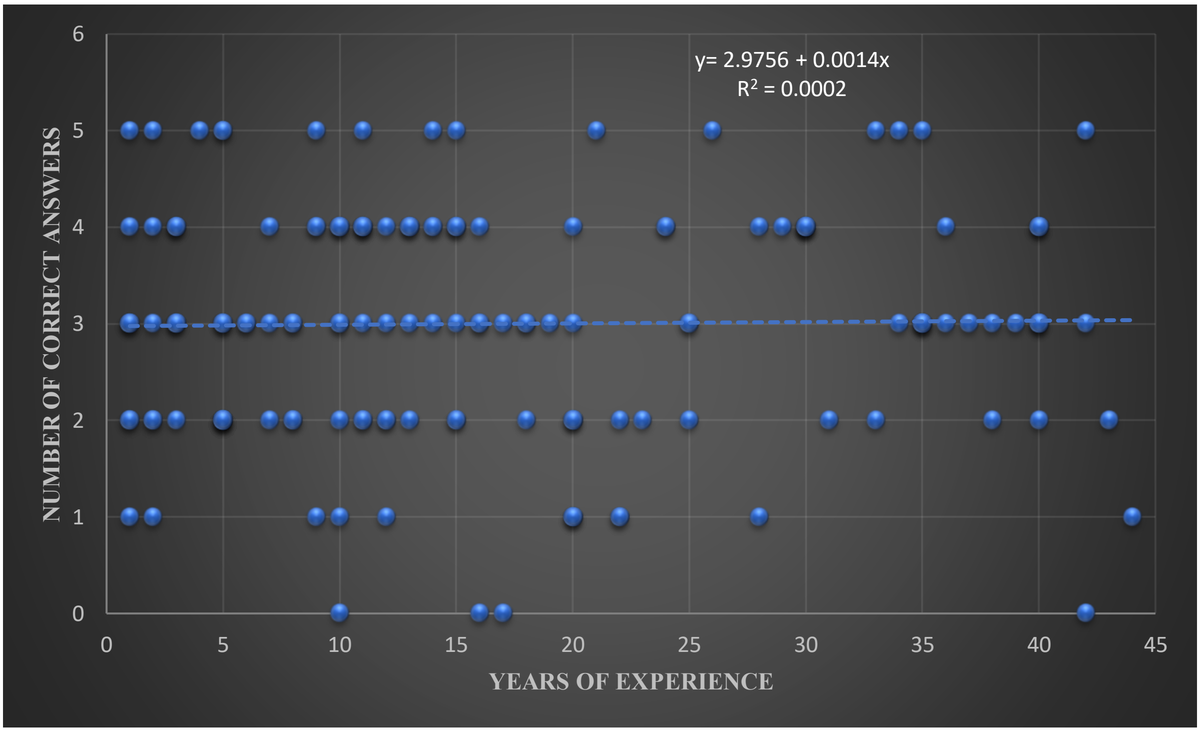

Figure 35. Correlation between years of experience and number of correct answers achieved for clinical cases in pre-workshop survey.

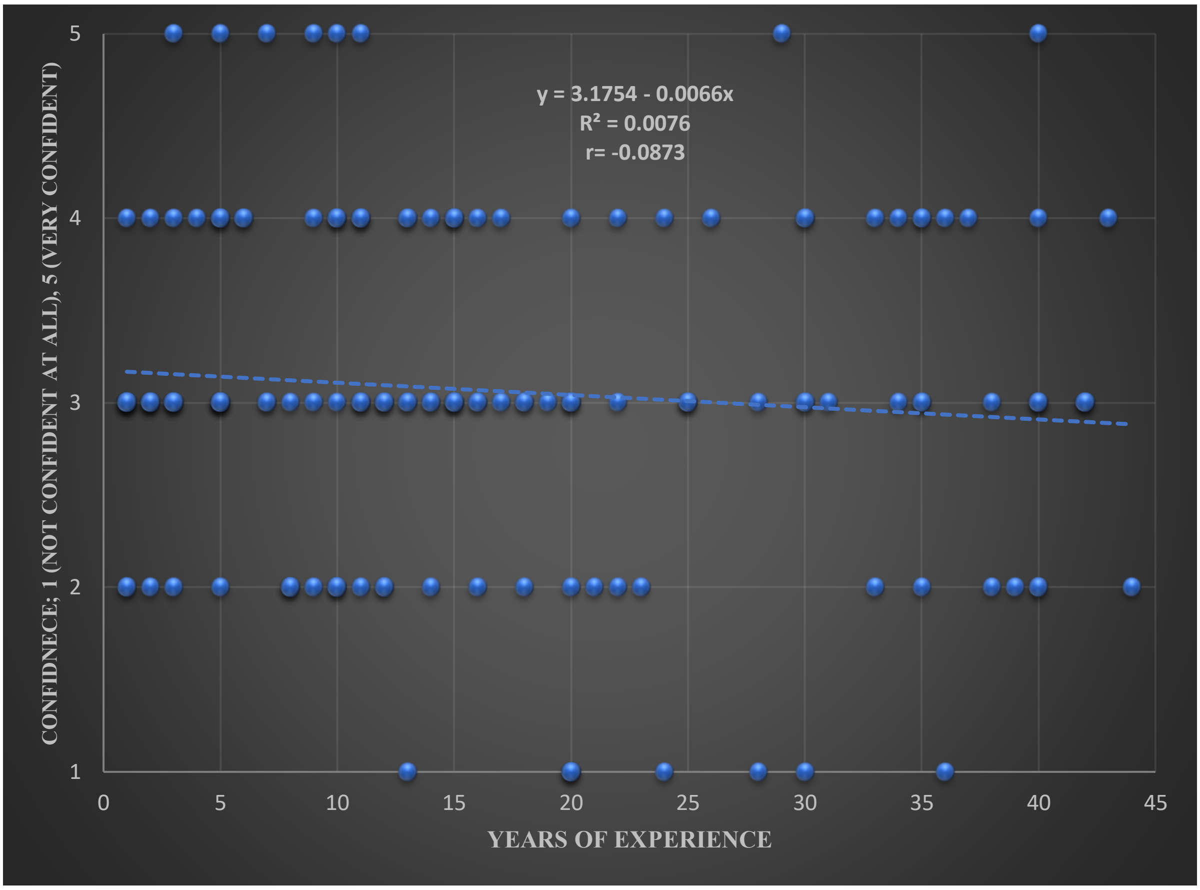

Figure 36. Correlation between years of experience and optometrists' pre-workshop self-perceived confidence levels in assessing OCT scans.

Optometrists' Understanding of the EMAC Referral Criteria

In the surveys, optometrists were asked to evaluate their level of understanding of the EMAC referral criteria utilising a five-point categorical scale, ranging from 'understand very well' to 'do not understand at all'. Pre-workshop survey results revealed over a third of optometrists understand the criteria or understand them very well, while 22% of optometrists do not understand the criteria or do not understand them at all. The remaining optometrists somewhat understand the criteria. Post-workshop survey results showed significant improvements in understanding of the EMAC referral criteria. No optometrists reported not understanding the referral criteria or not understanding them at all. Moreover, 32 optometrists answered, 'somewhat understand', a reduction of nearly 52%. An increase of over 90% was also noted for those who understand the criteria. A summary of findings is illustrated in figure 37.

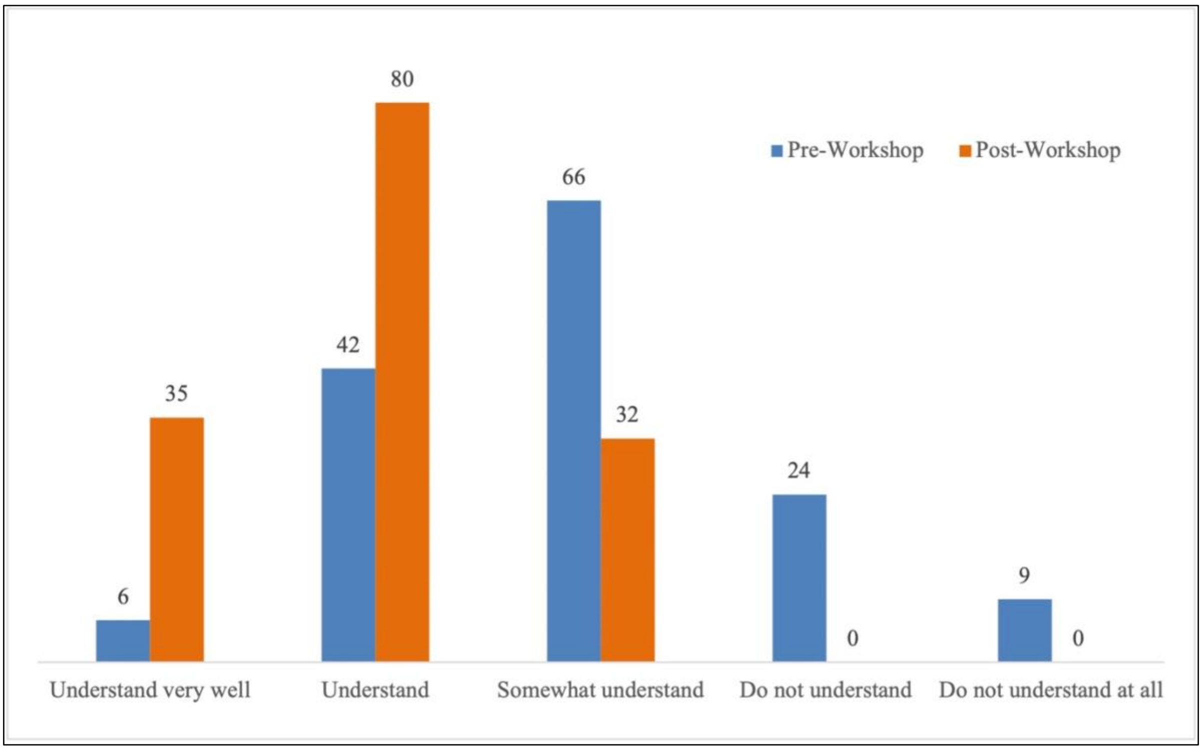

Figure 37. Optometrists' pre- and post-workshop level of understanding of the EMAC referral criteria (n= 147).

A two-tailed Wilcoxon signed-rank test was carried out to evaluate the effect of the workshop on optometrists' understanding of the EMAC referral criteria. The test exhibited statistically significant improvement in level of understanding following the workshop ($p < 0.001$). Levels of understanding were compared between primary care and secondary care optometrists. Pre-workshop understanding levels showed nearly identical average understanding scores between optometrists working in secondary care and those working in primary care. These results were also observed in post-workshop understanding levels between both groups. Unsurprisingly, a two-tailed Wilcoxon signed-rank test executed for each setting showed statistically significant higher mean understanding scores post-workshop compared to pre-workshop for both primary care and secondary care optometrists ($p < 0.001$).

Optometrists' Perceptions of Personal Macular Assessment Training

In the surveys, optometrists were asked to self-assess whether they feel adequately trained in assessing macular conditions utilising a five-point categorical scale, extending from 'very well trained' to 'not trained at all'. Pre-workshop survey results revealed 36% of optometrists felt adequately trained or very well trained in assessing macular conditions, while a little over 16% of optometrists reported not being well trained or not trained at all. The remaining optometrists felt they were 'somewhat trained' to assess macular conditions. Post-workshop survey results showed a 30% reduction in the number of optometrists who reported being somewhat trained. A two-third reduction was noted in the number of optometrists who reported not being well trained or not trained at all. On the other end of the scale, there was a 59% increase in the number of optometrists who felt adequately trained. Results are summarised in figure 38.

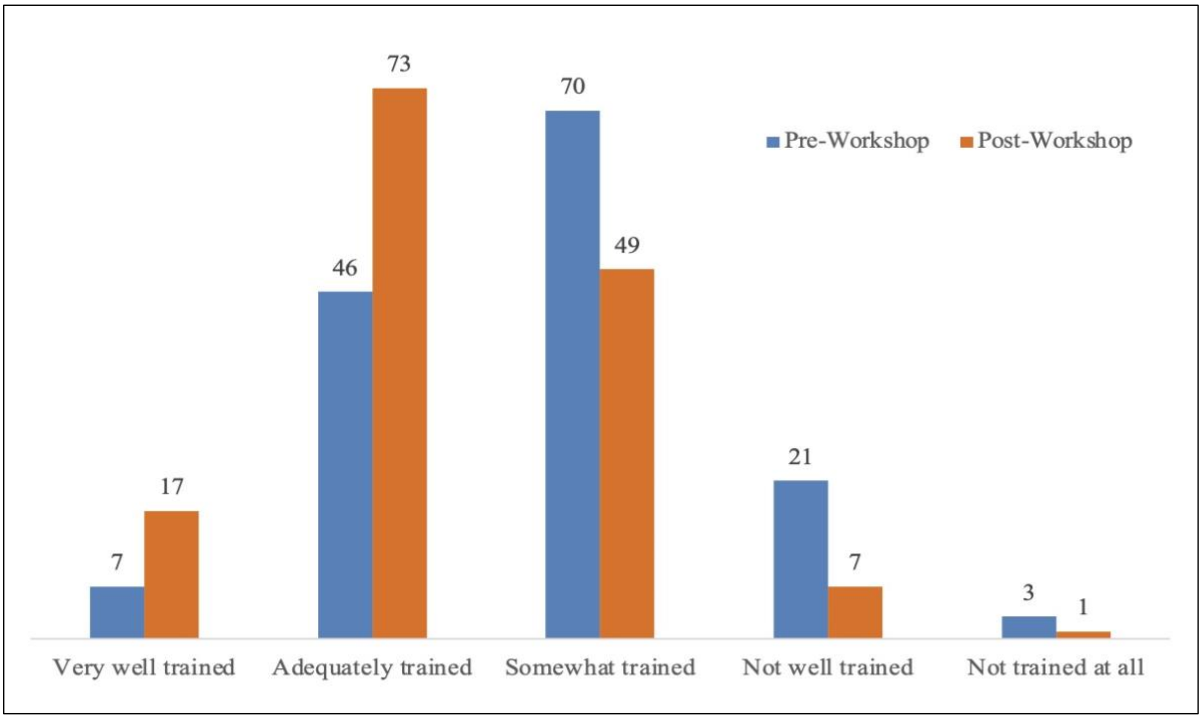

Figure 38. Optometrists' pre- and post-workshop perceptions of personal macular assessment training (n= 147).

A two-tailed Wilcoxon signed-rank test was carried out to evaluate the effect of the workshop on optometrists' perceptions on their personal macular assessment training. The test exhibited statistically significant improvement in perception levels about their personal macular training ($p < 0.001$). Self-assessment levels were compared between primary care and secondary care optometrists. Pre-workshop perception levels showed optometrists working in secondary care setting had a higher average self-perception score compared to those working in primary care. However, a two-tailed Mann-Whitney U-test showed this mean difference was not statistically significant ($p = 0.17$). Equally, post-workshop perception levels showed optometrists working in secondary care setting had a higher average perception score compared to those working in primary care. A two-tailed Mann-Whitney U-test showed this difference was not statistically significant ($p = 0.13$). A two-tailed Wilcoxon signed-rank test performed for individual settings showed statistically significant higher average perception scores post-workshop compared to pre-workshop for both primary care and secondary care optometrists ($p < 0.001$).

Optometrists' Perceptions on Benefits of Further OCT Training

In the surveys, optometrists were asked to evaluate the benefit of further OCT training utilising a five-point categorical scale, extending from 'very beneficial' to 'not beneficial at all'. Pre-workshop survey results showed about 81% of optometrists would find further OCT training very beneficial, and a further 14% of optometrists would find it beneficial. The remaining optometrists would find further training somewhat beneficial. No optometrists answered, 'not beneficial' or 'not beneficial at all'. Post-workshop survey results showed a similar number of optometrists who answered, 'very beneficial' or 'beneficial'. However, only 62% thought further OCT training would be very beneficial, and about 35% thought it would be beneficial. Four optometrists felt further training would be somewhat beneficial, and only one optometrist answered, 'not beneficial'. Once again, no optometrists felt further training would not be beneficial at all. Results are summarised in figure 39.

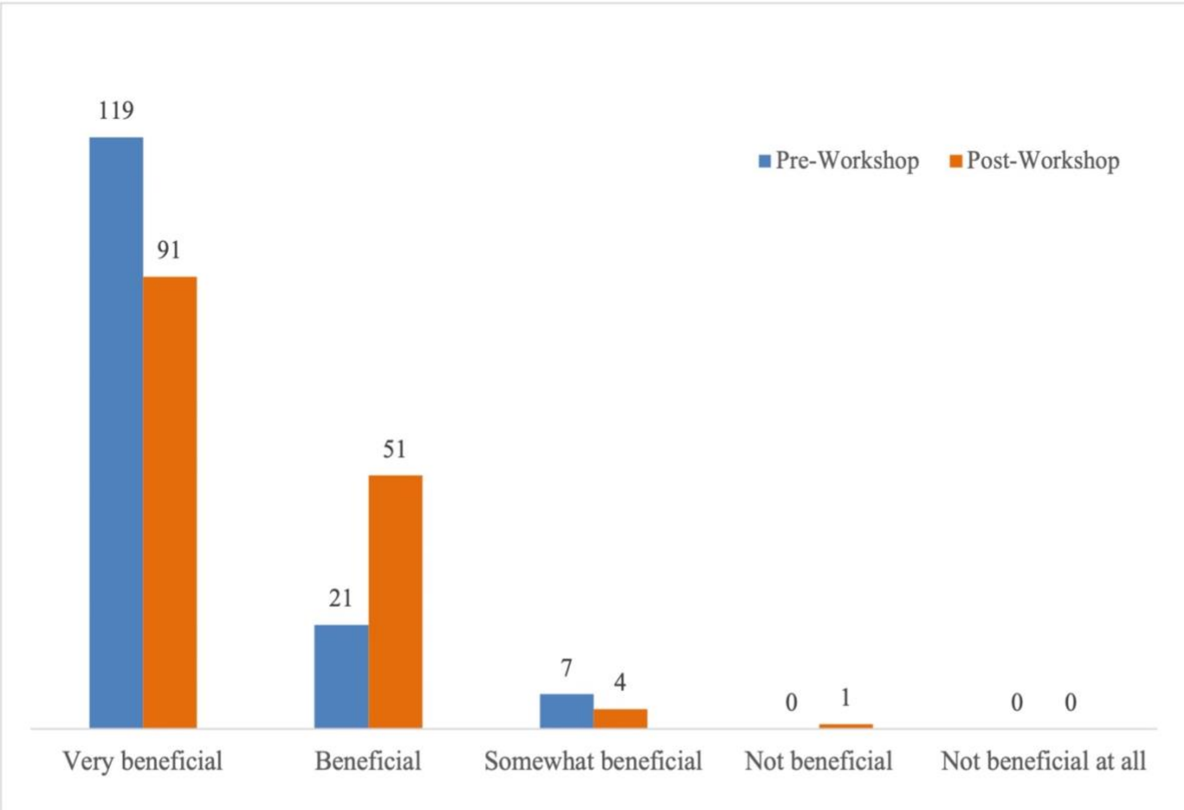

Figure 39. Optometrists' pre- and post-workshop perceptions about benefit of further OCT training (n= 147).

A two-tailed Wilcoxon signed-rank test was carried out to evaluate the effect of the workshop on optometrists' perceptions on benefit of further OCT training. The test exhibited statistically significant reduction in perception levels on benefit of further training ($p < 0.001$). Perception levels on benefit of further training were compared between primary care and secondary care optometrists. Pre-workshop perception levels revealed optometrists working in primary care setting had a higher mean benefit score compared to those working in secondary care. A two-tailed Mann-Whitney U-test illustrated this difference was statistically significant ($p = 0.03$). Similarly, post-workshop perception levels showed optometrists working in primary care had a higher mean benefit score compared to those working in secondary care. However, a two-tailed Mann-Whitney U-test showed this difference was not statistically significant ($p = 0.29$).

Although the mean benefit score for optometrists working in secondary care was slightly lower post-workshop compared to pre-workshop, a two-tailed Wilcoxon signed-rank test revealed this was not statistically significant ($p = 0.77$). A two-tailed Wilcoxon signed-rank test showed statistically significant lower average benefit score for optometrists employed in primary care post-workshop compared to pre-workshop ($p < 0.05$).

Optometrists' Clinical Management of Clinical Case Scenarios

In the surveys, optometrists were provided with five clinical scenarios and asked about their clinical management. For all the cases, included in the Appendix, optometrists were required to pick one of five options from 'Refer to Emergency Eye Department', 'Refer to EMAC', 'Refer to Medical Retina Clinic', 'Refer to Vitreoretinal Clinic', or 'No referral Required'. Table 26 summarises the average correct answers for each of the five clinical scenarios before and after the workshop. For statistical analysis, a correct answer was given a score of '1', while a score of '0' was given to an incorrect answer.

Table 26. Optometrists' average score of correct answers to clinical scenarios. Abbreviations: *SD* standard deviation.

Case	Pre-workshop mean score	Pre-workshop SD	Post-workshop mean score	Post-workshop SD
1	0.37	0.48	0.53	0.50
2	0.60	0.49	0.86	0.34
3	0.63	0.48	0.78	0.42
4	0.73	0.45	0.77	0.42
5	0.67	0.47	0.90	0.29

Optometrists' pre- and post-workshop performance levels were evaluated for all clinical cases combined. The average number of correct scores pre-workshop was 3, which improved to 3.84 post-workshop, an improvement of 28%. A two-tailed Wilcoxon signed-rank test showed this post-workshop improvement is statistically significant ($p < 0.001$). Looking at post-workshop scores, about 61% of optometrists achieved a change of one or more correct answers compared to their pre-workshop results, with two optometrists achieving four more correct answers. The median change is one. About 22% of optometrists had an identical score post-workshop, while the remaining optometrists achieved a worse score, with the majority having one less correct answer compared to pre-workshop results. A summary of findings is illustrated in figure 40.

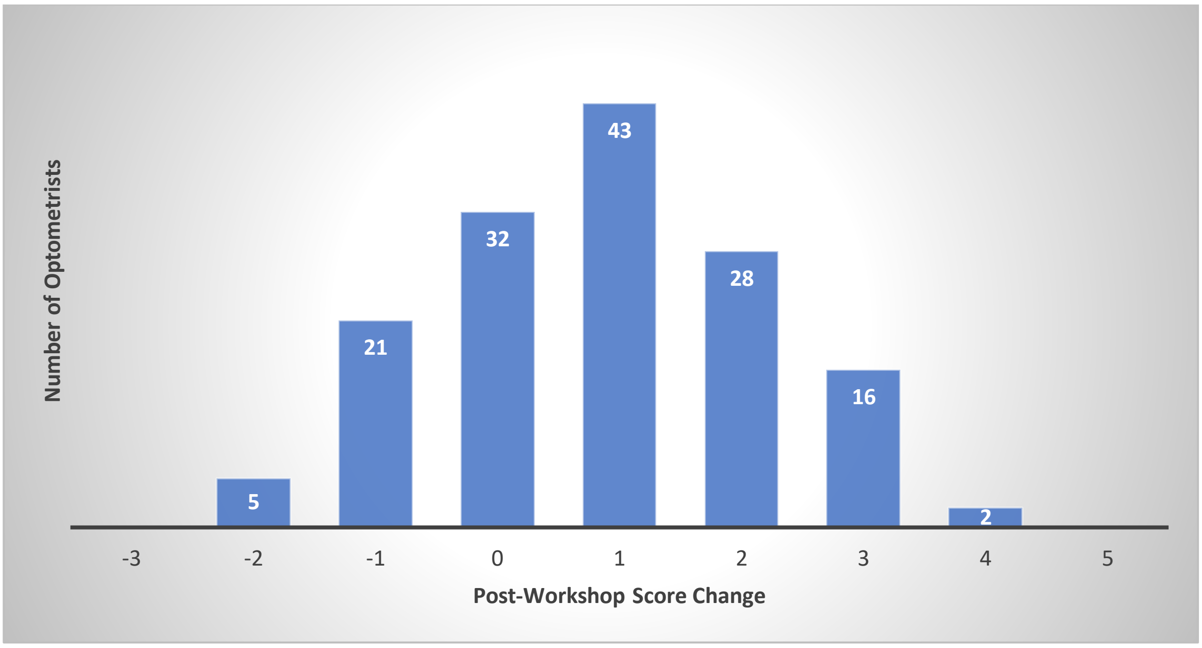

Figure 40. Optometrists' post-workshop score changes for all clinical cases.

Looking at individual clinical cases and starting with the first one, optometrists were presented with a small excerpt and two macula-centred OCT slices indicative of a symptomatic patient with bilateral AVMD who was not previously seen in HES. The correct answer for this scenario was referral to medical retina clinic. Pre-workshop survey results showed that no optometrist would refer this case to EED. About 37% of optometrists chose the correct answer of referring to MR clinic, while a third of optometrists suggested a referral to EMAC. Nine optometrists would refer to VR clinic, and a quarter of optometrists felt no referral is required. Post-workshop survey results also showed no optometrist would refer this case to EED, and a similar number referring to EMAC. Over 53% of optometrists would correctly refer to the MR clinic, an improvement of 16%. Five optometrists would refer to VR clinic, and over a tenth of optometrists thought no referral is necessary. Results are summarised in figure 41.

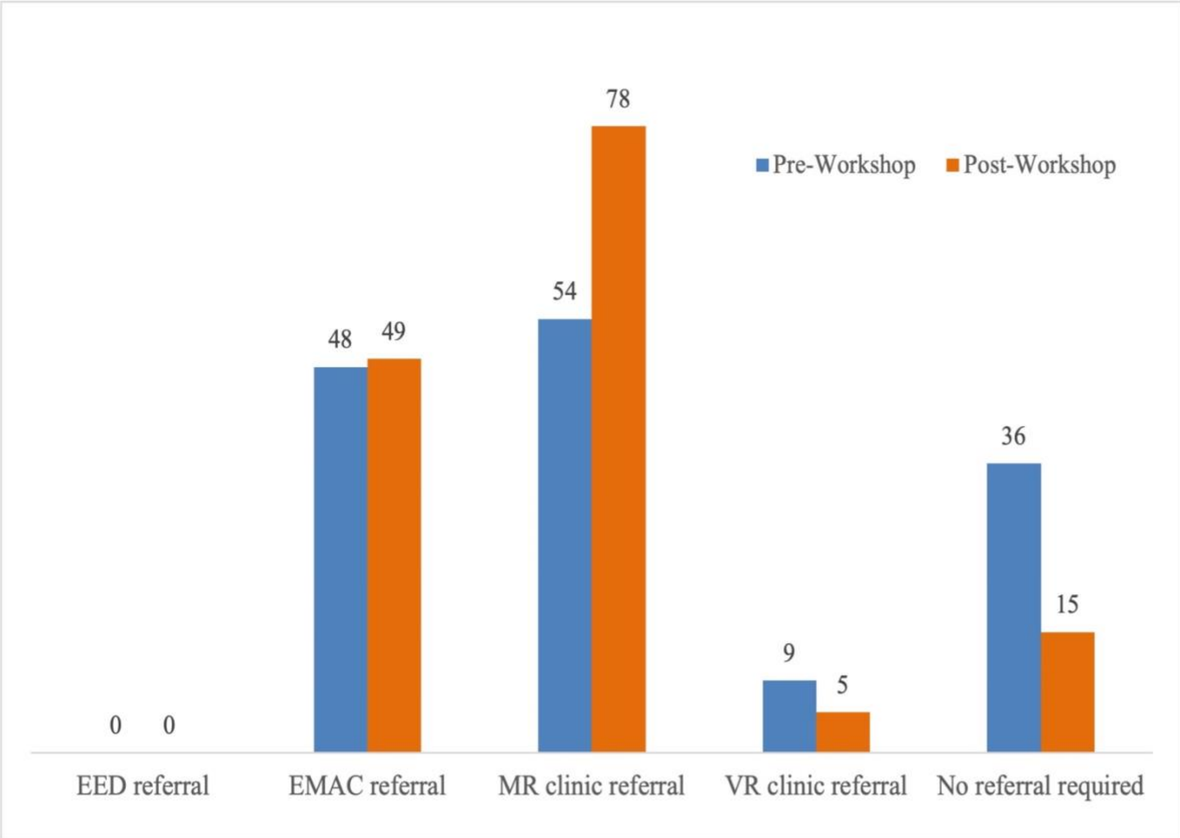

Figure 41. Optometrists' pre- and post-workshop clinical management of clinical case record 1. Abbreviations: *EED* emergency eye department, *EMAC* emergency macular assessment clinic, *MR* medical retina, and *VR* vitreoretinal.

A McNemar's test was performed to assess the effect of the workshop on optometrists' clinical management for case scenario 1. The test revealed statistically significant improvement in the proportion of optometrists appropriately managing the case (p= 0.003). As illustrated in table 26, the mean score of correct answers for case 1 improved by 0.16, from 0.37 to 0.53 after the workshop. Continuing with the second clinical case, optometrists were presented with a small excerpt and one macula-centred OCT slice indicative of a symptomatic patient with right eye CMO secondary to BRVO. The correct answer for this scenario was referral to EMAC. Pre-workshop survey results showed that all optometrists felt a referral to a given department in secondary care is required. About 60% of optometrists correctly chose referral to EMAC. Over 16% of optometrists suggested referral to MR clinic, and 21% of optometrists would refer to EED. Four optometrists suggested referral to VR clinic. Similar to the pre-workshop survey results, all optometrists felt a referral to secondary care is indeed necessary for this case. Over 86% of optometrists (127) correctly chose a referral to EMAC, while eighteen optometrists would refer to MR clinic. One optometrist suggested referral to EED, with the final optometrist suggesting referral to VR clinic. A summary of results is illustrated in figure 42.

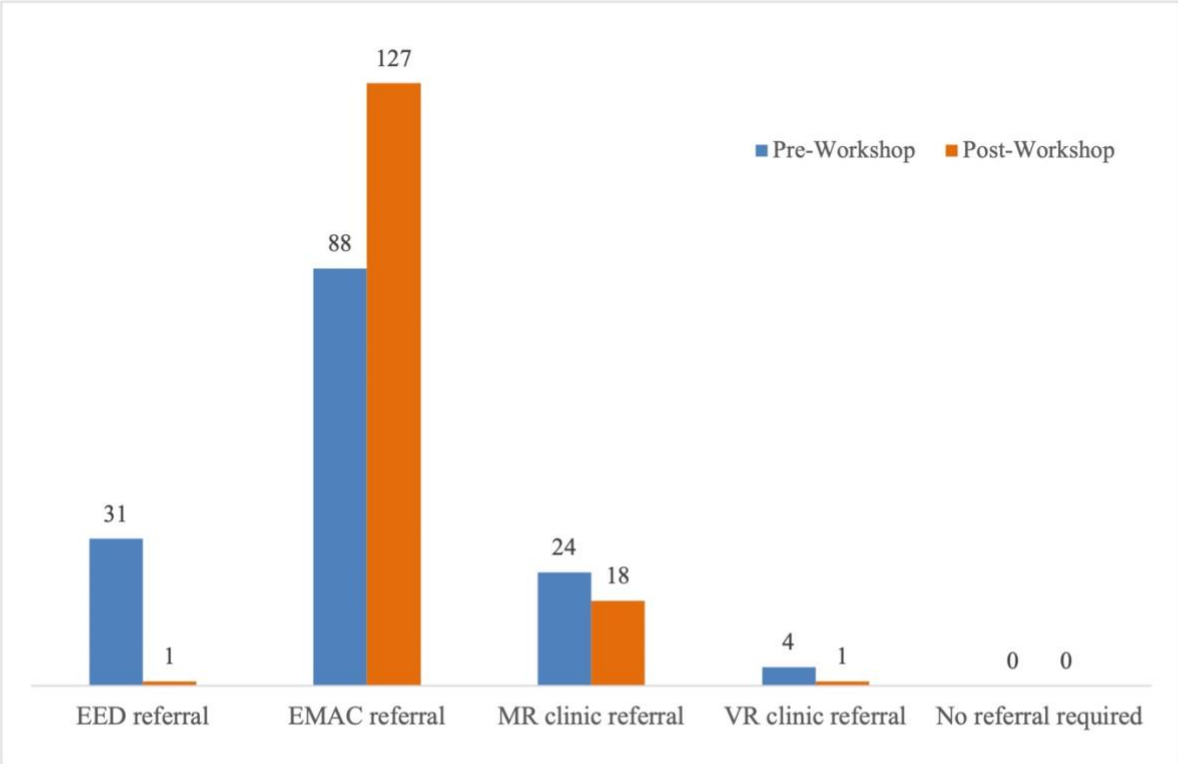

Figure 42. Optometrists' pre- and post-workshop clinical management of clinical case record 2. Abbreviations: *EED* emergency eye department, *EMAC* emergency macular assessment clinic, *MR* medical retina, and *VR* vitreoretinal.

A McNemar's test was performed to assess the effect of the workshop on optometrists' clinical management for case scenario 2. The test revealed statistically significant improvement in the proportion of optometrists appropriately managing the case ($p < 0.001$). As illustrated in table 26, the mean score of correct answers for case 2 improved by 0.26, from 0.60 to 0.86 after the workshop. Continuing with the third clinical scenario, optometrists were presented with a text and one macula-centred OCT slice indicative of an asymptomatic patient with right eye ERM and very good vision. The correct answer for this clinical scenario was no referral is required. Pre-workshop survey results showed no optometrist would refer this case to EED. Over 63% of optometrists chose the correct answer of not referring this case, and only three optometrists suggested referral to EMAC. About a quarter of optometrists would refer to VR clinic, with 11% of optometrists referring to MR clinic. Post-workshop results also showed no optometrist would refer this case to EED. About 78% of optometrists would correctly not refer this patient to HES, and five optometrists suggested referral to the EMAC service. A tenth of optometrists suggested referral to VR clinic, and thirteen optometrists would refer the case to MR clinic. A summary of results is illustrated in figure 43.

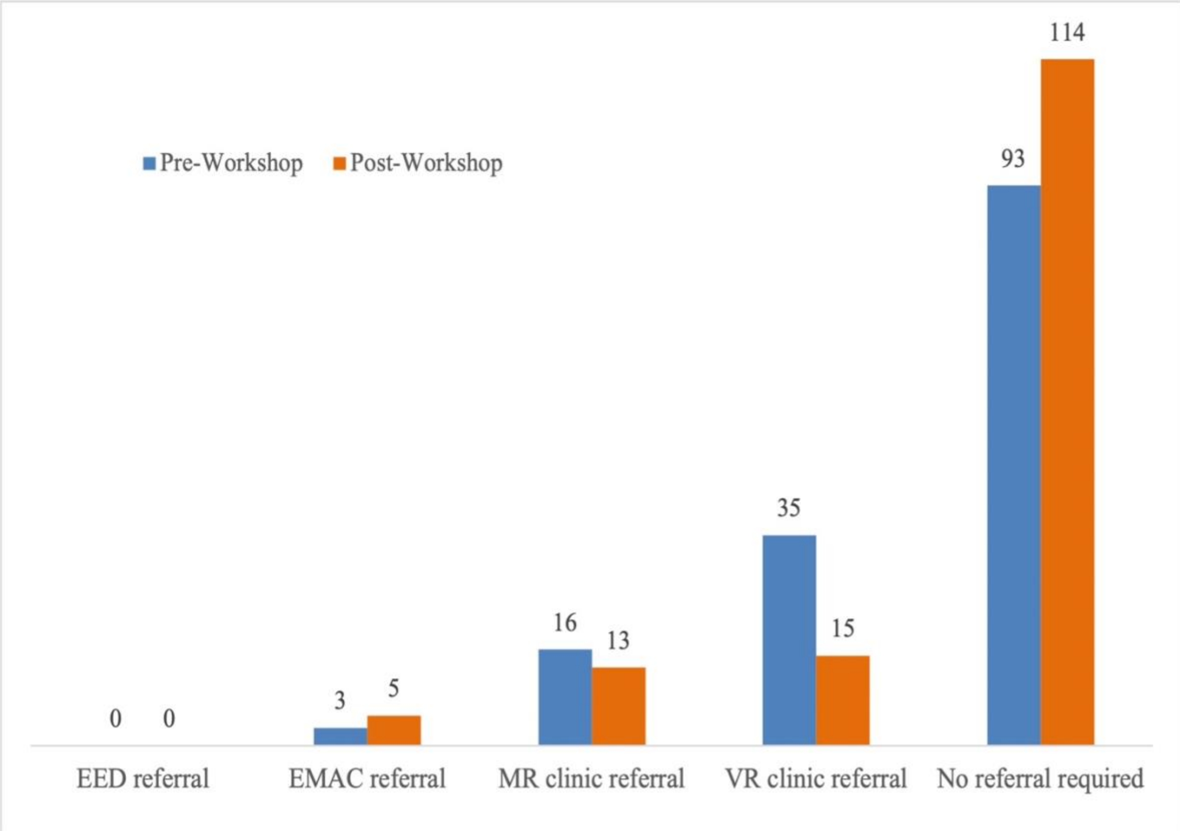

Figure 43. Optometrists' pre- and post-workshop clinical management of clinical case record 3. Abbreviations: *EED* emergency eye department, *EMAC* emergency macular assessment clinic, *MR* medical retina, and *VR* vitreoretinal.

A McNemar's test was performed to assess the effect of the workshop on optometrists' clinical management for case scenario 3. The test revealed statistically significant improvement in the proportion of optometrists appropriately managing the case (p= 0.003). As illustrated in table 26, the mean score of correct answers for case 3 improved by 0.15, from 0.63 to 0.78 after the workshop. Continuing with the fourth clinical case, optometrists were presented with a small excerpt and one macula-centred OCT slice indicative of a symptomatic patient with right eye wet AMD and significantly reduced vision. The correct answer for this scenario was referral to EMAC. Pre-workshop survey results showed two optometrists would not refer this case to HES. Five optometrists suggested referral to VR clinic, whilst three optometrists suggested a referral to EED. About 73% of optometrists would correctly refer the patient to EMAC, and a fifth of optometrists suggested referral to MR clinic. Post-workshop results also showed two optometrists who felt no referral was required for this case, and two further optometrists who suggested referral to VR clinic. About 77% of optometrists correctly chose referral to EMAC, whilst 12% of optometrists would refer to MR clinic. The final twelve optometrists decided a referral to EED was appropriate. A summary of results is illustrated in figure 44.

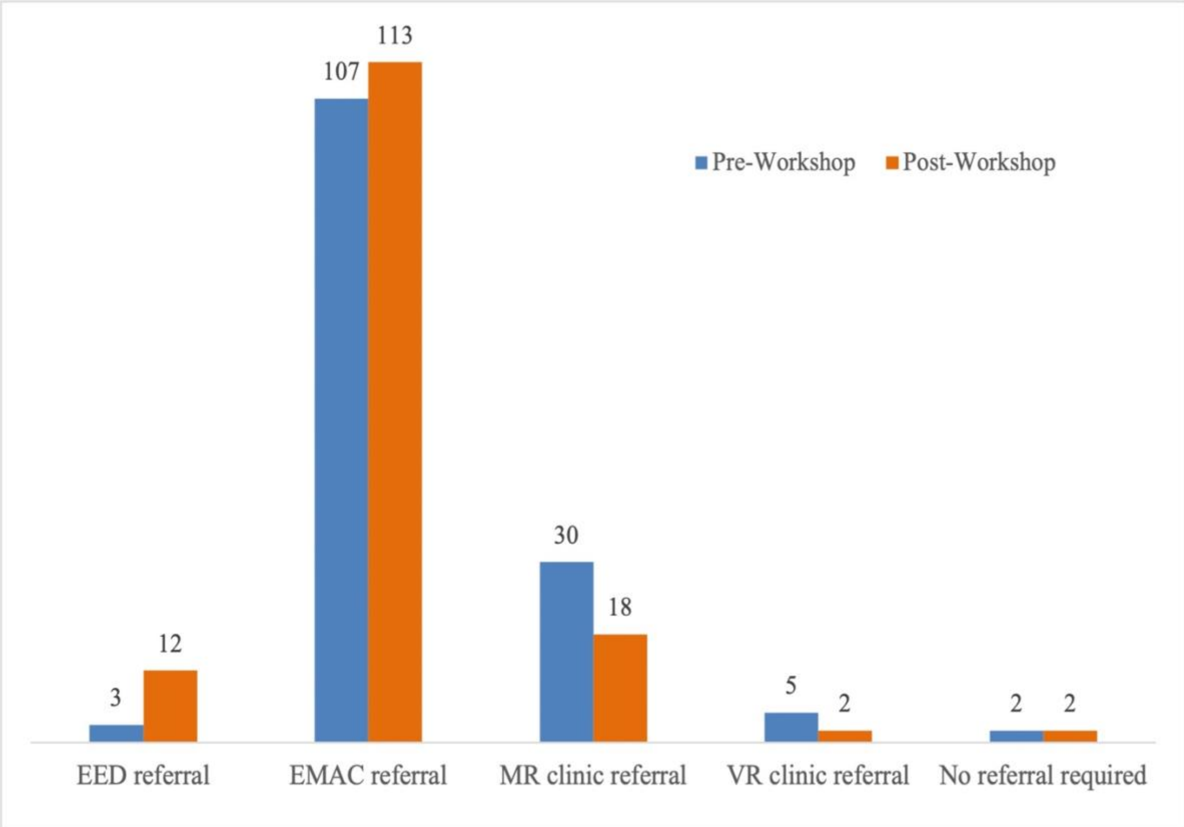

Figure 44. Optometrists' pre- and post-workshop clinical management of clinical case record 4. Abbreviations: *EED* emergency eye department, *EMAC* emergency macular assessment clinic, *MR* medical retina, and *VR* vitreoretinal.

A McNemar's test was performed to assess the effect of the workshop on optometrists' clinical management of clinical case 4. The test showed no statistically significant improvement in the proportion of optometrists appropriately managing the case (p= 0.38). As illustrated in table 26, whilst the mean score of correct answers improved for case 4, it was a modest increase of 0.04, from 0.73 to 0.77 after the workshop. Concluding with the fifth clinical case scenario, optometrists were presented with a small excerpt and one macula-centred OCT slice indicative of a symptomatic patient with a left FTMH and reduced vision. The correct answer to this case was referral to VR clinic. Pre-workshop survey results revealed eight optometrists would not refer this case, whilst two optometrists would refer it to EED. Over two-thirds of optometrists would correctly refer the case to VR clinic. About 16% and 10% of optometrists suggested a referral to MR clinic and EMAC, respectively. Post-workshop results showed all optometrists would refer this case to a given department in HES. Over 90% of optometrists correctly chose referral to VR clinic. Ten optometrists would refer to MR clinic, three would refer to EMAC, and a single optometrist suggested referral to EED. Results are summarised in figure 45.

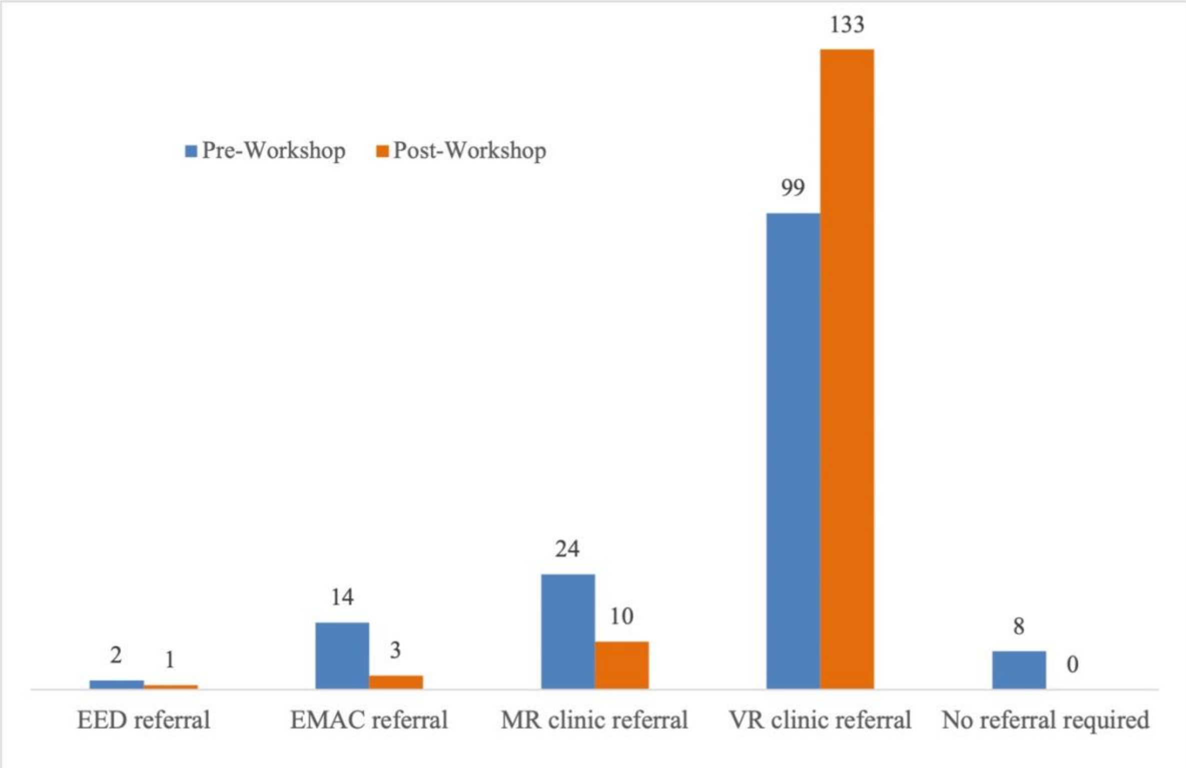

Figure 45. Optometrists' pre- and post-workshop clinical management of clinical case record 5. Abbreviations: *EED* emergency eye department, *EMAC* emergency macular assessment clinic, *MR* medical retina, and *VR* vitreoretinal.

A McNemar's test was performed to assess the effect of the workshop on optometrists' clinical management for case scenario 5. The test revealed statistically significant improvement in the proportion of optometrists appropriately managing the case ($p< 0.001$). As illustrated in table 26, the mean score of correct answers for case 5 improved by 0.23, from 0.67 to 0.90 after the workshop.

Chapter Discussion

This chapter outlined the impact of education and training on optometrists' confidence levels to assess macular OCTs and manage macular conditions accordingly, as well as understanding levels of the EMAC referral criteria. Over 85% of optometrists in this study worked in primary care, largely consistent with published figures showing about 77% of the 13000 optometrists registered in England work in this sector.[171] About 82% of optometrists indicated presence of OCT in their practice, an unsurprising figure given the rapid advancement of the technology in eyecare, which enhanced the optometrist's ability to diagnose and manage a multitude of ocular diseases. OCT is a non-invasive and quick imaging technique, which allows for high-resolution, in-vivo quantification and visualisation of ocular tissues.[172,173] These advantages propelled it to being regarded as a clinical standard for deployment in primary and secondary care for macular and anterior segment conditions, as well as glaucoma.[174-176] However, this increased frequency of using OCT is accompanied by demands on optometrists to accurately interpret scans and appropriately manage patients despite artefacts arising from technician-, patient-, or instrument-related factors.[177,178]

Significant improvement in confidence levels for assessing macular OCT scans was observed following the workshop. This positive impact on self-reported confidence levels as a result of training and education has been reported across various healthcare disciplines, including end-of-life care, optometry, and nursing.[179-181] Additionally, systematic reviews evaluating the impact of education and training revealed that interactive workshops in isolation or combined with other interventions are likely to improve professional practice and healthcare outcomes compared to didactic lectures alone.[182,183] Despite this, confidence levels varied between optometrists working in different sectors in this study. Optometrists working in secondary care had a higher pre-workshop mean confidence score than those working in primary care, despite an average of four years shorter in total years of experience. Although post-workshop average confidence scores were higher compared to pre-workshop scores for both groups, it was only statistically significant for those working in primary care. These differences may be explained by the continuous development and expansion of the hospital optometrist's scope of practice through working in specialist clinics and carrying out roles historically performed by medical practitioners.[184] As such, secondary care optometrists are more frequently exposed to OCT and other specialist imaging than primary care optometrists, thus improving their confidence. This confidence is supplemented by working in a multidisciplinary team including consultant ophthalmologists and senior optometrists where continuous feedback and teaching is provided on a regular basis.

No significant correlation was found between the total years of experience and pre-workshop self-perceived confidence levels for assessing macular OCT or the number of correct answers achieved for clinical cases in the pre-workshop survey. This is likely due to OCT being a novel technology necessitating formal training for its application and interpretation, where previous experience plays a minor role in the process. Previous studies have shown the complex nature between self-perceived confidence and clinical performance was due to the inherent variability between individuals' interpretations of self-confidence.[185,186] Unfamiliarity of new tasks as well as self-doubt and perceived knowledge deficits may also account for an initial lack of confidence.[187]

Similar to the significant improvement in confidence levels, there was a statistically significant improvement in optometrists' understanding of the EMAC referral criteria post-workshop. No optometrist reported not understanding the criteria or not understanding it at all. This illustrates the aforesaid impact of interactive workshops on improving professional practice and resultant healthcare outcomes. Presenting clinical case records of the most common macular conditions, combined with providing up-to-date referral guidelines for each condition likely helped with the overall understanding of the referral criteria by eliminating any ambiguity that may arise during the referral process. The significant improvement in optometrists' perceptions of their personal macular assessment training was another reassuring factor, bolstering the workshop's positive influence on their ability to interpret macular OCTs and manage patients accordingly. Whilst there was a statistically significant reduction in optometrists' perceptions about benefit of further OCT training, it is worth noting this was not a 'true' decline. A total number of 140 optometrists answered 'beneficial', or 'very beneficial' pre-workshop, nearly identical to the 142 optometrists who answered 'beneficial', or 'very beneficial' post-workshop. The value of further training was still present; however, it is not unusual the reported degree of this benefit would slightly decline directly after a teaching on that given topic.

The mean score of correct answers improved for all five clinical cases following the workshop, although the improvement was not statistically significant for case four. Starting with the first case, a patient with bilateral AVMD, only 37% of optometrists answered correctly, the lowest ratio of all cases. Although the workshop significantly improved the mean score by 16%, only 53% of optometrists answered correctly, the lowest ratio of all cases. The relatively low scores are likely due to overlap of observed clinical and OCT signs between AVMD and AMD, which include drusen, SRF, and PED. Additionally, most symptomatic patients fall in the same age group as those with AMD and report similar visual symptoms such as metamorphopsia and reduced or loss of central vision. As such, optometrists are likely to exercise caution and refer patients to EMAC instead of MR clinic. This pattern was observed in this study, where a nearly identical number of optometrists referred to EMAC pre- and post-workshop. Reassuringly, no optometrist would refer this to EED. Fifteen optometrists would not refer this case, which is not unreasonable if they are certain about the diagnosis, can appropriately counsel the patient, and given the patient does not require access to low vision services at HES. Five optometrists would refer to VR clinic, inappropriate management suggestive of an inaccurate provisional diagnosis. Given the above, there is scope for further improvement of management of AVMD by optometrists, which can be achieved through additional teaching and training.

Continuing with the second case, a patient with right eye CMO secondary to BRVO, only 60% of optometrists answered correctly pre-workshop. The workshop significantly improved the mean score by 26%, the largest improvement of all cases, with 86% of optometrists answering correctly. Although twenty optometrists answered incorrectly, reassuringly, eighteen of them would refer to MR clinic and one would refer to EED. The patient would get correctly triaged by an ophthalmologist or a senior optometrist to EMAC or directly to MTC for IVI treatment. Referral to EED or MR clinic is likely due to lack of understanding of EMAC criteria by these optometrists. One optometrist would refer to VR clinic, incorrect management suggestive of an inaccurate provisional diagnosis. Findings highlight the significant impact of the workshop on the management of RVOs by optometrists. Further teaching and training would consolidate results and focus on other equally important elements such as involving the GP in patient care.

Continuing with the third case, a patient with right eye ERM and very good vision, only 63% of optometrists answered correctly pre-workshop. The workshop significantly improved the mean score by 15%, with 78% of optometrists answering correctly. Although 33 optometrists answered incorrectly, reassuringly, none would refer to EED, and only five optometrists would refer to EMAC. The patient would likely get directly discharged from EMAC without being offered an additional appointment in an outpatient clinic. A similar outcome is likely when the patient is seen in MR or VR clinic, as chosen by thirteen and fifteen optometrists, respectively. A referral by an optometrist is likely due to overcaution after noting ocular pathology. Despite the improvement as a result of the workshop, further teaching and training is indicated to emphasise that asymptomatic patients with ERM and very good vision can be monitored in practice with appropriate advice issued. Referral to HES, directly to VR clinic is only indicated for surgical intervention if the patient is symptomatic of metamorphopsia and reduced vision.

Looking at the fourth case, a patient with right eye Wet AMD, 73% of optometrists answered correctly pre-workshop, the highest ratio of all cases. The workshop improved the mean score by a modest, statistically insignificant 4%, the lowest increase of all cases. Whilst about 77% of optometrists answered correctly post-workshop, 34 chose incorrectly. Reassuringly, twelve optometrists would refer to EED, and despite the incorrect urgency level, the patient would be triaged to MTC for IVI treatment. Eighteen optometrists would refer to MR clinic, and though the patient would get triaged to EMAC or MTC, the delay can be detrimental to the patient's visual outcome. Referral to EED or MR clinic is likely due to lack of understanding of EMAC criteria by these optometrists. Worryingly, two optometrists would refer to VR clinic and two optometrists would not refer the patient to HES, inappropriate management suggestive of an inaccurate provisional diagnosis. Given the above, there is definite scope for further teaching and training to ensure appropriate and timely diagnosis and management of wet AMD, and a ratio of referral to EMAC closer to 100%.

In the fifth and final case, a patient with left FTMH, 67% of optometrists answered correctly pre-workshop. The workshop significantly improved the average score by 23%, with 90% of optometrists answering correctly, the highest ratio of all cases. Although fourteen optometrists answered incorrectly, reassuringly, all optometrists would refer to HES, with ten referring to MR clinic and three referring to EMAC. Subsequently, the patient would get correctly triaged to VR clinic. Referral to EMAC or MR clinic is likely due to lack of understanding of EMAC criteria by these optometrists. The final optometrist would refer to EED, incorrect management suggestive of an inaccurate provisional diagnosis. The results outline the significant impact of the workshop on the management of FTMH by optometrists, with further teaching and training likely to consolidate these referral patterns.

In summary, it is evident further teaching and education in the form of an interactive workshop significantly improves optometrists' confidence levels, comprehension of the EMAC referral criteria, and appropriate management of various macular conditions. These factors combined will likely result in a more streamlined EMAC service and an overall improvement in quality of referrals to MREH, appropriately directed to the correct department. This will have positive clinical implications in the form of reducing the overall burden on HES and improving patient experience through reduced frequency of HES visits. The results will also encourage delivery of regular interactive educational workshops to primary care optometrists by senior EMAC and MR optometrists at MREH with informed specific areas of focus such as OCT technology and its interpretation. As previously discussed, OCT has been shown as a valuable tool for primary care optometrists in diagnosing macular disease, thus, improving their confidence and diagnostic performance.

Chapter VIII – Conclusions, Limitations & Future Work

Implications of Study Results

The results of this study provided a comprehensive picture of the EMAC service starting with referral pattens and the influence of deprivation and socioeconomic factors on these patterns, before exploring management of these referred macular conditions. It further demonstrated the exceptional level of which HES OSIs diagnose and manage referrals into the service and concluded with the positive impact of supplementary education and training on optometrists' confidence levels, understanding of the referral criteria, and management of various macular conditions. Combining results of the study's elements led to three major positive implications:

1. Updating the EMAC referral form. Considering the high FP rate of referrals reported, the form was amended and finalised in May 2022 to solely include referrable macular conditions to EMAC. These include wet AMD, RVOs with secondary CMO, myopic CNV, and any unknown diagnosis where pathology requiring urgent treatment is suspected. As per the previous version of the form, information about the patient and the referrer are required, as well as the patient's VA and clinical features observed by the optometrist. Figure 46 illustrates the updated EMAC referral form compared to the previous version shown in figure 47. A discernible difference is removal of conditions that do not require referral to EMAC such as DMO, CSR, VMT, ERM, macular hole, and RVOs without macular-involving oedema.
2. Training more OSIs. Results of this study reinforced well-established literature about the comparable abilities of specially trained HES optometrists to ophthalmologists for diagnosis and management of ocular conditions across different subspecialities. This, amongst other factors, supported the ongoing expansion of optometrists' scope of practice at MREH. Since the inception of the project, two OSIs completed their EMAC training, with other OSIs trained in macular, diabetic, glaucoma, and comprehensive care clinics, as well as the emergency eye department.
3. Organising further educational events. Results of chapter seven showed the significant positive value of further education and training on optometrists' confidence levels and diagnostic performance, in line with existing literature. As such, a decision was made to deliver two interactive workshops per year (i.e., once every six months). Workshops are delivered by advanced MR OSIs with extensive experience in macular clinics and knowledge about the workings of EMAC. An interactive workshop was delivered in late February 2023, with the next workshop planned for August 2023. Following the events, all optometrists received email correspondence, which included an educational

package. The package included a summary of the workshop presentation, the updated EMAC referral form, and an information sheet with guidelines for referring to EMAC.

NHS
Manchester University
NHS Foundation Trust

EMERGENCY MACULA (EMAC) SERVICE OPTOMETRIST REFERRAL FORM

Tel: 0161 7013419 Email: mft.macular@nhs.net

Patient Name:____________________

Patient Date of Birth:________________

Address:________________________

____

____

Urgent Contact no. ________________

Optometrist Name:_________________

GOC number: _______________

Practice phone number: ______________

Practice Address:

____

Clinical Features

History and Symptoms

Best Corrected Visual Acuity Right _____ Left _____

Clinical Features in affected eye

Macular Haemorrhage	Right ☐	Left ☐
Retinal Oedema	Right ☐	Left ☐
Exudates	Right ☐	Left ☐

3. Additional Comments:

____

____

Please confirm which disease you are suspecting based on your clinical examination:

1. ☐ Wet AMD ☐ Myopic CNV ☐ Central/Branch Retinal Vein Occlusion with macula oedema

2. ☐ Unknown / Diagnosis not possible clinically but possibly urgent pathology
Patients who you feel may require urgent treatment with intravitreal injection therapy.

Signature.. Date of referral..................

EMAC Referral Form – Rev May 2022

Figure 46. Updated EMAC referral form. Abbreviations: *GOC* general optical council, *AMD* age-related macular degeneration, and *CNV* choroidal neovascularisation.

Central Manchester University Hospitals NHS
NHS Foundation Trust

EMERGENCY MACULA (EMAC) SERVICE OPTOMETRIST REFERRAL FORM

Tel: 0161 7013419 Fax: 0161 7010262

Patient Name: ______________________

Patient Date of Birth: ______________________

Address: ______________________

____

____

Urgent Contact no. ______________________

Optometrist Name: ______________________

Practice Address:

____

____

____

Clinical Features

1. Best Corrected Visual Acuity Right ____ Left ____

2. Clinical Features in affected eye

Amsler distortion	Right	☐	Left	☐
Macular Haemorrhage	Right	☐	Left	☐
Retinal Oedema	Right	☐	Left	☐
Exudates	Right	☐	Left	☐

3. Additional Comments:

____

____

Please confirm which disease you are suspecting based on your clinical examination:

1. ☐ Wet AMD ☐ Myopic CNV ☐ Central Retinal Vein Occlusion / haemorrhagic branch retinal vein occlusion

2. ☐ Unknown / Diagnosis not possible clinically but possibly urgent pathology

3. ☐ Branch Retinal Vein Occlusion (without haemorrhage involving centre of fovea)
   ☐ Diabetic Macular Oedema ☐ Central Serous Retinopathy
   ☐ Vitreomacular Traction ☐ Macular Hole ☐ Epiretinal membrane

Please note, only patients in group 1 above require urgent referral or if group 2 i.e. you are uncertain of the diagnosis which may be urgent and patient needs OCT to confirm. Patients in group 3 if you are confident of the diagnosis may be referred via GP as normal.

Signature.. Date of referral..................

EMAC Referral Form – Sep 2015

Figure 47. Preceding version of EMAC referral form. Abbreviations: *AMD* age-related macular degeneration, *CNV* choroidal neovascularisation, *GP* general practitioner, and *OCT* optical coherence tomography.

Implications of Study Results on Referring Optometrists

Considering results of this study, a series of five recommendations has been produced to help referring optometrists in diagnosing and managing patients with macular conditions. The five recommendations can be summarised as the following:

1. If present in their workplace, optometrists are strongly advised to use OCT technology to aid or confirm a provisional macular diagnosis before referral to HES.
2. Optometrists are advised to consider well-established demographics information of the more common macular conditions, utilising it as an additional tool to aid diagnosis.
3. In line with the EMAC referral criteria and updated referral form, optometrists should only refer to the service if the following conditions are suspected: wet AMD, myopic CNV, RVOs with secondary CMO, and any unknown diagnosis where pathology requiring urgent treatment is suspected. All other conditions should be directly referred to the pertinent department at MREH in an appropriate timeline.
4. Optometrists should have an understanding about the impact of deprivation and other socioeconomic factors on patients' attendance and perceptions of the eye examination, as well as the onset of disease presentation. Innovative methods should be explored by optometrists such as method(s) and frequency of communication with patients to help improve access to eyecare services, which in turn reduces differences in overall referral patterns and disparities in visual outcomes due to these factors.
5. In line with CPD requirements of the GOC, optometrists are advised to seek continuous education and training on the evolving role of OCT technology in macular pathology as means of improving confidence, diagnostic performance, and overall management. This can be supplemented by considering additional professional certification.

Study Limitations

This study has several limitations, such as the small sample size of some macular conditions, which restricted the extent of analysis performed for demographics, management outcomes, and agreement levels. Analysing EMAC data over a longer time interval would not have undoubtedly rectified this, considering the low incidence rates of some of these macular conditions, in addition to the assumption they would continue to get incorrectly referred to the service at the same level over time. Moreover, some data points were excluded from analysis for reasons that could not be accounted for, such as patients passing away and non-attendance. Examples of conditions that would not have reached the required sample size despite a longer time interval include, but are not limited to CSR, ERM, and MacTel. Despite this, the project provides valuable information about demographics of these macular conditions, highlighting their incidence, management outcomes in secondary care, and reasons they may be incorrectly referred to the EMAC service by primary care practitioners.

The IMD and ACORN indices both have limitations. The ACORN index data was only available from 2015. This was the most up-to-date dataset available for research purposes, as more recent datasets are only accessible through purchase of a commercial license through CACI. Despite the somewhat outdated data, it remains a powerful and comprehensive source superior to other data sources as it combines open data, government data (through the national census), commercial data, and CACI's own propriety data. Utilising the above, it provides socioeconomic characteristics with a resolution of 15 residences per postcode, which cannot be replicated through other means (i.e., household survey). As previously described, since IMD combines 7 domains, lower scores in one or more domains may be masked by higher scores in other domains. As such, all deprivation analyses were repeated specifically focusing on the index of health and disability deprivation (IHDD). Some IMD indicators measured are estimates rather than counts, and as such, some of the index data are modelled. Additionally, some neighbourhoods are split across different LSOAs, leading to unexpected results. Despite shortcomings of IMD and ACORN, they are robust and comprehensive indices used in this study, with findings proving valuable in providing insights about the impact of socioeconomic factors on referrals to the EMAC service.

Another limitation is in the workshop's survey design. An additional open-ended sub-question could have been added to all clinical cases asking for the optometrist's provisional diagnosis. This would have been useful for two reasons. Firstly, it would allow understanding of whether incorrect answers were due to misinterpretation of clinical information or mismanagement of the case. For example, in case 1, if an optometrist correctly indicated a provisional diagnosis of AVMD, but chose to refer to EMAC, this would be an error of mismanagement. Secondly, it would identify cases where the correct management was chosen, but an incorrect diagnosis was stated. For example, in case 4, if an optometrist incorrectly stated a provisional diagnosis of BRVO, but chose to refer to EMAC, this would be an error of misinterpretation. Not only would this provide insights as to whether inappropriate referrals to EMAC are made as a result of misdiagnosis or mismanagement by optometrists, but it will help guide the design of future educational events provided to optometrists. Given the meaningful information this additional question could provide, it will be included in future surveys.

Future Works

With this work serving as baseline information, repeating several elements of this study in the future will prove useful for appreciating changes of referral patterns to EMAC and management outcomes of macular conditions to the service. Important comparable elements include assessing number of monthly referrals, ratio of appropriate referrals from various sources and conditions referred to the service including their demographics. A particular focus on referrals from optometrists will prove valuable to evaluate the impact of regular educational workshops on diagnosis and management, as well as inform changes required to these events through identification of any training requirements and specific topics requiring additional focus. The effectiveness of these educational events will be assessed through different means including comparative pre- and post-event surveys (as carried out in this study), VRICS (visual recognition and investigation of clinical signs), and feedback obtained by optometrists through surveys or the GOC website.

With recent approval of further intravitreal injection drugs for treatment of macular conditions, it will be useful to assess any changes to IVI-drug use patterns in MREH, and visual outcomes as a result of these changes, especially in wet AMD, CSMO, and RVOs with secondary CMO. A repeat analysis using up-to-date deprivation and ACORN index data will shed light on the magnitude of the existing gap for referral patterns and visual outcomes due to deprivation and socioeconomic factors. A collaborative study will be designed with other clinicians at MREH to assess the impact of socioeconomic factors in conditions such as AMD, glaucoma, and DR. An in-depth intra- and inter-group agreement analysis between EMAC OSIs and consultant MR ophthalmologists will offer constructive insights about the efficacy of EMAC training and changes required to improve it. Comparing the level of macular experience between OSIs and considering factors such as the type and frequency of clinics carried out as part of their HES role (i.e., MR, diabetic and macular clinics) will illustrate the importance of clinical experience as means of supplementing formal structured training.

All the above combined can reinforce findings of this study that showed a positive impact for all stakeholders involved, including patients, the HES, primary care optometrists, and EMAC OSIs. Only patients requiring referral to HES would get referred to the appropriate department in a suitable timeline, thus, reducing the number of unnecessary appointments and improving patient experience. This would in turn help reduce the growing burden on HES, supplemented by more accurate referrals from primary care optometrists benefiting from regular education and training to advance their OCT interpretation abilities and overall management of macular conditions. This results in a streamlined virtual service run by highly experienced and trained OSIs, which can be successfully implemented across other hospital eye services nationally. A national rollout of similar services could benefit from using the EMAC service at MREH as a template to benchmark against.

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Appendix

Ethics Approval

Aston University
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8 July 2020

Dr Shehzad Naroo
Student: Mohammed Abid
School of Life and Health Sciences

RE: Service Evaluation: Emergency Macular Assessment Clinic (EMAC): a review of referral, diagnosis, and treatment outcomes of patients with various macular conditions.

I am writing to confirm governance approval for the above project to proceed on behalf of Aston University. This approval is subject to the project being undertaken in accordance with the study protocol and attached AURIO100 service evaluation form (Appendix A).

Yours sincerely

Professor James Wolffsohn
Associate Pro-Vice Chancellor, Research Integrity

Medical Research Council

NHS Health Research Authority

Is my study research?

To print your result with title and IRAS Project ID please enter your details below:

Title of your research:

AN EVALUATION OF THE EMERGENCY MACULAR ASSESSMENT CLINIC (EMAC): REFERRAL, DIAGNOSIS AND TREATMENT OUTCOMES.

IRAS Project ID (if available):

You selected:

- **'No'** - Are the participants in your study randomised to different groups?
- **'No'** - Does your study protocol demand changing treatment/ patient care from accepted standards for any of the patients involved?
- **'No'** - Are your findings going to be generalisable?

Your study would NOT be considered Research by the NHS.

You may still need other approvals.

Researchers requiring further advice (e.g. those not confident with the outcome of this tool) should contact their R&D office or sponsor in the first instance, or the **HRA** to discuss your study. If contacting the HRA for advice, do this by sending an outline of the project (maximum one page), summarising its purpose, methodology, type of participant and planned location as well as a copy of this results page and a summary of the aspects of the decision(s) that you need further advice on to the HRA Queries Line at **Queries@hra.nhs.uk**.

Sample Size Calculations

Power calculations for each chapter were computed using G*Power. For demographic data in chapter 3, a total sample size of 84 subjects was required for each macular condition. This was calculated for an unpaired two-tailed t-test with an effect size (Cohen's *d*) of 0.80[1], an α error probability of 0.05, and a power (1-β) error probability of 0.95. For visual outcomes one-year post-IVI treatment in chapter 4, a total sample size of 23 eyes was required for each IVI drug. This was calculated for a paired two-tailed t-test with a Cohen's d of 0.80[1], an α error probability of 0.05, and a power (1-β) error probability of 0.95. For deprivation data in chapter 6, a sample size of 215 subjects was required for all groups combined. This was calculated for a one-way ANOVA with Cohen's d of 0.30[1], an α error probability of 0.05, and a power error probability of 0.95. For deprivation data in individual macular conditions, a sample size of 35 subjects was required for all groups combined. This was calculated for a one-way ANOVA with Cohen's d of 0.80[1], an α error probability of 0.05, and a power error probability of 0.95. For chapter 7, a sample size of 57 subjects was required to carry out statistical analysis. This was calculated for a two-tailed Wilcoxon signed-rank test with a Cohen's d of 0.50[1], an α error probability of 0.05, and a power error probability of 0.95.

Cohen's Kappa Statistic

Cohen's Kappa statistic (κ) is described as the following[1]:

$$\kappa \equiv \frac{p_o - p_e}{1 - p_e} = 1 - \frac{1 - p_o}{1 - p_e}$$

p_o is the relative observed agreement among raters, and p_e is the hypothetical probability of chance agreement.

1. Munro BH. Statistical methods for healthcare research. 4th ed. Munro BH, editor. Philadelphia, PA, USA: Lippincott Williams and Wilkins; 2000.

Visual Acuity Conversion Chart

Letter Score	LogMAR Score	Snellen Score
5	1.60	6/240
10	1.50	6/192
15	1.40	6/150
20	1.30	6/120
25	1.20	6/96
30	1.10	6/75
35	1.00	6/60
40	0.90	6/48
45	0.80	6/38
50	0.70	6/30
55	0.60	6/24
60	0.50	6/19
65	0.40	6/15
70	0.30	6/12
75	0.20	6/9
80	0.10	6/7.5
85	0.00	6/6
90	-0.10	6/5
95	-0.20	6/4
100	-0.30	6/3
Hand Movements (HM)	HM	HM
Perception to Light (PL)	PL	PL
No Perception to Light (NPL)	NPL	NPL

* 1. GOC Number (CPD purposes only)

* 2. What is your **primary** mode of practice?

- ◯ Primary Care (i.e. Multiples, Independent, etc)
- ◯ Secondary Care (i.e. HES)
- ◯ Other (i.e. Academia)
- ◯ None of the above

* 3. Total years of experience?

* 4. Do you have an OCT in practice?

- ◯ Yes
- ◯ No

* 5. How confident do you feel in assessing OCT scans?

- ◯ Very confident
- ◯ Confident
- ◯ Somewhat confident
- ◯ Not confident
- ◯ Not confident at all

* 6. How well do you understand the EMAC referral criteria?

- ◯ Understand very well
- ◯ Understand
- ◯ Somewhat understand
- ◯ Do not understand
- ◯ Do not understand at all

* 7. Do you feel adequately trained in assessing macular conditions?

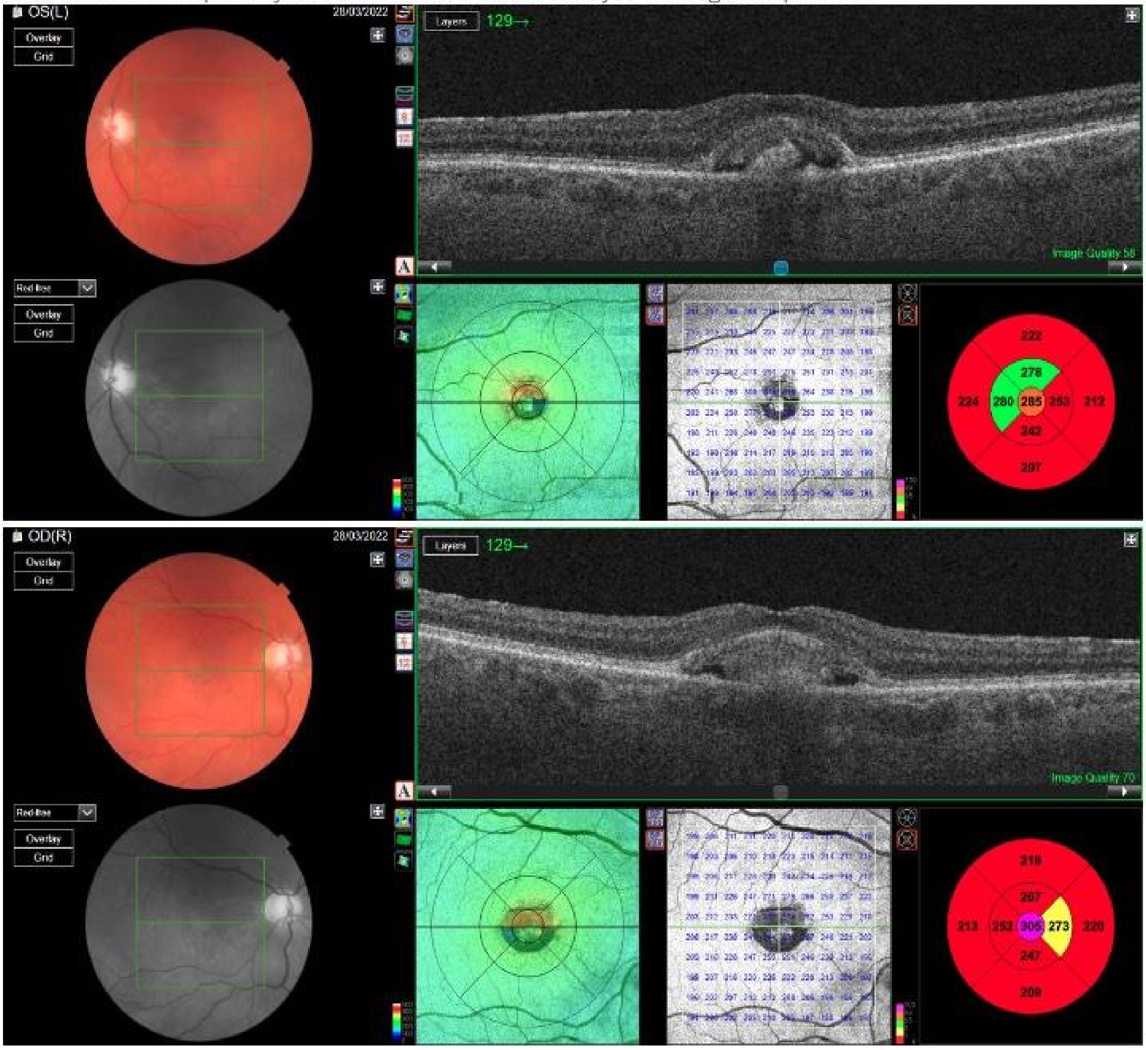
- ◯ Very well trained
- ◯ Adequately trained
- ◯ Somewhat trained
- ◯ Not well trained
- ◯ Not trained at all

* 8. How beneficial would find further OCT training?

- ◯ Very beneficial
- ◯ Beneficial
- ◯ Somewhat beneficial
- ◯ Not beneficial
- ◯ Not beneficial at all

Case 1. Bilateral AVMD not previously referred to HES.

* 9. An 83 year-old female patient attended for a routine eye examination. She reported 6-month onset of slight bilateral visual deterioration. VA is +0.22 (6/9) R&L. No distortion reported on Amsler. She has never been to Hospital Eye Service before. How would you manage the patient?



◯ Refer to Emergency Eye Department

◯ Refer to Vitreoretinal Clinic

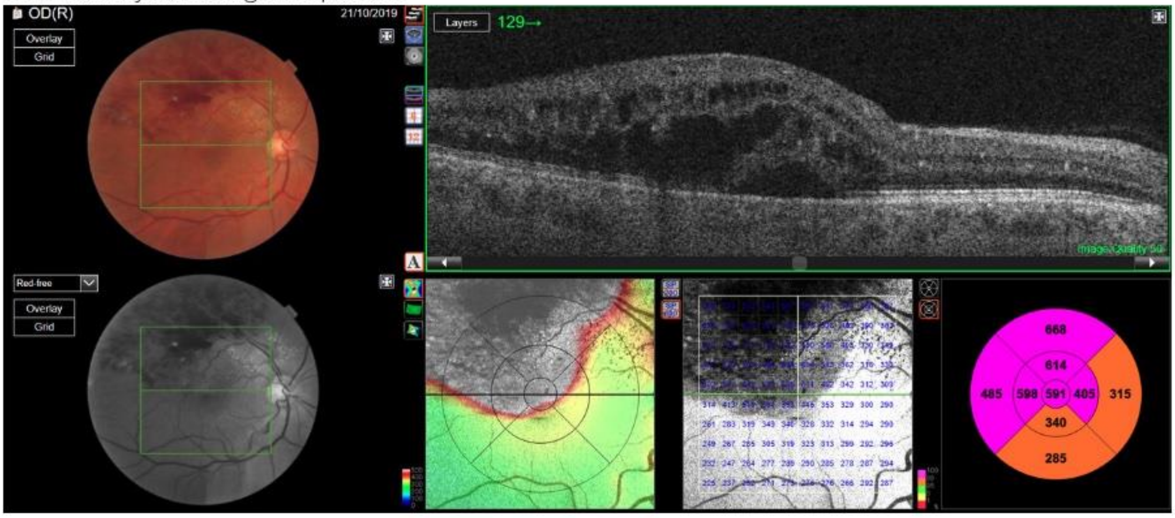
◯ Refer to EMAC

◯ No Referral Required

◯ Refer to Medical Retina Clinic

Case 2. RE BRVO with secondary CMO.

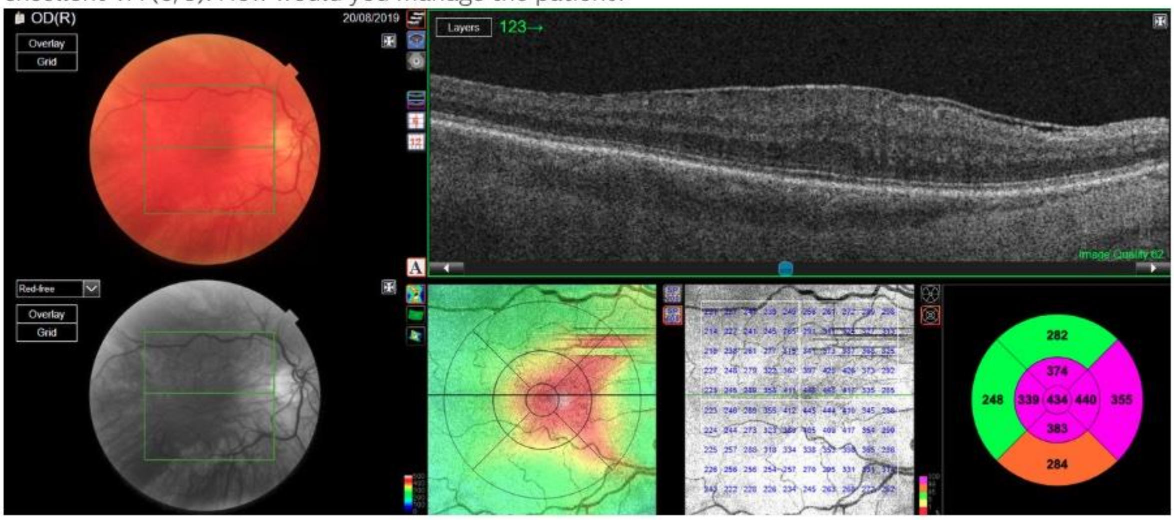
* 10. A 56 year-old male patient attended for an eye examination and reported a 3-week onset of blurred right eye central vision and distortion. RE VA is +0.42 (6/15). LE is unremarkable with excellent VA (6/5). How would you manage the patient?



- ◯ Refer to Emergency Eye Department
- ◯ Refer to Vitreoretinal Clinic
- ◯ Refer to EMAC
- ◯ No Referral Required
- ◯ Refer to Medical Retina Clinic

Case 3. RE ERM with very good VA.

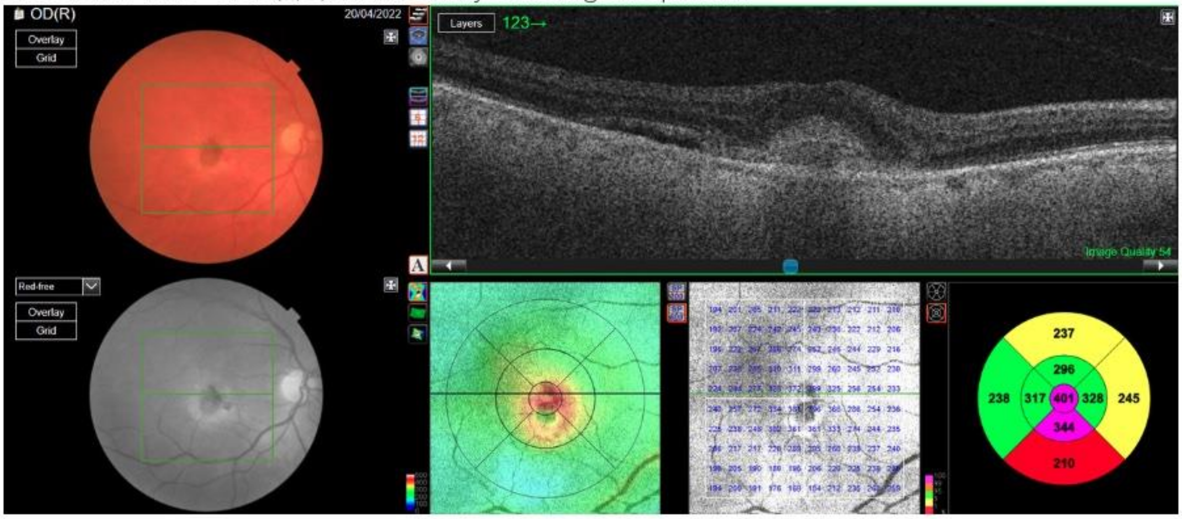
* 11. A 76 year-old woman female patient attended for a routine eye examination. She is completely asymptomatic and did not report distortion on Amsler. RE VA is +0.10 (6/7.5). LE is unremarkable with excellent VA (6/6). How would you manage the patient?



- ◯ Referral to Emergency Eye Department
- ◯ Referral to Vitreoretinal Clinic
- ◯ Referral to EMAC
- ◯ No Referral Required
- ◯ Referral to Medical Retina Clinic

Case 4. RE Wet AMD.

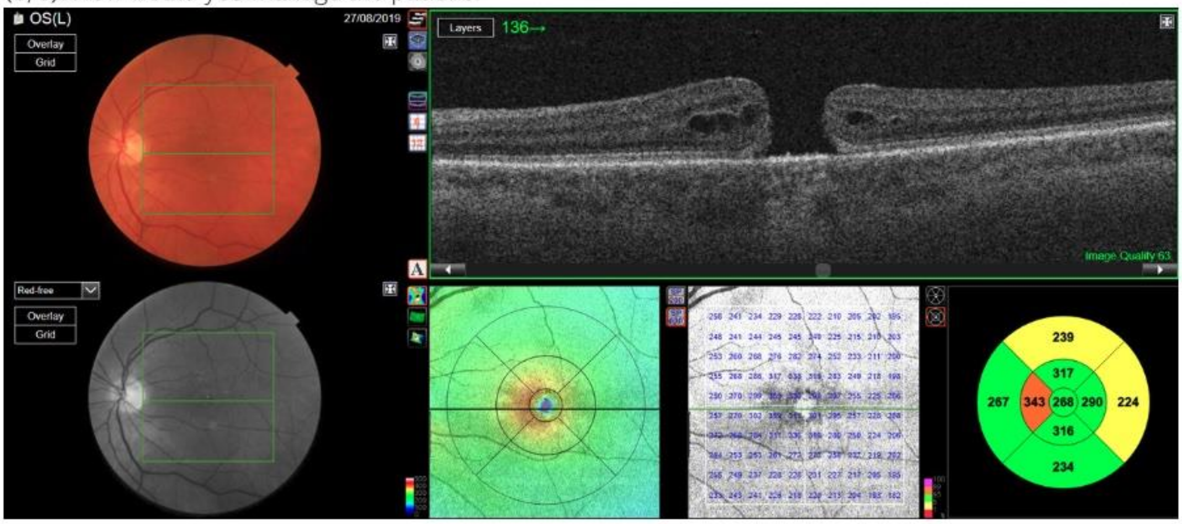
* 12. A 74 year-old male patient attended for an eye examination and reported a 4-week onset of grey cloud in central vision and distortion. RE VA is +0.90 (6/48). LE fundus examination only revealed drusen and VA is +0.20 (6/9). How would you manage the patient?



- ◯ Refer to Emergency Eye Department
- ◯ Refer to Vitreoretinal Clinic
- ◯ Refer to EMAC
- ◯ No Referral Required
- ◯ Refer to Medical Retina Clinic

Case 5. LE FTMH.

* 13. A 68 year-old female patient attended for an eye examination and reported 1-year onset of left eye gradual visual deterioration and distortion. LE VA is +0.90 (6/48). RE is unremarkable with excellent VA (6/6). How would you manage the patient?



- ◯ Refer to Emergency Eye Department
- ◯ Refer to Vitreoretinal Clinic
- ◯ Refer to EMAC
- ◯ No Referral Required
- ◯ Refer to Medical Retina Clinic