EXPLORING ROUTINE SIGHT TESTING AND THE MANAGEMENT OF EYE DISEASE BY PRIMARY CARE OPTOMETRISTS IN ENGLAND, UK

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Exploring Routine Sight Testing And The Management Of Eye Disease By Primary Care Optometrists In England, UK

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Abstract

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Keywords: Sight test, Socio-economic status, NHS, Eye examination, MECS, PEARS, Urgent eye care, optometry, ophthalmology, primary care

Abstract

Previous research has reported that inequalities exist in uptake of NHS sight tests in relation to socio-economic status, and that community optometric services have potential to improve system efficiency.

The current research found inequalities in sight test outcome related to socio-economic status and the type of practice that a patient visits (multiple, or independent). Patients attending multiples were more likely to receive a 'new or changed prescription' relative to 'no prescription' compared to patients that attended independent opticians (36-71% more likely). Those living in the least deprived areas were also less likely to receive a new prescription (1-12%) and those aged <16 years were less likely to be referred (9%). The study examining the need for a Minor Eye Condition Service in Leeds and Bradford found it would produce theoretical cost savings, whilst maintaining high patient satisfaction. Subsequently, a MECS was commissioned in Bradford. The study attempting to collect data from MECS across all areas of England found that data is not routinely collected, or shared. The limited data available typically showed that 73-83% of patients were retained in optometric practice with 12-18% receiving a hospital referral. A prospective evaluation of a COVID urgent eye care service found that teleconsultations frequently did not resolve patients' eye problems (27%). These telephone consultations failed to detect some serious conditions such as scleritis, wet macular degeneration, retinal detachment.

The results from the thesis support the view that the current method of delivering eye care in England is contrary to the public health interest.

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Abbreviations

Acronym	Meaning
A&E	Accident And Emergency
ABDO	Association of British Dispensing Opticians
AMD	Age-Related Macular Degeneration
ANOVA	Analysis Of Variance
AoP	Association of Optometrists
CCG	Clinical Commissioning Group
COVID-19	Coronavirus Disease 2019
CUES	Covid-19 Urgent Eyecare Service
DNA	Did Not Attend
DRS	Diabetic Retinal Screening
DS	Digital Surveillance
EHEW	Eye Health Examination Wales
EPVm	Multinomial Event Per Ratio
F2F	Face to Face
FODO	Federation of Ophthalmic and Dispensing Opticians
FVDR	First Visit Discharge Rate
GOC	General Optical Council
GOS	General Ophthalmic Services
GP	General Practitioner
GRM	Glaucoma Repeated Measures
HES	Hospital Eye Service
IMD	Index of Multiple Deprivation
IOP	Intra Ocular Pressure
IP	Independent Prescriber
LOC	Local Optical Committee
LOCSU	Local Optical Committee Support Unit
LSOA	Lower-layer Super Output Area
MECS	Minor Eye Condition Services
NCT	Non-Contact Tonometry
nERC	Effective Number of Regression Coefficients
NHS	National Health Service

NICE	National Institute of Health and Care Excellence
OHT	Ocular Hypertension
OMP	Ophthalmic Medical Practitioner
PEARS	Primary Eyecare Acute Referral Schemes
POAG	Primary Open Angle Glaucoma
PVD	Posterior Vitreous Detachment
RDS	Routine Digital Screening
SES	Socio-Economic Status
SLB	Slit-Lamp Biomicroscopy
UK	United Kingdom
USA	United States of America
YAG	Neodymium-Doped Yttrium Aluminium Garnet

Chapter 1

1. Introduction

The majority of eye tests in the United Kingdom (UK) are provided by the National Health Service (NHS) (Association of Optometrists 2018c), and performed by optometrists under the terms of the general ophthalmic services (GOS) contract (NHS England 2019b). The GOS *mandatory* services contract covers aspects of providing NHS eye tests in a fixed location (e.g. high street practice), whereas the *additional* services contract covers domiciliary sight testing. These rules state that a qualified professional, either an optometrist or ophthalmic medical practitioner (OMP) performing a sight test must do so in accordance with the opticians act (1989) (The Opticians Act 1989). Specifically, signs of ocular abnormality, if present, should be detected and a prescription for spectacles should be provided. Following this sight test, in accordance with the Opticians Act, if the examined patient has signs of ocular injury or pathology that requires onward referral, the optometrist should refer the patient to a hospital providing ophthalmic services via their General Practitioner (GP). Additional tests should be performed if clinically necessary *(The Sight Testing (Examination and Prescription) (No. 2) Regulations 1989).* A large proportion of eye pathology is discovered opportunistically at routine eye examinations by an optometrist while assessing the health of a patient's eyes as part of a sight test. For example, glaucoma represents one of the leading causes of blindness in the world (Quigley and Broman 2006; Pascolini and Mariotti 2012; Bourne et al. 2016) but, in the UK, it is typically detected opportunistically at routine sight tests where the patient is in asymptomatic stages of the disease (Myint et al. 2010).

For patients presenting with an ocular problem that cannot be resolved with refractive correction (for example, sudden onset flashing lights and floaters), however, following advice from a legal body of the optometric profession (the Association of Optometrists), a NHS funded GOS sight test is not appropriate and shouldn't be utilised (Association of Optometrists 2015). This leaves patients with potentially serious or sight threatening eye problems, the option of

paying privately for an eye health examination or presenting to their GP or Accident & Emergency department. Often these doctors have neither received adequate training nor have access to appropriate equipment to manage these patients (Featherstone et al. 1992; Shuttleworth and Marsh 1997; Baylis et al. 2011; Welch and Eckstein 2011; Kilduff and Lois 2016). In turn, this doctor's appointment would result in a referral into hospital ophthalmology departments for an ophthalmologist to manage the patient. This increases the number of NHS funded visits a patient requires, increasing costs and the time taken before a diagnosis can be made. Furthermore, this referral into secondary care can increase patient anxiety (Davey et al. 2013). Specifically, Davey and colleagues (2013) reported that the anxiety levels found in patients referred to an ophthalmology hospital department was similar to that of patients who were perceived to be at a medium-to-high risk of breast cancer. The authors commented that although their study did not assess temporal aspects of this anxiety, the studies relating to breast cancer have shown possible long term increased anxiety in patients who experienced a false-positive referral and a reduced likelihood of attending future screenings (Brett et al. 2005). For the cohort of patients that could have been successfully managed by community optometrists without onward referral into hospital ophthalmology departments, this referral-associated anxiety is unnecessary. The effect of false positive referrals and anxiety on future attendance at sight tests, and therefore subsequent opportunistic pathology detection, is currently unknown.

A further limitation of the sight test is its narrow scope. Specifically, providing additional information on a referral isn't required. For example, repeating tests to ascertain the reliability of a single spurious reading is beyond the scope of a GOS sight test (Parkins and Edgar 2011). As such, referrals can be based on a reading that, when repeated, is within normal limits. Furthermore, ascertaining patient suitability for surgery or intervention is also beyond the scope of a sight test. Both patient suitability assessment (Sharp et al. 2003; Newsom et al. 2005; Lash et al. 2006; Park et al. 2009; Holmes et al. 2013; Fung et al. 2016) and repeat readings (Azuara-Blanco et al. 2007; Devarajan et al. 2011; Parkins and Edgar 2011) have been found to reduce the number of false positive referrals and ease demands on hospital ophthalmology departments. Moreover, as care

provided by a community optometrist is typically cheaper than that of the NHS tariff for ophthalmology (NHS Improvement and NHS England 2017), it is possible that this would be cost-effective while making the case mix within secondary care more appropriate. The funding of NHS trusts, however, is changing. NHS trusts are beginning to be paid a block tariff which is independent of small changes in activity. This therefore may result in small variations of cost of care, relative to the NHS tariff.

To extend the scope of practice of community eye care and address the limitations of GOS NHS sight tests, community optometric services are commissioned locally. Community optometric services are commissioned with the aim of reducing unnecessary hospital ophthalmology or accident and emergency (A&E) department appointments (LOCSU 2018). This is done by providing remuneration for examinations, or by determining suitability judged on local criteria for surgical intervention (e.g. cataract extraction) prior to patients being referred to secondary care. These enhanced services are expected to provide benefits to both patients and hospitals alike. There is a growing body of published evidence on such enhanced services. As such, this literature review will subsequently provide an overview of these schemes.

The scope of practice of optometrists varies from country to country. In the UK and the United States of America (USA) optometrists are trained to detect eye disease. Optometry in the USA is a post-graduate qualification and optometrists are further empowered to treat certain eye conditions including prescribing rights depending on the state in which they practice (Fremont et al. 2003). Optometrists in the UK, on the other hand, do not have rights to prescribe without further qualifications. Optometrists in Australia and New Zealand historically did not have therapeutic prescribing rights. However, since 2014, all optometry graduates are granted the ability to prescribe certain medications (Optometry Australia 2016; Kiely et al. 2017; Turnbull and Craig 2020). Optometry in the these countries, however, differs from the majority of Europe where issuing of spectacle prescriptions and sale of spectacles are differentiated from the provision of eye health care (Kirkness 2002; Audo 2010; Cheloni et al. 2021). In Asia, similar variations exist as in Europe (Thai and Yap

2010). Countries such as the Philippines train optometrists in a six year ‘doctor of optometry’ degree programme that provides knowledge on the diagnosis, management, prevention of visual problems (Centro Escolar University Manila 2015; Cebu Doctors' University n.d). By Philippine law, this empowers optometrists to detect abnormalities of the eyes, prescribe spectacles and install prosthetics (Congress of the Philippines 1995). Other countries such as Japan do not recognise optometrists (Thai and Yap 2010). These same variations exist in Africa (Oduntan et al. 2014) and South America (Leasher and Pike 2009). Due to these differing scopes of practice between the UK and the rest of the world, this literature review will be predominantly focussing on optometry within the UK although knowledge gained may be beneficial to other countries with similar primary eye care systems.

1.1.1. Aims of the thesis

The present thesis aims to investigate the current system of primary care optometry. This is both with regards to the basic provision of eye care: the GOS sight test and services aimed to provide care to patients beyond the scope of the GOS sight test in detection and management of patients with eye problems (e.g. MECS/ PEARS/ DRS). Adaptations made to primary eye care in the UK during the COVID 19 pandemic were also investigated.

1.2. GOS sight tests

1.2.1. England and Northern Ireland

13,355,060 NHS funded eye tests were conducted in England for the year ending March 2020 (NHS Digital 2020). This figure represents a quarter of the population of England. Within England, NHS GOS funded sight tests are provided free of charge for all UK residents under the age of 16 or aged 60 and above (NHS 2017). Additionally, students aged 16,17 and 18 who are in full time education, or patients who receive a variety of government funded, means-tested benefits are also eligible for an NHS funded sight test (NHS 2017). Small subsets of at-risk populations are also entitled to an NHS funded eye test. Specifically, patients who are: aged over 40 with a first-degree relative diagnosed with glaucoma, diabetic, deemed at risk of glaucoma by a consultant ophthalmologist, registered blind or partially sighted or have complex prescriptions are eligible for NHS funded sight tests (NHS 2017).

Since April 2021, remuneration of £21.71 is provided for performing a GOS sight test (Association of Optometrists 2021). Whilst this value is approximately half of the estimated true cost of a sight test (Bosanquet 2006; Optical Confederation 2013; Shickle et al. 2015b), it is in line with the fee typically charged for a private eye examination (Optical Confederation 2013). Since April 2015 this increased by approximately 1.9%. It's important to note, therefore, that given the below inflation increase of the GOS sight test fee, any potential consequences (e.g. sight test outcomes / uptake of NHS sight tests) that are influenced by loss leading services are likely to increase over time (Shickle et al. 2015a).

GOS services in Northern Ireland, although devolved to the Northern Ireland assembly, are largely the same as that provided in England. Eligibility for NHS funded sight tests in England are Northern Ireland are similar, with the exception that those needing sight tests due to a disability for which the patient receives a war pension are eligible for free eye tests in Northern Ireland, but not

in England (NI Direct n.d.). The remuneration for an NHS funded sight test is in line with that of England (£21.71).

1.2.2. Scotland

In 2004, the Scottish government commissioned a review into the delivery of eye care services in Scotland. This was conducted with the aim of improving both the quality and efficiency of these services (Scottish Executive 2006). The review found that, typically patients with eye problems that were unlikely to be resolved with refractive correction, presented to the general practitioner (GP). In turn, the GP subsequently referred the patient to a specialist ophthalmology department at a local hospital. This led to the hypothesis that making more appropriate use of primary care resources (optometrists) could reduce the number of patients attending ophthalmology clinics that did not need to, thereby reducing waiting lists and the costs associated with managing patients in secondary care (Scottish Executive 2006). As a result, sight testing in Scotland was redesigned. Specifically, from April 1st 2006, all residents of the UK became eligible for an NHS funded eye examination in Scotland (ISD Scotland 2010; NHS Inform 2018). In the year to March 2020, 2,182,534 NHS funded eye examinations (including domiciliary) were conducted in Scotland (Public Health Scotland 2020a). The Scottish eye examination was designed to include screening for the leading three causes of blindness in the UK: Glaucoma, age-related macular degeneration (AMD) and diabetic retinopathy (Liew et al. 2014; Cheng et al. 2015).To reflect the more in-depth nature of the Scottish *eye examination*, relative to English *sight test*, an optical practice received £37 remuneration per eye examination performed on patients under 60 years of age in 2021. For those aged 60 or over, a practice received remuneration of £40 or £45 depending whether or not fundus photography was performed (Foggo 2018; Optometry Scotland 2021). In addition to the standard fee, optometrists in Scotland who decide, for any of the reasons listed in table 1.1, that the patient requires further investigation, a fee of £24.50 can be claimed in 2021. Should the patient require an examination for a reason from the right-hand column, £38.00 can be claimed.

*Table 1.1. Situations that, in Scotland in 2021, result in a standard supplementary examination charge (£24.50, central column) and situations that result in an enhanced supplementary examination charge (£38.00, right hand column). * denotes a task that can be performed in addition to a standard eye examination. ** denotes a task that is performed without a standard eye examination.*

Patient	Standard examination	Supplementary examination
Cycloplegic refraction of a child	following a sight test*	requested by hospital eye department**
Paediatric follow up examination	without cycloplegia or dilation**	with cycloplegia or dilation**
Follow up / repeat measures that are unrelated to glaucoma	without dilation*	with dilation*
Suspect glaucoma review	without dilation*	with dilation*
	Dilation of a patient aged under 60*	n/a
Diagnosed or suspect anterior eye problem	without dilation**	with dilation**
Post-operative cataract assessment	without dilation*	with dilation**
Unscheduled visit, earlier than the recommended interval	without dilation**	with dilation**
	Cataract referral, advice and counselling*	n/a
	Extra appointment (complex needs)*	n/a

The success of the Scottish government's reform on eye care has been mixed. Specifically, GOS eye examination uptake increased to a greater extent in the highly educated and high income, relative to those in lower socio-economic,

groups (Dickey et al. 2012; Dickey et al. 2016). In line with this, Dickey et al. (2018) proposed that as hypertension has ocular signs (hypertensive retinopathy), an increase in those presenting for sight tests would increase the number of patients being subsequently referred to their GP for BP checks. It was reported that since the introduction of the free eye examination for all, numbers of patients reporting for blood pressure checks increased significantly in patients from higher socio-economic classes (Dickey et al. 2018). There was, however, no significant increase in blood pressure checks in middle or low socio-economic groups. Accordingly, the authors reported that as uptake increased more in the higher, relative to lower socio-economic classes, the abolishment of the sight test fee has in fact widened differences in access to eye care between socio-economic classes (Dickey et al. 2012; Dickey et al. 2018). The result for those in the lower socio-economic classes, however, could be partially explained by this group already having access to NHS funded sight tests (patients in receipt of means-tested benefits). The papers by Dickey and colleagues also use data from one year after the change in policy. The effects of patients regularly having sight tests, and increased awareness over time would not have been seen in this study.

On the other hand, it is expected that in the long term, preventable sight loss and costs associated with wider health and social care could reduce as a result of this change in policy as a greater proportion of Scottish residents receive regular eye tests (Dickey et al. 2016). In line with this it has been reported that since the reform of Scottish GOS, there has been a reduction in false-positive referrals for glaucoma (Ang et al. 2009; El-Assal et al. 2015), and an associated reduction in hospital waiting times (El-Assal et al. 2015). The data used in the study by El-Assal and colleagues (2015), however, straddles a period of time (April 2017 when the National Institute for Health and Care Excellence (NICE) in England introduced now superseded guidelines on the management of glaucoma (Syrogiannis et al. 2015; National Institute for Health and Care Excellence 2017). The consequence of this is that the direct effects of Scottish eye care reform were not measured. A recent report by Optometry Scotland has reported that the change in the GOS contract in 2006 has led to a significant reduction in ophthalmology outpatient attendances in Scotland, relative to

England (Optometry Scotland 2018). Care should be taken in interpreting this data, however, as the rate of increase in outpatient attendances prior to 2006 is not reported. Accordingly, it could be that outpatient attendances in Scotland have, historically, been increasing at a slower rate than England. Further research, therefore, is required to substantiate these claims. Nevertheless, the report details that the NHS in Scotland has both incurred cost-savings and assisted with the capacity issues that exist within the overburdened ophthalmology departments (Optometry Scotland 2018). A preliminary report comparing the detection of eye disease between Scotland and England failed to find significant differences between the two areas (Henderson et al. 2012). The authors do report, however, that this could be attributable to a greater proportion of patients incurring a private fee or local NHS funding, in England, relative to Scotland.

On balance, it remains unclear as to whether the reforms to the Scottish eye care system provide significant benefits to eye health or its associated costs to the health services.

1.2.3. Wales

GOS sight tests exist in Wales with similar eligibility criteria to those found in England. In 2003, however, the eye care system in Wales was reviewed by the Welsh government, the Welsh Assembly. In order to facilitate early detection of eye diseases in at risk groups, the Welsh Eye Health Examination was introduced. This enhanced eye examination aimed to increase uptake of eye examinations by those who were more at risk of developing sight-threatening conditions (Sheen et al. 2009; McAlinden et al. 2016). Specifically, the Welsh eye health examination is an NHS funded eye examination for Welsh residents who: are of black or Asian ethnicity, have retinitis pigmentosa or those for whom losing sight would have a disproportionately larger impact (e.g. those who have a hearing impairment or are already blind in one eye) (Shickle et al. 2015a; Statistics for Wales 2017; Primary Care One 2018). Additionally, patients that do not fall into the aforementioned categories, but fall into the other means-tested benefits or ages that entitle them to a standard GOS sight test, can still receive a free of charge NHS funded sight test. For this standard sight test, the

practice is remunerated £21.71, in line with England and Northern Ireland (Association of Optometrists 2019a).

Subsequently, in 2013, other enhanced optical services and the Welsh eye health examination were amalgamated into the new Eye Health Examination Wales (EHEW), the aims and eligibility remained largely unchanged (McAlinden et al. 2016). For the latest year on record (2019) there was 795,188 GOS funded eye tests and 184,366 EHEW examinations (Welsh Government 2020d). The Welsh eye care system breaks eye examinations into three bands (table 1.2). Band two appointments can be performed after a standard GOS (or private) sight test, but not after a band one eye health examination. Band three appointments, however, are performed as follow up appointments to band one (O'Sullivan-Adams 2014).

Table 1.2. Eligibility criteria for each band of the Welsh eye care system. 'Needs investigations' includes patients referred via the diabetic retinal screening programme, dry AMD monitoring and the Pharmacy Common Ailments Scheme. Costs taken from Association of Optometrists (2019a). F/U: Follow up

Band	One	Two (after sight test)	Three (F/U to band one)
Eligibility	Eye problem require urgent investigation	Cycloplegic refraction of a child	Unresolved flashing lights / floaters
	At risk patient (ethnic group: black or Asian)	Wide visual field test (e.g. for headaches)	Review of marginal keratitis
	Only one eye that has good vision	Repeat IOP or visual fields (glaucoma)	Review of corneal abrasion
	Hearing impairment	Tests to diagnose macular issues.	Review of foreign body
	Diagnosed retinitis pigmentosa		Unresolved red eye
	At request of GP / ophthalmologist		Review of unknown corneal lesions
Fee	£60	£40	£20

Published investigations into the effectiveness of the Welsh eye care system, although limited in number, are positive (Sheen et al. 2009; McAlinden et al. 2016; Rehan et al. 2020). Sheen and colleagues have reported that the current system is cost-effective, doesn't delay access to ophthalmologists and receives high levels of patient satisfaction and safety (section 1.3.1).

1.2.4. The effectiveness of the sight test

Although the *exact* number of sight tests in the UK is not known, it has been *estimated* that in 2014 approximately 22.5 million sight tests were performed (Optical Confederation 2014a). Of this number, 70% of are done so under the GOS contract (Association of Optometrists 2018c). The majority of eye tests in the UK, therefore, are performed by optometrists under terms of the GOS contract and in accordance with the Opticians Act 1989 (The Opticians Act 1989) and the Sight Testing (Examination and Prescription) (No. 2) Regulations 1989. These rulings specify that the optometrist (or ophthalmic medical practitioner) should perform the tests required to detect "signs of injury, disease or abnormality in the eye", and any additional examinations as the optometrist determines is *clinically* necessary. By definition, therefore, repeating measurements and/or providing additional information on referrals (e.g. suitability for surgery etc.) is not clinically necessary and is outside the scope of a sight test. Accordingly, although the 2021 sight test is useful for detecting eye disease and subsequently referring patients onto GPs or hospital ophthalmology departments, it is not appropriate for managing patients who present with eye problems (Association of Optometrists 2015), or for providing additional information beyond the remit of a sight test. For example, ascertaining appropriateness for cataract extraction, or fulfilling criteria for evidence based interventions (e.g. Chalazia removal) (NHS England 2019a) are not requirements of a sight test. It is also worth noting that, using the Bank of England's inflation calculator (https://www.bankofengland.co.uk/monetary-policy/inflation/inflation-calculator) a sight test in 2021/2022 (£21.71) is remunerated, in real terms approximately 19% less than that of 2000/2001(~ £26.86, in today's money) (Wilson 2000). Concurrently, the scope of practice of UK optometrists (Needle et al. 2008) and population eligible for a loss-leading

NHS funded sight test (e.g. those aged ≥ 60 years), is increasing, resulting in the NHS sight test as it currently stands becoming increasingly unsustainable.

The lower than cost price that is paid for providing a GOS sight test (Optical Confederation 2013; Shickle et al. 2015b) requires that spectacles or other optical instruments have to be sold for an optical business to break even (Cross et al. 2007; Shickle et al. 2015a; Shickle et al. 2015b). One unintended consequence of this business model is that a number of patients don't access eye care due to the anticipated cost of the visit. For example, it has been reported that the anticipated cost of purchasing spectacles deters patients from obtaining a sight test, even in cases where the sight test itself is NHS funded (Webster et al. 1992; Patel et al. 2006; Cross et al. 2007; Awobem et al. 2009; McLaughlan and Edwards 2010; Hayden 2012; Leamon et al. 2014; Shickle and Griffin 2014). In line with this, in Scotland where since 2006 everyone is entitled to a free of charge eye test, uptake increased to greater extent in higher, relative to lower socio-economic groups (Dickey et al. 2012). This is perhaps unsurprising as those in lower socioeconomic groups were already receiving GOS funded sight tests (I.e. those in receipt of means-tested benefits). Reports of lower socio-economic status (SES) affecting sight test uptake in the rest of the UK, however, are mixed. Lower SES may (Van der Pols et al. 1999; Shickle and Farragher 2014; Shickle et al. 2017) or may not (Sabates and Feinstein 2008) be associated with reduced uptake of sight tests. Specifically, Knight and Lindfield (2015) conducted a systematic review of studies assessing the relationship between access to eye care services and SES. The authors found that, on balance, the evidence provided for an association between reduced SES and reduced access to eye care was equal to the evidence reporting no association. Knight and Lindfield (2015) report that the evidence up until 2013 was low quality and diverse. They summarised by stating more research is required to draw firm conclusions. Subsequently, Shickle and colleagues more robustly examined access to sight tests in Essex (Shickle et al. 2017) and Leeds (Shickle and Farragher 2014), UK and found that lower SES was associated with a reduced uptake of GOS sight tests in patients aged under 16 and over 60. As expected, due to the means-tested eligibility of the 16-59 age

group, it was reported that lower SES was associated with an increase in uptake of GOS sight tests for those in that age group.

It has been proposed that early detection and diagnosis is essential for successfully managing and treating a number of eye conditions (Mills et al. 2006; Dart et al. 2009; Olafsdottir et al. 2016). In line with the proposals from this hypothesis, barriers to access of eye care can have detrimental effects on patient wellbeing and incurs significant economic costs (Pezzullo et al. 2018). Addressing these inequalities of access, therefore, remains an important issue. Another unintended consequence is that optometrists may be under commercial pressure during their clinic. Recently (2019) the General Optical Council (GOC) commissioned a qualitative study that found that optometrists perceived time constraints and commercial pressure to be the top two risk factors for putting patients at risk of harm (Thurman et al. 2019). For Australian optometrists this has recently been reported to lead to increased levels of mental health issues and burnout (Bentley and Jackson 2014; Bentley et al. 2021). The impact of this on patient care is not currently known.

Although, as detailed above, anticipated cost of the eye examination and/or the subsequent spectacle purchase is a deterrent for accessing sight tests, a number of other factors also influence sight test uptake. For example, It has been reported that factors such as lack of understanding that an eye examination is a health check (including when no symptoms are experienced) (McLaughlan and Edwards 2010; Hayden 2012; Leamon et al. 2014; Shickle and Griffin 2014; Shickle et al. 2014), optometrist mistrust (Shickle and Griffin 2014; Biddyr and Jones 2015; Donaldson et al. 2018), fear of failing tests (Shickle and Griffin 2014) and putting reduction of vision down to a general aging process (Biddyr and Jones 2015) are reasons for non-attendance to sight tests. In support of the view that an ocular health check is important even when asymptomatic, a Canadian study published in 2016 reported that a total 58% (n = 1535) of asymptomatic patients (n = 2656) had a change in ocular status. Of these 2,656 patients, 16% (n = 434) were found to have serious pathologies. The authors state that these serious pathologies could include conditions such as retinal detachment, melanoma, glaucoma, papilledema and uveitis (Irving et

al. 2016). These studies highlight that although cost is a factor, the issue of non-attendance is multifactorial and further work is required to promote the public awareness that optometrists provide important eye health checks and not just spectacles. Mistrust of optometrists is a hard issue to tackle given the nature of optometry in the UK and the business models used, in part, due to the GOS sight test contracts. Specifically, optical practices are dual purpose: Optometrists provide sight tests and issue spectacle prescriptions in the same location as spectacles are sold. The result of this is that it has been reported that patients can feel pressured into a spectacle purchase that they feel is unnecessary (Shickle et al. 2014; Donaldson et al. 2018). Donaldson et al. (2018) state, however, that a further audit of clinical practice would be required to substantiate these claims. A possible way of gaining patient's trust is to separate businesses that offer sight tests from those that dispense spectacles. In turn, this could change public perception of optometrists from spectacle sellers to health care professionals. Moreover, many opticians' public advertisements are based around spectacle sales and are not about the health aspect of the sight test which could be promoting how the public views the profession in the UK. However, given the loss leading nature of the sight test, it is understandable why this is this case. Further work is needed to explore public attitudes towards this.

On balance, current evidence points to the conclusion that providing free *sight tests* to all may not be the way forward. Increasing public awareness and targeting specific sub-groups of at-risk population with a more comprehensive eye examination with an appropriate level of funding combined with a service where patients with acute eye problems and chronic diseases may be managed in community, however, may be more successful in reducing the burden on secondary care eye services.

1.3. The management of eye disease by General Practitioners and Pharmacists

In primary care, as an alternative to their optometrist, patients typically present with eye problems to either their GP or pharmacist. However, there is currently

a lack of recently published literature on the management of eye disease by UK GPs. It has been estimated that for the year November 2017 to October 2018, there were approximately 309 million GP appointments (NHS Digital 2018a). Whilst the proportion of these appointments that is currently related to ophthalmic issues is unknown, historical evidence suggests that approximately 1.5% to 2.7% were eye related (Dart 1986; McDonnell 1988; Sheldrick et al. 1993). Accordingly, approximately 4,635,000 to 8,343,000 general practice appointments per year are related to eyes.

The amount of training that these health care professionals receive on ophthalmology, however, is limited. For example, It has been reported that the time devoted to ophthalmology in UK undergraduate medical schools is approximately 8 days (Baylis et al. 2011; Welch and Eckstein 2011; Kilduff and Lois 2016). Beyond this basic undergraduate level, 96% of GPs receive no further ophthalmological training (Kilduff and Lois 2016). The end result is that although GPs are *qualified* to manage and treat minor eye problems, a number of studies have reported that GPs typically lack confidence in this (Wilson 1987; Featherstone et al. 1992; Shuttleworth and Marsh 1997; Kilduff and Lois 2016) and 38% of GPs feel that eyes are the hardest part of the body to diagnose problems (Optegra Eye Health Care 2017). This issue is compounded by GPs lacking access to equipment that is commonplace in hospital ophthalmology departments and high street optometric practice (Teo 2014; Kilduff and Lois 2016). As GPs deal with a vast variety of health problems, it is unaffordable and impractical to purchase and store the equipment commonplace in most optometric practices. For example, it has been reported that typical costs to purchase equipment necessary to provide basic NHS eye services are around £16,000 (Shickle et al. 2015b).

Although GP's confidence in ophthalmic conditions may be low, a study into optometry and GP referrals into a private secondary care ophthalmology clinic in Northern Ireland found that GPs refer appropriately within the context of their scope of practice, with relatively few false positive referrals (Pierscionek et al. 2009). This is supported by Davey et al. (2016) who found that within the limited scope of practice of a GP, the number of false positive referrals into hospital

ophthalmology departments was low. Specifically, most referrals by GPs are correct when the lack of equipment is considered. This result is unsurprising given that GPs relative lack of training and equipment, almost any referral will be classified as appropriate. The results of the study by Pierscionek et al. (2009), are questionable. It is unclear, for example, how GPs were able to correctly diagnose conditions such as glaucoma and retinal conditions without the appropriate equipment to assess this. Their finding that 42% of referrals were from GPs (and 58% from optometrists) suggests that referrals from the GP could have actually been referrals from optometrists via the GP (Davey et al. 2011) as it differs markedly from other literature that have put GP referrals at 14% (Fung et al. 2016) and 28% (Davey et al. 2011). Other studies, however, have found that GPs may incorrectly diagnose 36% (Statham et al. 2008) to 58% (Sheldrick et al. 1993) of patient's eye problems. This misdiagnosis results in preventable adverse complications in up to 18% of patients (Statham et al. 2008) and include irreversible loss of vision and severe pain resulting from acute glaucoma misdiagnosed as cataract or a space occupying cerebral lesion misdiagnosed as migraine (Sheldrick et al. 1993). Similarly, it has been reported that doctors in Australia have prescribed chloramphenicol for conditions that transpired to be glaucoma, herpes zoster ophthalmicus and acute anterior uveitis (Statham et al. 2008). Although Sheldrick and colleagues found that misdiagnosis resulting in severe adverse outcomes was low (1.36%) it is important to consider that each of these cases could result in irreversible blindness or even mortality.

In order to reduce the impact of these issues, two studies have found that paper based equipment (e.g. reminder card, instructions on how to use equipment, vision chart, red tipped object) and a pen torch costing between £0.50 and £3.50 per patient provide a significant increase in the proportion of patients with eye problems being appropriately screened (Teo 2014; Kilduff and Lois 2016). Moreover, this ensues a modest increase in the number of patients being appropriately referred (Kilduff and Lois 2016). These studies point to the conclusion that improving GP equipment may improve the GPs ability in deciding which patients require an urgent referral into ophthalmology and which

could be managed within primary care. What the equipment does not do, however, is assist with capacity issues within GP practices or GP knowledge.

Another method of aiding GP's with management of acute eye problems are NHS 'red flags' (National Institute for Health and Care Excellence 2016b). Specifically, if a patient presents with any of the following acute signs or symptoms: sudden appearance of flashes or floaters, abnormal pupil reactions, moderate to severe pain or photophobia, marked redness of one eye, reduced visual acuity, reduced visual field, haloes around lights or foreign bodies, double vision, or certain red eyes, an urgent referral into the ophthalmology department is recommended (Kilduff and Lois 2016; Robinson 2017). It would be expected, however, that after examination by an optometrist, a lower number of referrals would be required than that based solely upon presenting symptoms as is the case in red-flags. Moreover, it has been reported that, although 'red flags' (Kilduff and Lois 2016; National Institute for Health and Care Excellence 2016b) exist to assist GPs in managing eye conditions, they aren't always followed (Teo 2014; Kilduff and Lois 2016).

Similarly, pharmacists are trained to deal with a wide range of conditions and problems and subsequently offer a wide range of services (Hassell et al. 2011). In line with this, although studies on how pharmacy staff manage patients presenting with eye problems are limited, two studies from the same research group found that typically, pharmacy staff have a tendency to prescribe in nearly all cases of dry and allergic eye disease and generally don't recommend seeking professional advice or follow up from an optometrist (Bilkhu et al. 2013; Bilkhu et al. 2014). The authors propose that more training is required and specify a need to improve collaboration between optometrists, GPs and pharmacists. Further studies, however, are needed to better understand how community pharmacy manages eye disease.

On balance, current research points to the conclusion that GPs and Pharmacists may not be the appropriate first port of call for patients with eye problems. Further work, however, is needed to address the management of eye disease by GPs at the present time. Optometrists based in community practices

may provide solutions to capacity issues in secondary care but issues relating to unmet demand and false negatives should be explored first.

1.4. Community Optometry Services

Elderly patients make up the largest proportion of health service users (Rice and Fineman 2004), which, combined with an increasingly ageing UK population is increasing the demand on hospital services. Ophthalmology departments are no exception (Chalk and Smith 2013; Kotecha et al. 2015). A number of reports have pointed to the conclusion that the overburdening of secondary care eye services directly results in a negative impact on patient safety and treatment (Gulland 2003; National Patient Safety Agency 2009; Tatham and Murdoch 2012; Malik et al. 2013b; Boyce. 2014; Kotecha et al. 2015; Foot and MacEwen 2017). Patient safety, combined with issues of accessibility, sustainability and convenience requires the current practice of delivering eye care within a hospital setting to be reviewed (Gulland 2003; National Patient Safety Agency 2009; Boyce. 2014; Foot and MacEwen 2017).

One way of reducing the demand on hospital ophthalmology departments is to promote the management of certain eye conditions by optometrists (Chalk and Smith 2013). Indeed, it has been reported that optometrists within ophthalmology departments are increasing in responsibility by facilitating doctors' clinics (Harper et al. 2016). For example, optometrists have been reported to be performing YAG laser capsulotomy and training on intravitreal injections (Greenwood et al. 2020). This increase in practitioner scope, however, is often confined to optometrists within a hospital setting. The reason for this is unclear, however, it has been reported that optometrists tend to be performing these procedures under direct supervision of a consultant, more so than other non-medical health care practitioners such as orthoptists and nurses. On the one hand, this could reflect increased complexity of patients, relative to what other practitioners can manage. This however, does not seem be to the case as it has been reported that, for example, nurses are more likely to perform cataract post-operative clinics unsupervised, whilst optometrist perform these with supervision from a consultant (i.e. consultant led) (Greenwood et al.

2020). On the other hand, therefore, this might reflect optometrist's lack of medical training or other reasons unknown why optometrists might be perceived to require direct supervision to manage these patients. The end result is that although the efficiency of doctor's clinics may improve, the demand on hospital ophthalmology departments remains unchanged.

Prior to community optometric services, for patients in the UK to access free of charge, non GOS eye care they have to present to either hospital-based accident & emergency (A&E) departments (general or ophthalmic), or to their GP. The limitations of utilising GPs are detailed in the previous section (1.2). A&E departments in the UK are over-crowded (Boyle et al. 2012; Morris et al. 2018). Specifically, there are too many patients to be effectively managed with the finite resources of the NHS. This leads to a plethora of issues such as: increased mortality rate (Richardson 2006; Sprivulis et al. 2006), increased waiting times (Bernstein et al. 2009), prolonged pain (Derlet and Richards 2000; Pines and Hollander 2008), reduced patient confidentiality and privacy (Olsen et al. 2008), and reduced staff productivity (Derlet and Richards 2000). As such, unnecessary presentations to A&E departments should be kept to a minimum. It has been reported, however, that up to 60% of patients presenting with ocular issues to general A&E departments could have been successfully managed in primary care by an optometrist (Hau et al. 2007; Rumney 2019). In line with this, a number of studies have shown that between 25% and 37.5% of patients attending to ophthalmology specific accident & emergency (A&E) departments could have been successfully managed by an optometrist (Hau et al. 2008; Wasfi et al. 2008; Davey 2014).

Moreover, it has been reported that optometrists with additional qualifications in prescribing (independent prescriber (IP) status) could effectively manage 68% of patients who presented to a rapid access ophthalmology clinic at Bradford Royal Infirmary (Davey 2014). More recently, it has been reported that over 95% of patients attending urgent eye care schemes in primary care can be safely managed by IP optometrists (Ansari et al. 2021) and over 90% of patients attending during an IP optometrists placement predominantly at eye casualty in Wye Valley NHS trust (Rumney 2019). Similarly, in Scotland, where there is

national funding for optometrists to gain IP qualification it has been reported that, once qualified, IP optometrists refer less relative to when they were not IP qualified (Loffler et al. 2011). This is supported in a small sample by Parkins and colleagues who reported that, in their vignette study, the three optometrists with IP qualifications would have referred less patients to ophthalmology, relative to their non- IP colleagues (Parkins et al. 2018). Furthermore, it has been reported that both optometrists with (Todd et al. 2020) and without (Hau et al. 2007) IP qualification can make similar ophthalmic managements plans for the majority of patients with acute eye problems. Interestingly, Hau (2007) and colleagues reported no sight-threatening conditions misdiagnosed, whilst Todd and colleagues (2020) reported similar levels of serious pathology missed in IP optometrists (n=5) as consultant ophthalmologists (n=4). These results together suggest that optometrists may be able to manage these patients effectively and point to the conclusion that redirection of these patients from A&E to an optometrist would reduce the number of patients unnecessarily presenting to secondary care services for ophthalmological issues (Hau et al. 2007; Hau et al. 2008; Davey 2014). A more recent study by El-Abiary and colleagues (2021) reported that since the introduction of IP, optometrists' referrals to GPs have reduced by approximately 10%. Although the study doesn't specify details it is assumed that this is a 10% reduction in optometry to GP referrals in the year 2018/2019, relative to 2010/2011. Referrals to the HES, in contrast, have increased over 100% (from 44,174 per year to 96,315) in the same time period (El-Abiary et al. 2021). This is perhaps unsurprising given the increasingly ageing population will increase numbers of patients with pathologies. The authors did comment, however, that although not necessarily relatable to IP, HES outpatients activity increased by 38% in England, relative to 9.8% in Scotland in the same time period (El-Abiary et al. 2021). In line with this, it has recently been reported that IP optometrists in Scotland reduce the workload of primary care GPs, but not necessarily secondary care hospitals (Jonuscheit et al. 2021). The authors state, however, as forementioned in sectioned 1.1.2 that the IP optometrists may be have contributed to the lower rate of increase in hospital appointments in Scotland, relative to England. In summary, utilising optometrists with IP qualifications may not lead to a reduction in hospital workload, but may have advantages in slowing the increase in workload.

Of note, in countries where optometrists have an enhanced role as a health care provider, the UK is the only one which requires this as a further post-graduate qualification and not incorporated into the undergraduate degree programme and, interestingly, this appears to be due to the UK optometrists' professional body: the College of Optometrists (Rumney 2019). Incorporating this qualification into the undergraduate training programme could be of benefit to patients, the NHS (as detailed above) and for practitioners who would no longer need to take time out of providing care to patients to complete the course later in their career.

In December 1999, the regulator for the optical profession, the GOC, put forward an amendment relating to their rules of referral of ophthalmic issues. This amendment was subsequently approved and came into force from January 2000 (General Optical Council 1999). The compulsory nature of referring patients with pathology into hospital ophthalmology departments or to a general practitioner (GP) was revoked in line with optometric practice. Instead, for the first time in UK optometric legislation an optometrist was legally able to manage patients within their scope of practice. Specifically, if the patient refused referral or, if according to the professional judgment of the optometrist the patient did not require referring, the optometrist may choose to not refer to a medical practitioner (General Optical Council 1999). Since this change in legislation, in England, COSs have been commissioned on a local level to meet the rising demand for secondary care ophthalmology services.

There are a number of community optometry services currently operating across the UK. These services mainly operate in the areas of acute eye care, glaucoma referral management, cataract referral management and post-operative assessment, low vision and paediatrics and are commissioned on a local basis (Dabasia et al. 2014; Baker et al. 2016).

1.4.1. Acute Eye Care: PEARS/ MECS

Minor eye conditions services (MECS, also known as primary eye-care acute referral schemes: PEARS) exist in some of the clinical commissioning group (CCG) areas in England and Northern Ireland. These COSs are commissioned on a local level to enable appropriate use of community resources to manage minor eye problems within routine optometric practice. They provide funding for optometrists to perform examinations on patients who are either not eligible for, or have symptoms beyond the scope of, the NHS sight test. Typically, once becoming accredited through training, optometrists are able to offer NHS funded eye-care beyond the scope of a GOS sight test (Konstantakopoulou et al. 2014). Specifically, MECS aim to offer rapid access to cost-effective professional eye care, thereby reducing unnecessary referrals into hospital ophthalmology departments (Konstantakopoulou et al. 2014; Konstantakopoulou et al. 2018; LOCSU 2018). Generally, patients with acute eye problems that are not related to spectacle prescription can be seen at short notice (within 24 hours) by participating optometrists. While the exact conditions eligible for MECS schemes may vary from scheme to scheme, they typically include flashing lights and/or floaters, red eyes, sore eyes, dry eyes, painful eyes, sudden loss of vision and ocular foreign bodies.

Studies into the success and financial viability of MECS schemes, however, are lacking (The Royal College of Ophthalmologists 2017a). To date, there are only a handful of published studies reporting on MECS schemes (Sheen et al. 2009; Chaturvedi et al. 2015; Konstantakopoulou et al. 2016; Mason et al. 2017; Konstantakopoulou et al. 2018; Hill and Hanspal 2020). Reports of the absolute cost savings of MECS are inconclusive. Specifically, Sheen and colleagues obtained access to data for PEARS covering the entirety of Wales, UK and telephone interviews were conducted to assess the patient satisfaction and whether the patient's eye condition had resolved. This study, however, combined both acute eye consultations (PEARS) and enhanced sight tests (Welsh eye health examination), making it hard to examine the effects of the PEARS appointments exclusively. Moreover, where an initial outpatient appointment in England is valued at £139 (NHS Improvement and NHS

England 2017), Sheen and colleagues used the value of £69.80 (Sheen et al. 2009). Nevertheless, they found the service to be cost-effective, albeit increasing costs by approximately £12 per episode (Sheen et al. 2009). Using the outpatient appointment cost of £139, results in a cost saving of approximately £4 per episode. Reviews of the MECS in Lambeth and Lewisham, on the other hand reported that cost savings were 0.6% and 16.9% respectively, relative to a control region in close proximity (Southwark) that didn't have a MECS scheme (Mason et al. 2017). Specifically, in the time period examined, costs increased in the control region by 3.1%, whereas in Lambeth costs increased 2.5%. Lewisham, on the other hand, had cost savings of 13.8%. These cost savings, however, need to be interpreted with caution as it is unclear whether variations in workforce/ hours worked between the two years were accounted for. Whereas the data from Wales encompasses the entirety of the country, the data from England is limited to two areas and the differing results between these areas highlights the dangers in generalising across the whole of England due to varying demographics, unmet need, referral pathways and attitudes of professionals (Mason et al. 2017). Furthermore, a report on MECS in Stockport found that in the five month period following the introduction of a MECS, there was no reported reduction in the number of patients attending hospital ophthalmology services (Chaturvedi et al. 2015). This result is perhaps unsurprising given hospital waiting lists. To reduce the number of ophthalmology department appointments, a scheme would have to, at the very least, reduce the waiting list to zero and close doctor's clinics reducing capacity.

Beyond the financial element, MECS are commissioned with the aim of reducing unnecessary (false-positive) referrals to hospital departments (Konstantakopoulou et al. 2016; LOCSU 2018). As referral is reported to cause negative psychological consequences to patients (Tymstra 1986; Brewer et al. 2007; Davey et al. 2013), reducing the number of referrals into secondary care by promoting successful management of eye disease within optometric practice, should decrease the prevalence of referral-associated anxiety. Moreover, providing enhanced eye-care within the community allows patients to have care closer-to-home with a more flexible appointment booking system that will bring

greater patient satisfaction (Konstantakopoulou et al. 2016) and increased sustainability (Malik et al. 2013a).

A common reservation when commissioning community optometric services is the potential to awaken previously unmet demand and thus, unnecessarily increasing costs (The Royal College of Ophthalmologists 2017a). Although there are increasing numbers of published reports of cost-effectiveness of MECS (Sheen et al. 2009; Baker et al. 2016; Mason et al. 2017), there is only one peer-reviewed study that demonstrates cost savings (Mason et al. 2017). Indeed, a larger scale study indicated potential cost increases (Sheen et al. 2009) coupled with anecdotal reports from ophthalmologists suggesting MECS do not work (The Royal College of Ophthalmologists 2017a) suggests that further investigation is required. Moreover, there are currently no studies of the false negative rate of community optometrists involved in MECS scheme any such service will require careful auditing to ensure patient safety is adequately maintained.

1.4.2. Glaucoma

Glaucoma is a progressive optic neuropathy resulting in a loss of the optic nerve head neural retinal rim that ultimately results in a loss of peripheral vision. Damage to the optic nerve head is irreversible so that once vision is lost, it cannot be recovered. Treatment, therefore, is aimed at slowing or halting the progression of the disease. In line with this, in order to manage patients with glaucoma successfully, early intervention is required (Weinreb and Khaw 2004; Varma et al. 2011). Glaucoma is one of the leading causes of blindness worldwide (Quigley and Broman 2006; Pascolini and Mariotti 2012; Bourne et al. 2016) and it was expected to affect 79.6 million people by 2020 (Quigley and Broman 2006).

Due to the symptomless early stages of the disease, open-angle glaucoma in the UK is often detected opportunistically during routine eye examinations (Burr et al. 2007). While optometrists in other parts of the world (e.g. United States) can diagnose and treat glaucoma, optometrists in the UK can typically neither

diagnose nor treat (Fremont et al. 2003). Optometrists in the UK who hold both the College of Optometrists' higher certificate (or diploma) in glaucoma and diploma in independent prescribing, however, are able to offer pharmacological treatment of glaucoma. Diagnosis, on the other hand, can still only be provided by an ophthalmologist (The College of Optometrists 2019). In line with this, the majority of referrals into UK hospital ophthalmology departments for suspected glaucoma or ocular hypertension are initiated by community optometrists (Harrison et al. 1988; Bell and O'Brien 1997; Pierscionek et al. 2009; Davey et al. 2011; Khan et al. 2012). Despite optometrists being trained in the detection of glaucoma, the number of false-positive referrals for glaucoma from optometrists is high (Shah and Murdoch 2011; Khan et al. 2012). This 'high' false positive rate is unsurprising given the low prevalence of primary open angle glaucoma (Association of Optometrists 2019b). In addition, however, this is partially due to the introduction of the National Institute for Health and Care Excellence (NICE) guideline (CG85) on diagnosis and management of glaucoma in 2009. This, now superseded guideline, led the legal and professional bodies of UK optometry (Association of Optometrists (AoP), Association of British Dispensing Opticians (ABDO) and the Federation of Ophthalmic and Dispensing Opticians (FODO)) to recommend that all patients presenting with an intraocular pressure (IOP) greater than 21mmHg be referred into hospital ophthalmology (Shah and Murdoch 2011). As a direct result of this policy, the number of referrals for suspect glaucoma (e.g. raised IOP) into hospital ophthalmology departments increased, with an increase in false positives (e.g. no glaucoma) (Shah and Murdoch 2011; Ratnarajan et al. 2013a). Specifically, it has been reported that 27% to 50% of patients been referred into hospital ophthalmology departments for suspect glaucoma were false positives (Newman et al. 1998; Vernon and Ghosh 2001; Bowling et al. 2005; Salmon et al. 2007; Khan et al. 2012; Davey et al. 2016). Consequently, as reported by a number of studies (Parkins and Edgar 2011; Ratnarajan et al. 2013a; Ratnarajan et al. 2013b; Ratnarajan et al. 2013c; Syrogiannis et al. 2015), the Royal College of Ophthalmologists and College of Optometrists issued joint guidance aimed at reducing the number of patients referred for suspect glaucoma. Specifically, it was proposed that, in line with NICE guidance (National Institute for Health and Clinical Excellence 2009), optometrists can

choose not to refer patients who are not at significant risk of visual loss in their lifetime. This meant that patients aged above 65 with an IOP of less than 25mmHg or aged 80 or over, an IOP of less than 26mmHg do not necessarily require referral into hospital ophthalmology departments and, accordingly, services have been commissioned on a local level to reduce the number of false positive referrals. This original NICE guidance has since been updated to state patients with IOPs of less than 24 no longer necessarily require referral if they have no other signs of pathology (National Institute for Health and Care Excellence 2017). Although this is expected to reduce false-positive referrals, to date, there are no published studies specifically examining this. Similarly, Optical Coherence Tomography is now becoming increasingly common in high street practice (Jindal et al. 2019). On the one hand, this could be expected to improve accuracy of referrals for patients with suspected glaucoma (Jindal et al. 2019), On the other hand, it could be that optometrists unfamiliar with the equipment may refer more patients due to parameters outside the normative database without any other signs of disease, thereby increasing false positive referrals.

In the UK at present, there are two types of community-based optometry services for Glaucoma and/or intra-ocular pressure. Broadly, these can be categorised into pre (Henson et al. 2003; Azuara-Blanco et al. 2007; Devarajan et al. 2011; Parkins and Edgar 2011; Keenan et al. 2015) and post, diagnosis (Mandalos et al. 2012).

Tonometry in primary care is typically performed in optometric practice in the UK using a non-invasive method such as a non-contact tonometer (NCT) (Willis et al. 2000; Myint et al. 2011). This method is popular as it does not require anaesthesia and can be performed by support staff making it more convenient for some optical practices. NCTs, however, have been reported to over-estimate (Ogbuehi and Almubrad 2008; Hubanova et al. 2015) or under-estimate (Jorge et al. 2002) IOP measurements in the normal population, relative to the gold-standard contact tonometry. Other NCTs on the other hand, such as the Reichart AT550 (Jorge et al. 2002) or the Topcon CT80 (Ogbuehi 2006) have been found to produce IOP readings comparable to that of the gold-

standard, contact tonometry in the population with normal IOPs and similarly, in glaucomatous eyes with normal IOP (i.e. on treatment) (Jorge et al. 2003). NCT has, however, been reported to underestimate (Gupta et al. 2006) or overestimate (Hubanova et al. 2015) IOP in patients with elevated IOP. More recently, however, Gazzard and colleagues have suggested that a form of NCT known as the ocular response analyser (Reichert Technologies, Depew, NY, USA) may be an improved way of measuring a patients IOP, relative to applanation tonometry. Specifically, the authors suggest the addition of measuring the corneal hysteresis which has been shown to be an independent risk factor for glaucomatous visual field progression makes the Ocular Response Analyser a more informative method of measuring IOP, relative to contact tonometry (Gazzard et al. 2021). Another method of measuring IOP is by using a rebound tonometer. This method utilises probes that make contact with the cornea and rebound back into the machine. This technique is non-invasive and does not require anaesthesia. Rebound tonometry has been reported to overestimate IOP in both the normal (Fernandes et al. 2005; Diaz et al. 2008; Martinez-de-la-Casa et al. 2011) and hypertensive (Diaz et al. 2008) populations.

The ability of these devices to overestimate IOPs in the normal range can results in a number of false-positive referrals into the hospital ophthalmology service. However, as applanation tonometry and repeated measurements are not a requirement of a sight test, it is expected for the reasons aforementioned, that introducing schemes to refine or repeat measurements prior to referral into hospital ophthalmology departments would reduce the number of false-positives and could reduce the number of outpatient appointments for glaucoma services, and in turn, waiting lists. This is particularly the case when patients are solely referred for raised intra-ocular pressure: due to non-contact devices tendency to overestimate IOP, it has been reported that the number of false positive referrals could be reduced if the pressure was repeated with applanation tonometry (Salmon et al. 2007; Khan et al. 2012).

Beyond the aforementioned limitations of routinely performed non-contact tonometry, visual field assessments are another commonly used test for

assessing glaucomatous damage. These tests however, can often produce unreliable visual field results (Katz and Sommer 1988; Katz and Sommer 1990; Katz et al. 1991) for patients that are performing these tests for the first time. These unreliable visual field results can appear to present as a visual field defect (Wood et al. 1987; Katz and Sommer 1990; Horani et al. 2002). The effect of learning could account for a significant improvement in a patients performance of visual field tests (Chauhan et al. 2008). Therefore, repeating of anomalous visual field results is an essential step in ascertaining whether or not they are true positives. This, however, isn't required as part of the NHS GOS sight test (Myint et al. 2011). Moreover, the performing of visual field tests using automated perimetry itself is not financed by the NHS sight test but by the optometry practice making repeating this test particularly burdensome on the practice (Association of Optometrists 2018b).

Accordingly, and in line with the latest NICE guidance on glaucoma diagnosis and management (National Institute for Health and Care Excellence 2017), a first step in any scheme designed to reduce the workload in hospital ophthalmology departments would be to refer on the basis of applanation tonometry or repeated readings. There are a number of documented reports of this type of service that we will refer to as 'Glaucoma Repeat Measures' (GRM). This is in line with latest NICE guidance suggesting stratification of glaucoma refinement services (National Institute for Health and Care Excellence 2017; The Royal College of Ophthalmologists 2017b). The phrase that some enhanced glaucoma schemes were known as: glaucoma referral refinement, is now reserved for schemes including other clinical measures where the optometrist is required to have obtained the College of Optometrists Professional Certificate in glaucoma (The Royal College of Ophthalmologists 2017b). Schemes not requiring such level of qualification are renamed as GRM.

Typically, GRM appointments involve repeating visual field and/or IOP measurements to confirm a potentially pathological finding prior to referring the patient into secondary care (Henson et al. 2003; Azuara-Blanco et al. 2007; Ang et al. 2009; Warburton 2010; Devarajan et al. 2011; Parkins and Edgar 2011; Ratnarajan et al. 2013b). Specifically, these commissioned schemes aim to

reduce the false-positive rate and absolute number of glaucoma referrals into hospital ophthalmology departments. It has been reported that GRM appointments reduce referrals by approximately 44% (Ratnarajan et al. 2013b) to 76% (Parkins and Edgar 2011) of patients. These results combined with reports that optometrists can make decisions to a similar standard of what would occur in hospital ophthalmology departments (Azuara-Blanco et al. 2007; Marks et al. 2012) support the view that community based GRM services could reduce the number of false positives and produce financial savings to the NHS (Azuara-Blanco et al. 2007; Devarajan et al. 2011; Parkins and Edgar 2011). These studies, however, cannot be used to generalise to other areas and with wider optometrist participation. These studies typically use experienced optometrists who undergo hospital-based training. For example, Azuara-Blanco et al. (2007) selected the top three scoring optometrists in a theoretical written examination followed by practical training with a consultant ophthalmologist. It is expected that results obtained by the three top scoring optometrists in the area wouldn't be representative of the optometric population if the scheme was rolled out to include more optometrists. Furthermore, as other authors have mentioned, repeat reading schemes have potential to be 'misused' by some optometrists who may potentially take the view that they do not need to do certain tests that may be re-done once they've referred the patient into a scheme (Henson et al. 2003; Devarajan et al. 2011). These arguments point to the conclusion that widespread optometric participation in these schemes could increase costs and alter the balance of cost and clinical effectiveness.

Moreover, there is a lack of evidence examining the false negatives rate of optometrists when managing patients with eye disease. Two studies, however, have reported that when an optometrist discharged a number of patients, who had initially been referred for a suspicion of glaucoma, as normal, up to 15% of these patients were subsequently retained after consultant virtual overview (Bourne et al. 2010; Ratnarajan et al. 2015). At first sight this may appear high, but is likely due to inter-clinician variability rather than suggesting a 15% optometric false negative rate. Banes et al. (2006), reported that when evaluating the care of a patient with glaucoma between two consultant ophthalmologists, agreement ranged from 62% to 99% depending on which

aspect of the examination was being assessed. The agreement between a consultant ophthalmologist and an optometrist was between 54% and 98% and very similar. The lowest levels of agreement were surrounding visual field interpretation, whereas the highest levels of agreement were regarding clinical management and recall interval. Similar studies evaluating optometrists vs. ophthalmologists have reported good agreement. Accordingly, a significant proportion of the 15% disagreement found by Ratnarajan and colleagues (2015) is likely attributable to inter-clinician (inter-ophthalmology as well as ophthalmology versus optometry) variability, and not indicative of high false negative rates for optometrists.

As an alternative to community GRM schemes, some areas have utilised optometrists in a referral refinement scheme after the patient has been referred into secondary care (Ratnarajan et al. 2013c; Keenan et al. 2015). For example, in Nottingham, a scheme exists where hospital-based optometrists who have completed additional accreditation refine a proportion of the suspect glaucoma and ocular hypertension (OHT) referrals. 53.7% of referrals from community optometrists are discharged by the refining hospital-based optometrist in the Nottingham GRM. Although the results of this hospital based scheme are similar to that of community based GRMs, as previously mentioned, the demand on secondary care resources remains as, depending on the funding structure, the cost of a hospital appointment is typically greater than that of community GRM appointments (Ratnarajan et al. 2013c).

In order to facilitate hospital ophthalmology doctors' clinics, some hospital ophthalmology departments have introduced virtual glaucoma clinics (Trikha et al. 2012; Kotecha et al. 2017). These glaucoma screening clinics are delivered by non-ophthalmologists (e.g. optometrists, orthoptists, and technicians) who are trained to perform certain tests. These results are then reviewed at a later date by a consultant ophthalmologist. This consultant then determines the outcome for the patient; the patient can either be discharged or followed up. Specifically, in the scheme reported by Trikha et al. (2012), optometrists referrals were reviewed by a consultant ophthalmologist who subsequently decided whether the patient required referral into the hospital ophthalmology

department. Alternatively, in the scheme described by Kotecha et al. (2017), the consultant virtually reviewed the notes of an appointment within the hospital ophthalmology department that was received in response to the community optometrists referral. While the two schemes have differing methodologies, it has been reported that they are effective and should be considered in areas where community based GRMs are not commissioned (Kotecha et al. 2017).

Regardless of where GRM schemes may be located, categorisation of patients based on risk stratification could be utilised (Bourne et al. 2010; Ratnarajan et al. 2013a; Ratnarajan et al. 2013b; Keenan et al. 2015; Kotecha et al. 2017). Those deemed low-risk are eligible for a GRM appointment, whilst those that are categorised as high-risk are referred directly into the hospital ophthalmology department. As it has been reported that most of the high-risk patients receive a follow up appointment (Bourne et al. 2010; Ratnarajan et al. 2013b), creating an intermediary appointment could slow down those at a higher risk of developing problems that require specialist intervention and could increase costs. On balance, optometry-based GRM appointments have proven to be cost-effective and clinically safe. In areas where community schemes are not commissioned, virtual or hospital based GRM schemes can be used to reduce the number of false positive referrals being seen in doctor's clinics. In turn, this will alter the case-mix of doctors' appointments to be more appropriate to their level of expertise.

As forementioned, In 2017 NICE updated their clinical guidance on glaucoma (National Institute for Health and Care Excellence 2017). Following this updated guidance, the College of Optometrists issued guidance that patients with an IOP of less than 24mmHg do not necessarily require referral into hospital ophthalmology if that is the sole sign of glaucoma (The College of Optometrists 2017). It is expected that this update in guidance will reduce the number of referrals for suspect glaucoma.

1.4.3. Ocular Hypertension/ Glaucoma Monitoring

The outcome of a patient being referred for suspect glaucoma could be either discharged or diagnosed with glaucoma, OHT or another eye disease. OHT can be defined as raised IOP (>21mmHg) in the absence of any pathology suggestive of glaucoma (e.g. optic nerve head damage and visual field loss) (Vass et al. 2007; Burr et al. 2012). It has been reported that patients with OHT are at an increased risk of developing glaucoma, relative to patients with IOP below 21mmHg (Burr et al. 2012). As glaucoma ultimately results in irreversible vision loss, patients with OHT and glaucoma require lifelong monitoring to promptly detect any deviation in clinical status (Vass et al. 2007). Due to the shortage of UK ophthalmologists and the increasing and ageing UK population, the current practice of providing glaucoma and ocular hypertension care in hospital ophthalmology departments may not be sustainable (Bruce and Tatham 2018). Care in the community could provide the extra capacity required to effectively manage the predicted 49% increase in patients with glaucoma that is expected between 2015 and 2035 (Buchan et al. 2019).

In support for the hypothesis of optometrists providing adequate care of patients with OHT and Glaucoma (Health Improvement Scotland 2015; The Scottish Government 2017), it has been reported that optometrists who have undergone additional training can make decisions comparable to that of ophthalmologists in the management of patients with suspected glaucoma and glaucoma (Banes et al. 2006; Azuara-Blanco et al. 2007; Bourne et al. 2010; Ho and Vernon 2011; Marks et al. 2012; Roberts et al. 2015). Specifically, Roberts and colleagues reported that optometrists who receive specialist training in glaucoma management performed to acceptable levels of accuracy (disagreement in 5.6-10.4% of patients), when compared to a consultant with a specialist interest in glaucoma. Moreover, the authors reported that these schemes are cost-effective and ease the burden on hospital ophthalmology departments by allowing patients to be appropriately managed in the community (Roberts et al. 2015). Importantly, however, as with other studies on GRM schemes mentioned in section 1.2.2, these studies typically use optometrists who undergo additional

training or hospital-based optometrists, and may not be representative of the general optometric profession.

A number of hospitals in the UK currently employ optometrists and other non-medical staff in glaucoma services in order to reduce demand on doctor's clinics (Vernon and Adair 2010; Gunn et al. 2018). Vernon and Adair (2010) conducted telephone interviews with all ophthalmology departments in the Royal College of Ophthalmologists training handbook in England. The authors found that 58% of ophthalmology departments were operating shared care schemes in glaucoma or suspect glaucoma while a further 12% were in the developmental phases of a scheme. These schemes are generally operated within the hospital ophthalmology department utilising combinations of optometrists, nurses, orthoptists and GPs with specialist interest. Only 27% (n = 14) of the shared care schemes were community based. Oversight of these schemes is typically in the form of virtual review (Vernon and Adair 2010; Mandalos et al. 2012; Clarke et al. 2017; Gunn et al. 2018). Consultant ophthalmologists in the UK typically approve of virtual clinics and rate them as both clinically safe and efficient (Gunn et al. 2018). Moreover, a study specifically assessing the agreement in decisions of virtual and consultations suggests that virtual clinics are clinically safe (Clarke et al. 2017). These studies, however, often cite lack of staff and space as reasons for not using virtual clinics (Vernon and Adair 2010; Gunn et al. 2018). This points to the conclusion that the larger population of community, relative to hospital, optometrists with the larger space afforded by the increased number of private optometric practices, relative to hospitals, could provide a solution for those hospitals without the resources, or those with that are struggling to manage increasing waiting lists. Whilst it has been reported that patients who attend virtual clinics did not have significantly inferior knowledge or understanding of their condition, there are currently no qualitative studies exploring patients' opinions on virtual clinics, compared to 'normal' clinics. For example, whereas, historically, the patient would have been informed of their outcome at the time of appointment, with virtual clinics there is a delay from having the appointment (tests performed) and receiving an outcome (e.g. letter via post weeks later). The effect of this delay on anxiety experienced by patients is unknown.

There are currently a number of studies that have examined the effects of monitoring of OHT and/or glaucoma patients by community optometrists (Spencer et al. 1995; Gray et al. 1997; Spry et al. 1999; Syam et al. 2010; Vernon and Adair 2010; Mandalos et al. 2012; Roberts et al. 2015; Wright and Diamond 2015). These schemes typically find that glaucoma care in the community is clinically safe (Roberts et al. 2015), but can be improved through virtual consultant review (Wright and Diamond 2015). Wright and Diamond (2015) reported on the glaucoma shared care scheme in Bristol. They found that whilst the number of high-risk cases mis-categorised was low (low-risk: 0.02%, unstable 0.03%), the authors commented that each misdiagnosed high risk case could result in a patient experiencing irreversible loss of vision. As such, they deemed consultant virtual review an important part of the scheme. The rate of false-negative discharges or management of consultant ophthalmologists, however, is not known and as mentioned in section 1.2.2 inter-ophthalmologist variability may account for some of that 0.05%. Similarly, the number of patients experiencing irreversible loss of vision due to delayed follow ups (National Patient Safety Agency 2009), may outweigh the 0.05% of patients optometrists miscategorise. Similarly, this misclassification is unlikely to lead to significant vision loss given the slow progression nature of glaucoma and the short recalls that optometrists tended to put patients on, relative to ophthalmologists. Further work, therefore, is needed to examine this risk/benefits of delayed follow up in hospitals versus potentially small numbers of misclassifications in community. The virtual review, however, also corrects optometrists' tendency to be cautious and recall glaucoma patients back at shorter than clinically necessary intervals. This resulted in a cost saving, relative to no virtual review (Wright and Diamond 2015). The scheme reported by Gray and colleagues over 20 years ago (Spencer et al. 1995; Gray et al. 1997; Spry et al. 1999; Gray et al. 2000), on the other hand, details a pilot scheme and it is not clear as to whether this scheme still exists.

Another issue is whether optometrists are actually interested in increasing their clinical responsibility by working within community glaucoma schemes. Bruce and Tatham (2018) conducted a study investigating whether Scottish

optometrists are interested in community management of glaucoma, and the barriers they feel that they face. The authors found that insufficient remuneration (29%), poor communication with secondary care (18%) and perceived resistance from ophthalmological colleagues (13%) were the three main perceived barriers to stable glaucoma care in the community. In line with concerns about poor remuneration of a glaucoma shared care scheme, it has been reported that care in the community comes with increased costs, relative to care provided in the hospital (Coast et al. 1997; Sharma et al. 2012). Specifically, it has been reported that costs to the business (e.g. rent/ utilities/ staff costs) make monitoring of glaucoma in the community more expensive. Importantly, however, community monitoring could be made more cost-effective by increasing patient numbers (Sharma et al. 2012). This provides support for the hypothesis that appropriate levels of funding and sufficient numbers of patients being discharged to optometrists participating in glaucoma enhanced services is essential to promote adequate community engagement. Whilst these studies have provided estimates of costs to providers of glaucoma monitoring services, they have not evaluated costs to the health system of the UK. A review of ocular hypertension monitoring in community clinics in Cambridgeshire, on the other hand, found that community monitoring of OHT was cost-effective and provided cost savings to the NHS. In this scheme, optometrists with specialist interest in glaucoma were recruited and the results of consultations were reviewed by the hospital based glaucoma team (Mandalos et al. 2012). Further work, however, is needed to understand the cost implications to the NHS. It is important to mention that community based enhanced schemes are unlikely to reduce the total costs of the health service due to oversubscribed hospital ophthalmology departments and waiting lists. They may, however, offer a cheaper alternative compared to hospital eye departments and create service efficiency by releasing capacity. Due to the paucity of evidence from currently commissioned enhanced glaucoma schemes any new scheme commissioned to deliver this service would require careful auditing to ensure patient safety and cost effectiveness.

1.4.4. Pre-operative assessment/ direct cataract referral

Cataract is the leading cause of blindness in the world (Bourne et al. 2013) and cataract extraction is the most common operation performed in the UK (Chan et al. 2010; Day et al. 2015). As such, it represents an area that occupies a large number of hospital eye service outpatient appointments. Until the development of community services for direct cataract referral, patients experienced a long process with multiple visits to various health care professionals before they would have their cataract removed and good vision typically restored. This process typically involved an initial presentation to their GP, who sent them to their optometrist, who then referred them back to their GP. The GP subsequently performed a general health examination and referred the patient into the hospital ophthalmology department. Once in the hospital eye department, the patient would receive an appointment to confirm the diagnosis and discuss the pros and cons of cataract surgery. Following this, they would attend a pre-operative assessment and then they would receive the surgical intervention. Following the surgery, the patient would receive a 24 hour post-operative assessment and a final hospital based post-operative assessment, 4-6 weeks after the surgery where the patient could be listed for the second eye. Alternatively, the patient would finally be discharged and attend an optometrist's appointment for the patients journey to be completed (Department of Health 2004; Newsom et al. 2005; Holmes et al. 2013). As such, 41.7% of patients being referred for cataract extraction had to wait more than 3 months, and 38% experienced a wait greater than 4 months (Siciliani and Hurst 2005).

As optometrists are responsible for the majority of cataract referrals into the hospital eye service (Davey et al. 2011), it is expected that optometric refinement of referrals could reduce the number of unnecessary presentations of cataracts to ophthalmology departments (i.e. those referred for potential surgery who do not require/ want it). A number of studies have examined the effects of optometrist pre-operative assessments (Gaskell et al. 2001; Sharp et al. 2003; Lash et al. 2006; Park et al. 2009; Holmes et al. 2013; Amin et al. 2014; Fung et al. 2016). These studies typically find that the introduction of a direct cataract referral pathway, with specific instructions to counsel the patient

on risks of surgery and examine the effect the cataract has on the patient's lifestyle, significantly increases the proportion of people who are referred for cataract extraction, to receive it (Sharp et al. 2003; Newsom et al. 2005; Lash et al. 2006; Park et al. 2009; Holmes et al. 2013; Fung et al. 2016). Not only does this save patients the stress of being inappropriately referred, but this also reduces waiting lists enabling patients who would benefit from surgery, to receive it more timely (Holmes et al. 2013). Approximately 90% of patients referred directly receive cataract surgery (Gaskell et al. 2001; Sharp et al. 2003; Newsom et al. 2005; Holmes et al. 2013; Bowes et al. 2018). This figure typically represents a 10-20% increase, relative to the traditional route (Sharp et al. 2003; Lash et al. 2006; Park et al. 2009; Holmes et al. 2013). As this assessment is beyond the scope of a GOS sight test, additional funding is required to remunerate the participating optometrist for the additional work (Department of Health 2004). As with other enhanced eye care services in the UK, lack of funding is often cited as the reason for schemes collapsing (Amin et al. 2014).

1.4.5. Post-operative Cataract Assessment

Cataract surgery is typically successful with a low rate of complications both intraoperatively and postoperatively (Chan et al. 2010; Day et al. 2015). Post-operative assessment, however, is required (Chan et al. 2010). Typically, refractive outcome and an ocular health check is required to assess the success of the surgery and to examine for any post-operative complications such as cystoid macular oedema, posterior capsular opacification, inflammation or other pathology (Chan et al. 2010; Bowes et al. 2018). To assist with the reduction of hospital visits required in the cataract pathway, this follow up could be performed by optometrists in the community (Newsom et al. 2013; The Royal College of Ophthalmologists 2021). In line with other enhanced optometric services in the UK, accreditation may be required depending on the scheme, but it is usually acquired through attendance at training days at a local hospital ophthalmology department or distance learning lectures. Two older studies in the United States have examined optometrist performed, post-operative assessments and reported that optometrists may miss some conditions and

incorrectly refer patients back to hospital ophthalmology departments (Revicki et al. 1993; Bass et al. 1996). In line with this, until recently, the position of the American Academy of Ophthalmology was that optometrists should not be used in co-management of patients with cataracts (Kim and Kim 2011; American Society of Cataract and Refractive Surgery 2015). In contrast, in the UK, ophthalmologists reported that specially trained optometrists involved in post-operative care provided a standard of care similar to that in the hospital, with no clinically significant abnormalities missed (Booth et al. 1998; Muthucumarana and Rimmer 2000). Although a limited number of studies have specifically examined community based post-operative schemes, it has been reported that care in the community can reduce the number of hospital appointments a patient requires, and provide the patient the benefits of receiving care closer to home (Newsom et al. 2013; Voyatzis et al. 2014; Bowes et al. 2018).

On balance, streamlining the cataract referral pathway with the utilisation of community optometrist appears to be of benefit to both patients and hospital ophthalmology departments alike.

1.4.6. Children's eye care

There is a paucity of published literature on optometric management of children's eye care in the UK. Currently, Public Health England recommends that the local authority commission school screening of all children aged between four and five years of age. The purpose of this is to detect conditions such as amblyopia and strabismus early so that they can be subsequently treated. These screening programmes may also determine whether the child might have uncorrected refractive error (Public Health England 2019). Orthoptists are typically responsible for vision screening, with optometrists occasionally involved (The Royal College of Ophthalmologists 2019). Studies have demonstrated that orthoptic led screening can capture large numbers of patients, with a low rate of false positives for refractive error (Masqud and Medforth 2015; Garretty 2017). Worryingly, although the majority of children may attend for screening (Bruce and Outhwaite 2012; Masqud and Medforth 2015), up to half of patients are failing to attend an appointment when they have

been subsequently referred (Bruce and Outhwaite 2012). Furthermore for detection of ocular abnormalities not related to refractive error, false positives have been reported to be 69% (53 out of 77 referrals) (Taylor and Whibley 2012) and the rate of false negatives is unknown. As such, more work is needed to understand patients' attitudes towards follow up appointments. The commissioning of school vision screening, although recommended, is not compulsory. Accordingly, 45% of the UK does not have a school screening programme (Association of Optometrists 2018a). The NHS, therefore, recommends that patients who live in areas that don't have a screening programme, should attend an optometrist for a sight test at age four or five (NHS 2019a).

The Local Optical Committee Support Unit (LOCSU) currently has a pathway developed for children's eye health (LOCSU n.d.), but it is unknown which areas have these services commissioned or the involvement of the primary care optometrist. Anecdotal evidence from optometrists, however, suggests that a pathway for commissioning children's vision pathways would be helpful in providing appropriate examination for those presenting at the request of hospital ophthalmology departments for refractions requiring cycloplegia. These examinations currently are not able to be performed under the terms of the GOS in England as forementioned (section 1.1.4). Accordingly, any child requiring cycloplegia not eligible for a NHS sight test could be unnecessarily referred to the hospital for further examination.

1.4.7. Diabetic Retinal Screening

Diabetes is a general health condition affecting approximately 8.8% of adults worldwide in 2015. By 2040, this number is expected to increase to 10% (Ogurtsova et al. 2017). The prevalence of diabetes in the UK is lower than the global average (6.2%), but is also increasing (Holman et al. 2015; NHS Digital 2018b). The most common complication of diabetes is diabetic retinopathy (Sivaprasad et al. 2012), which is one of the leading causes of blindness in the developed world (Quartilho et al. 2016; Flaxman et al. 2017). As such, prevention of the development of diabetic retinopathy and improving detection

rates to facilitate earlier treatment could potentially reduce the number of people becoming visually impaired by the disease (Stefánsson et al. 2000; Nentwich and Ulbig 2015). As with other conditions, the prevalence of both the disease and its ocular complications (e.g. diabetic retinopathy) increase with age (Sivaprasad et al. 2012; Ogurtsova et al. 2017). Specifically, the risk of a patient having diabetic retinopathy is correlated with the duration of the disease (Klein et al. 1984b; Yau et al. 2012). It is reported that 76.3% of patients who have had a diagnosis of diabetes for more than 20 years have diabetic retinopathy. As such, this represents a large population of people that require regular and careful monitoring (Yau et al. 2012). Accordingly, it appears that this population satisfies criteria to develop and utilise a screening programme (Stefánsson et al. 2000; Mead et al. 2001).

Diabetic retinal screening (DRS) programmes have been utilized over the previous four decades to appropriately detect potentially sight-threatening diabetic complications prior to patients experiencing visual symptoms. These schemes typically employ a technician to capture retinal photographs that are then graded by an experienced technician or ophthalmologist (Stefánsson et al. 2000; Olson et al. 2003; Usher et al. 2004; Arun et al. 2009; Thomas et al. 2015; Fenner et al. 2018). For screening programmes to be effective, they are required to have high sensitivities and specificities with low rates of image obtainment failure (Ku et al. 2013). In line with this, it has been reported digital retinal photography grading ensures clinical safety while simultaneously improving ophthalmologists' time efficiencies (Williams et al. 2004; Rein et al. 2011; Gangwani et al. 2016). Moreover, this screening improves access to care for those living in rural locations (Shi et al. 2015) and results in high levels of patient satisfaction (Rani et al. 2006). Without early detection, patients present to hospital ophthalmology departments typically with advanced disease incurring high costs of intervention (Ross et al. 2016) with lower levels of effectiveness, relative to those presenting with less advanced disease.

In line with the rationale for developing these schemes in the UK, the proportion of people becoming sight impaired (partially sighted) and severely sight impaired (blind) due to diabetic retinopathy in relation to all diseases has

reduced over the last 15 years (Quartilho et al. 2016). This reduction, however, could also be partly attributable to increased public awareness and improved treatments (Quartilho et al. 2016). As such, further work is required to assess the specific impact of diabetic retinopathy screening services.

1.4.8. Low Vision Service

Whilst many of the services mentioned thus far are aimed at preventing loss of vision that is permanent without intervention, for those patients who have irrevocably lost their vision, access to low vision services and rehabilitation may be required. It has been reported that individuals who are visually impaired have a higher rate of falls (Ivers et al. 2000; Legood et al. 2002; Lamoreux et al. 2008; Brundle et al. 2015), which may increase the risk of subsequent hip fractures (Felson et al. 1989; Legood et al. 2002) and mortality (Reed-Jones et al. 2013). Furthermore, visual impairment has strong associations with depression (Tsai et al. 2003; Evans et al. 2007; Giloyan et al. 2015; Ribeiro et al. 2015; Schuster et al. 2018), that may (Ip et al. 2000) or may not (Noran et al. 2009) be independent of the duration of visual impairment. This depression has been reported to leave patients with feelings of worthlessness (Tsai et al. 2003). Additionally, patients with low-vision can experience visual hallucinations which are poorly understood and can have a negative impact on a patient's life (Carpenter et al. 2019) Accordingly, low vision services are required to improve both quality of *life* and quality of *vision* for these patients. These services should provide support with low vision aids, and also with counselling and advice to ease the burden of the negative psychological consequences of being visually impaired (Culham et al. 2002).

Although visual impairment may occur at any age, it is more commonly found in elderly population groups owing to age-related eye disease (Zhao et al. 2019). Due to a combination of the increasingly ageing UK population and the finding that common causes of visual impairment increase with age, the demand on low-vision services is expected to increase significantly in years to come (Taylor et al. 2005; Bentley and Jackson 2014). Historically, low-vision services were provided by optometrists in hospital ophthalmology departments (Culham et al.

2002; Binns et al. 2012). Culham et al. (2002) found that although approximately 64% of community optometrists provided some form of service for patients with visual impairment, the majority (41%) only dispensed low vision aids, without any professional support. The remaining 23% of optometrists provided a low-vision service similar to that provided in the hospital. The authors commented that this represents an underutilisation of these professionals. More recently, in line with the hypothesis that community care is more sustainable, it has been reported that the majority of low-vision services are now provided by optometrists in community practice (Ryan 2014).

An example of low-vision services within the UK is the Low Vision Service Wales. This was commissioned in 2004, in part due to lengthy hospital waiting lists and low numbers of patients accessing the service who required it (Margrain et al. 2005; Ryan et al. 2010). Specifically, the Low vision service Wales aims to increase independence by offering support with low-vision aids (Margrain et al. 2005). The optometrists work as part of a multidisciplinary team that includes social services who can provide additional support beyond the scope of an optometrist capability (e.g. social care) (John and Ryan 2017). The Low vision service Wales was found to increase patient numbers while concurrently reducing waiting times and significantly improving patients quality of vision. Moreover, almost all users of this service found it to be helpful (Ryan et al. 2010). Ryan et al. (2013) further reported that the benefits of the service appeared to remain over the period of 18 months post intervention. Whilst the patient satisfaction and clinical outcomes are positive, the large increase in patient numbers accessing the service (unmet demand) would be expected to significantly increase costs. No cost-effectiveness analysis has been conducted on the Low vision service Wales to present. Importantly, meeting unmet demand is not a negative as improving access to care is likely to increase demand which would improve population health.

Although there are strong links between visual impairment and depression, it has been reported that the majority of low-vision services do not routinely screen for depression (Nollett et al. 2016). Furthermore, it has been reported that improving patients' visual function, through low vision services, does not

necessarily significantly reduce symptoms of depression (Stelmack et al. 2008). Other studies, on the other hand, report that low vision services including aspects of self-management and specific counselling have a significant effect on the reduction of symptoms of depression (Horowitz et al. 2000; Brody et al. 2005; Girdler et al. 2010). It is important to note that although an optometrist may help improve patients with visual impairment's quality of *vision*, further help is required to improve their quality of *life* (Jones et al. 2019). Greater support is required signposting to local support groups, voluntary organisations and psychological counselling and/or therapy as part of a multi-disciplinary approach to holistically improve life for these patients (Ryan 2014).

One way of trying to improve these patients' quality of life is to see an eye clinic liaison officer at a time convenient for the patient. ECLOs, situated in hospital ophthalmology departments, provide dedicated support to patients without the time pressures of a medical clinician. It is expected, therefore, that these staff members could be of benefit to patients suffering with low vision (Norwell and Hiles 2005). Although ECLOs are perceived to be of benefit by ophthalmology department staff for easing workloads of already overburdened staff (Llewellyn et al. 2019), the benefits to patients have yet to be reported (Conway et al. 2012). If benefits to patients are found, it may be useful to have eye clinic liaison officer in a mobile role linked with primary care, to be able to provide care to those most disadvantaged by loss of vision.

On balance, low vision services provided by multi-disciplinary teams in the community appear to improve both the quality of life and quality of vision in patients who are visually impaired. Further work on examining the cost-effectiveness, however, is required before widespread adoption of community services is to be adopted (Binns et al. 2012; Ryan 2014).

Chapter 2

2. Socio-economic effects on the outcome of NHS funded sight tests in Essex, UK.

2.1. Introduction

As detailed in chapter 1, primary eye care in the UK is typically carried out by optometrists. This is generally in the form of a 'sight test' defined by the Opticians Act (1989), which results in a prescription for refractive correction being issued (if required) and an ocular health check being provided. This is performed either at a cost to the patient (i.e. private), or under the terms of the General Ophthalmic Services (GOS) contract (Association of Optometrists 2018c; Association of Optometrists 2019a). GOS in England enables anyone under the age of 16 years or 60 years and older to have a National Health Service (NHS) funded sight test at no cost to the patient, usually every two years (Figure 2.1a) (NHS Inform 2018; NHS 2019b). Sight tests performed earlier than the recommended interval are permitted if the patient presents with symptoms or other reasons requiring investigation (Figure 2.1b and Figure 2.1c).

a)

GOS Sight Test (Primary Eye Examination) Minimum Intervals

Age	Clinical Condition	Interval
Under 16	All patients	1 year
16 – 59	All patients	2 years
60 – 69	All patients	1 year 2 years
70 & over	All patients	1 year
Any age	Diabetes	1 year
Any age	Glaucoma	1 year 2 years
40 & over	Glaucoma family history (not in monitoring scheme)	1 year 1 year
Any age 40 & over	Ocular hypertension (not in monitoring scheme)	1 year
Under 7	BV anomaly / corrected refractive error	6 months
7 – under 16	BV anomaly or rapidly progressing myopia	6 months

b)

England, Wales

Early Re-test Reason Codes

1.	Patient is at risk of frequent changes of prescription for reasons not requiring medical referral or for reasons already known to a medical practitioner.
2.	Patient has pathology likely to worsen, for example age-related macular degeneration, cataract, corneal dystrophy or congenital anomalies.
3.	Patient has presented with symptoms or concerns requiring ophthalmic investigation: 3.1 resulting in referral to a medical practitioner; or 3.2 resulting in issue of a changed prescription; or 3.3 resulting in either no change or no referral (the patient's record should indicate any symptoms shown to support this category of claim if necessary).
4.	4.1 Patient needing complex lenses; or 4.2 with corrected vision of less than 6/60 in one eye.
5.	Patient has: 5.1 presented for a sight test at the request of a medical practitioner; or 5.2 is being managed by an optometrist under the GOC referral rules, for example suspect visual fields on one occasion which is not confirmed on repeat, or abnormal IOP with no other significant signs of glaucoma; or 5.3 identified in protocols as needing to be seen more frequently because of risk factors.
6.	Other unusual circumstances requiring clinical investigation.

c)

Scotland

Supplementary Codes

2.0	Cycloplegic refraction following primary examination
2.1	Paediatric follow-up
2.2	Referral refinement/repeat or follow-up procedures
2.3	Suspect glaucoma
2.4	<60 dilation and biomicroscopy
2.5	Anterior segment disorder
2.6	Cycloplegic refraction at request of hospital
2.7	Postoperative cataract examination
2.8	Reduced acuity, sudden vision loss, flashes and floaters or neurological symptoms – requires sight test, macular assessment and slit lamp biomicroscopy (possible mydriasis)

Primary Examination Codes

7	Patient new to practice (no access to patient's record)
8	Patient aged 16 (who should have attended at age 15 but did not attend until age 16)

Figure 2.1. Sight test frequency and reasons allowed for presenting early. GOS sight tests (England and Wales, Green font) and Eye Examinations (Scotland, Purple font) or both (Black font) can be performed at various intervals depending on the age of the patient, and eye health. For example, a patient

who is ocular hypertensive, can receive a free of charge GOS sight test in England or Wales, providing they are over 40 and not attending regular monitoring appointments, typically once a year. In contrast, in Scotland a patient with ocular hypertension could receive a free of charge eye examination independent of age and whether they are on some form of monitoring scheme at that same interval (once a year). Figure 2.1b. In England and Wales, patients who present earlier than the recommended interval (figure 2.1a), can be seen at no cost to the patient, providing they fall into one of the six categories listed. Figure 2.1c. Patients in Scotland can present earlier than the recommended interval (figure 3.1a) providing that they fall into one of the 11 recall codes listed (Adapted from Optical Confederation 2014b).

The sight test includes a refraction and basic ocular health check to determine whether or not the patient is required to be referred to an ophthalmologist or general practitioner. Accordingly, the outcome of a NHS sight test can be the issuing of: a new (or changed prescription), an unchanged prescription, a statement that no prescription is required or a referral to another health care professional. A patient is free to change between optometry practices each visit, however, a practice may send a patient a reminder letter when they are due a routine sight test.

A GOS sight test in England is currently (April 2021) remunerated at £21.71 (Association of Optometrists 2021). This figure represents approximately half the cost of delivering a sight test (Bosanquet 2006; Optical Confederation 2013; Shickle et al. 2015b), but is in line with the typical fee charged for a private eye examination (Optical Confederation 2013). This loss leading of sight tests requires that spectacles have to be sold for an optical business to break even or make profit (Cross et al. 2007; Shickle et al. 2015a; Shickle et al. 2015b). This has undesirable consequences. Specifically, the anticipated cost of subsequent spectacle purchases deters patients from obtaining sight tests, even in cases where the sight test itself is free (Patel et al. 2006; Cross et al. 2007; Awobem et al. 2009; McLaughlan and Edwards 2010; Hayden 2012; Leamon et al. 2014; Shickle and Griffin 2014). The cost of a sight test and spectacles, however, are just two of many reasons why adults in the UK may not regularly attend for sight tests (Shickle and Griffin 2014; Shickle et al. 2014). For example, Shickle and Griffin (2014) reported that, in addition to cost of subsequent spectacle purchases, distance to opticians, mistrust of optometrist, hard selling, perceived

lack of need when having no problems and looking frail if misunderstanding questions of the sight test were all reasons reported by focus groups of people living in socio-economically deprived areas of Leeds, UK. Shickle and colleagues have also examined access to sight tests in Essex (Shickle et al. 2017) and Leeds (Shickle and Farragher 2014), UK and found that lower socio-economic status (SES) was associated with a reduced uptake of GOS sight tests in patients aged under 16 and over 60 years old. As expected, due to the means-tested eligibility of the 16-59 year old age group, it was reported that lower SES was associated with an increase in uptake of GOS sight tests for that age group.

In addition to receiving a free of charge sight test, everyone younger than 16 years of age is entitled to a voucher that subsidises the costs of spectacles. For those aged over 60 only those patients in receipt of means tested benefits are eligible to receive an NHS voucher (GOS3 voucher). This voucher is issued by the performer of the sight test if there is a change in spectacle prescription or if the patient's spectacles are broken beyond reasonable repair. If these requirements are not met the voucher is not issued and a spectacle purchase would not be subsidised. The monetary value of the voucher is dependent on both the patient's prescription (higher prescriptions = higher value) and type (varifocal/bifocal > single vision, table 2.1).

Table 2.1. Breakdown of NHS GOS3 vouchers by prescription. The letter corresponds to the voucher name. The figure is the fee, in Great British Pounds (year 2021) that the optometric practice receives for supplying a pair of spectacles that are either single vision (lower value) or multifocal (higher value) spectacles.

Cylinder / Sphere	< 2.00	2.25 - 6.00	> 6.00
< 6.00	A (39.10) E (67.50)	B (59.30) F (85.60)	D (196.00) H (215.50)
6.25 – 9.75	B (59.30) F (85.60)	B (59.30) F (85.60)	D (196.00) H (215.50)
10.00 – 14.00	C (86.90) G (111.20)	C (86.90) G (111.20)	D (196.00) H (215.50)
> 14.00	D (196.00) H (215.50)	D (196.00) H (215.50)	D (196.00) H (215.50)

The outcomes that are recorded on the sight test form used to claim payment from the NHS are: Patient referred to GP or ophthalmic hospital, a statement is issued that no prescription is required, an unchanged prescription is issued, or, a new prescription is issued. There is also a separate box that details whether the patient has been issued with an NHS voucher. These outcomes have not previously been published in detail, nor has the potential for any relationship with patient demographics been investigated. It is possible that similar commonalities as seen between SES and NHS sight test uptake may exist between SES and NHS sight test outcomes. Factors that deter patients from having sight tests that are more common in those potentially requiring spectacles (e.g. fear of subsequent cost), (Shickle and Griffin 2014) would be more likely to disproportionately affect the refractive outcome of patients of lower, relative to higher, SES. For example, if these patients are having sight tests less often they may be more likely to need spectacles when they do attend. Similarly, factors independent of spectacle wear (e.g. distance to optometry practice, lack of awareness of health check aspect), (Shickle and Griffin 2014) could result in a differing referral rate among patients from lower, relative to higher, SES

The present study extracted data from all GOS sight tests performed in Essex from April 2015 to September 2016. During this time, Essex was one of the few places within the UK to routinely capture these data electronically (Shickle et al. 2017) and it represented an area where it was possible to analyse large samples. The aim of the present study was to assess the impact of SES on GOS sight test outcome and uptake.

2.2. Method

Data from 821,624 GOS sight tests performed in Essex (from April 2015 to September 2016) were obtained from Evolutio Care Innovations Ltd, who was the provider that managed the GOS claims and were employed by NHS England to process GOS sight test payments in Essex during the time period (via a data sharing agreement with NHS England and Evolutio Care Innovations). Data were entered onto GOS forms by optometrists, who then submitted to Evolutio Care Innovations Ltd for claiming payment. The forms were scanned using optical character recognition and these data were analysed by the research team. The content of this GOS form can be found at: https://pcse.england.nhs.uk/media/1272/gos1-form_original.pdf (Primary Care Support England 2008).

Data were anonymised (patient names removed and date of births changed to age in years) prior to the research team accessing these data. The data were transferred on a password protected memory stick. 157,144 entries were removed from analysis due to incomplete / missing data or patients living outside of the study area. In total, 664,480 results remained. Due to the difference in eligibility criteria for different age ranges, only the age groups where NHS sight test eligibility is independent of SES (<16 years and ≥60 years) were included in the present study. Accordingly, a further 136,212 records were removed for patients aged 16-59 years. Although there are 11 reasons to justify an early sight test, only three give detail regarding outcome. These are coded as 3.1 (resulting in referral, n = 11,833), 3.2 (resulting in a new prescription, n = 73,239) and 3.3 (resulting in either no change or no referral, n

= 18,042). The 64,138 sight tests that were performed earlier than the previous optometrist recommended that do not contain information about outcome were therefore removed from analysis. Accordingly, the final sample size was 464,130 (361,016 routine and 103,114 early sight tests) Analyses were performed using SPSS (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp).

Lower-Layer Super Output Areas (LSOAs) are small areas of the UK controlled for population size. LSOAs in England have an average population size of 1500 (Ministry of Housing Communities and Local Government 2018) and are created using clusters of adjacent postcode boundaries. The Index of Multiple Deprivation (IMD) is the ranking of LSOAs in order from most to least deprived, nationally based upon weights of various deprivation measurements. In total, this is based on 39 measurements in seven domains: Income, employment, health deprivation and disability, education skills and training, crime, barriers to housing and services, living environment (Ministry of Housing Communities and Local Government 2019). In line with previous research, the present study examined LSOAs in quintiles (Shickle et al. 2017). LSOAs in quintile one are in the top 20% of socio-economically deprived LSOAs in the UK (i.e. most deprived) (Ministry of Housing Communities and Local Government 2015). The data set used in the present study contained patients' postcodes that were subsequently converted to LSOAs with their corresponding IMD rankings using GeoConvert (http://geoconvert.mimas.ac.uk/).

Ethical approval had been granted by the Chair of the Biomedical, Natural, Physical and Health Sciences Research Ethics Panel at the University of Bradford on 07/05/19. Reference number EC25621.

2.3. Results

2.3.1. Socio-economic status

There are 1,498 LSOA's in the county of Essex (Ministry of Housing Communities and Local Government 2018). The number of LSOAs in each IMD quintile is displayed in table 2.2

Table 2.2. Number of LSOA of each IMD quintile in Essex.

IMD Quintile	1	2	3	4	5
LSOA (n)	207	358	328	328	277

A binomial logistic regression was performed to examine the relationship between attendance at routine NHS sight test (attend and not attend), SES (IMD: 1 to 5) and age group (<16 and ≥60) ($\chi^2(2) = 35346.36$, $p < .001$, $R^2 = .044$). Both SES (Exp (β) = 1.192, $p < .001$), and age (Exp (β) = 1.766, $p < .001$) had a significant effect on attendance at routine NHS sight test (Table 2.3).

Table 2.3. The results from the binomial logistic regression examining routine NHS sight test attendance with respect to age group and IMD.

	Variable	β (S.E)	Exp (β)	95% C.I for Exp (β) (lower – upper)
Attend		$\chi^2(2) = 35346.36$, $p < .001$, $R^2 = .044$		
	IMD	0.176 (0.002)	1.192 ($p < .001$)	1.188 – 1.196
	Age	0.569 (0.004)	1.766 ($p < .001$)	1.751 – 1.780

β: Coefficient for the constant, S.E: standard error, Exp (β): odds ratio, CI: Confidence Intervals; IMD: Index of Multiple Deprivation.

Specifically, for every one-unit increase in IMD (from most to least deprived), the likelihood of attending a routine NHS funded sight test increased 19.2%. Similarly, patients aged 60 years or older were 76.6% more likely to attend, relative to patients aged younger 16 years.

Data from the present study spanned an 18-month period. Attendance rates per LSOA were converted to 12 months by multiplying by 2/3 and total attendance per IMD quintile is shown in figure 2.2.

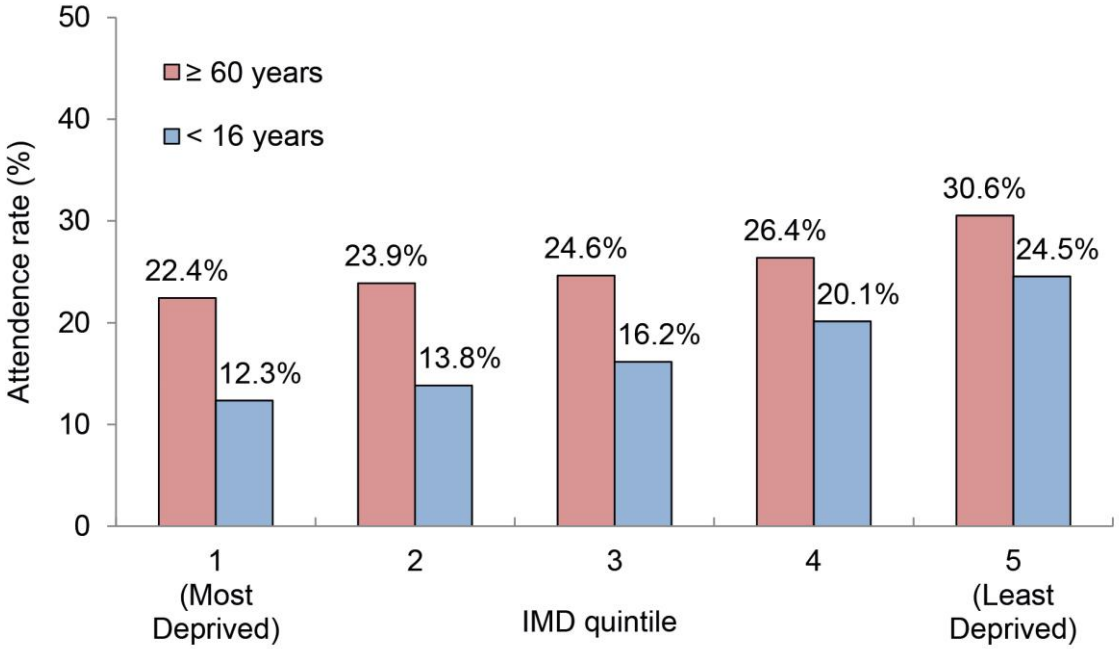

Figure 2.2. Percentage uptake of NHS funded sight tests per year in each socio-economic status quintile based on IMD (Index of Multiple Deprivation). Red bars represent patients aged ≥60 years old, whereas the blue bars represent patients aged <16 years of age.

Specifically, in a 12 -month period, only 12.3% of the population of Essex living in the most deprived IMD quintile attended for a routine NHS funded sight test. In contrast, in the least deprived quintile, approximately double (24.5%) the population of the same age attended for a routine sight test. For those aged over 60 years, the affect is less pronounced: 22.4% of those living in the most deprived IMD quintile attended routine sight testing, relative to 30.6% of the population living in the least deprived quintile.

2.3.2. Routine GOS eye test outcome

There were 361,016 routine GOS sight tests performed in the sample period. Separate binomial logistic regression analyses were performed to determine the relationship between IMD and GOS outcome. For the under 16 years old age group, IMD had a statistically significant effect on predicting whether there was

a new prescription issued, no prescription issued or whether the patient was referred. Specifically, as IMD increased from most, to least deprived, patients were less likely to be referred (Exp (β) = 0.915, $p < .001$) or receive a new/changed prescription (Exp (β) = 0.893, $p < .001$), but more likely to receive no prescription (Exp (β) = 1.126, $p < .001$). In contrast, IMD could not make significant predictions about unchanged prescriptions (table 2.4).

Table 2.4. The effect of IMD on GOS sight test outcome for patients aged under 16 years.

	Variable	*b* (S.E)	Exp (β)	95% C.I for Exp (β) (lower – upper)
New prescription		$\chi^2(1) = 990.72$, $p < .001$, $R^2 = .010$		
	IMD	-0.132 (.004)	0.877 ($p < .001$)	0.869 – 0.884
No prescription		$\chi^2(1) = 1103.48$, $p < .001$, $R^2 = .011$		
	IMD	0.136 (.004)	1.145 ($p < .001$)	1.136 - 1.155
Referral		$\chi^2(1) = 38.06$, $p < .001$, $R^2 = .002$		
	IMD	-0.098 (.016)	0.906 ($p < .001$)	0.878 – 0.935
Unchanged Prescription		$\chi^2(1) = 1.33$, $p = .249$, $R^2 < .0001$		
	IMD	-0.010 (.009)	0.990 ($p = .248$)	0.973 – 1.007

β: Coefficient for the constant, S.E: standard error, Exp (β): odds ratio, CI: Confidence Intervals; IMD: Index of Multiple Deprivation.

For the 60 years and older patients, IMD had a statistically significant effect on predicting whether there was a new prescription issued or an unchanged prescription issued. Specifically, as IMD quintile increased from most, to least, deprived patients were less likely to receive a new prescription (Exp (β) = 0.986, $p < .001$) and more likely to receive an unchanged prescription (Exp (β) = 1.016, $p < .001$). In contrast, IMD could not make significant predictions about when no prescriptions were issued or whether the patient was referred (table 2.5).

Table 2.5. The effect of IMD on GOS sight test outcome for patients aged 60 years and above.

	Variable	*b* (S.E)	Exp (β)	95% C.I for Exp (β) (lower – upper)
New prescription		$\chi^2(1) = 15.53$, $p < .001$, $R^2 < .001$		
	IMD	-0.014 (0.004)	0.986 ($p < .001$)	0.979 - 0.993
No prescription		$\chi^2(1) = 1.15$, $p = .28$, $R^2 < .001$		
	IMD	0.025 (0.023)	1.025 ($p = .284$)	0.980 – 1.072
Referral		$\chi^2(1) = 1.52$, $p = .22$, $R^2 < .001$		
	IMD	0.008 (0.007)	1.009 ($p = .22$)	0.995 – 1.022
Unchanged prescription		$\chi^2(1) = 14.48$, $p < .001$, $R^2 < .001$		
	IMD	0.015 (0.004)	1.016 ($p < .001$)	1.008 – 1.024

β: Coefficient for the constant, S.E: standard error, Exp (β): odds ratio, CI: Confidence Intervals; IMD: Index of Multiple Deprivation.

2.3.3. Outcome of sight tests performed earlier than the routine interval recommended at the previous sight test.

There were 103,114 GOS sight tests performed earlier than the recommended interval in the study period. Differences between age groups can be readily identified (figure 2.3). A factorial ANOVA was conducted to compare the main effects of age and outcome of an early sight test and the interaction effect between age and outcome of early sight test on the uptake of NHS funded sight tests.

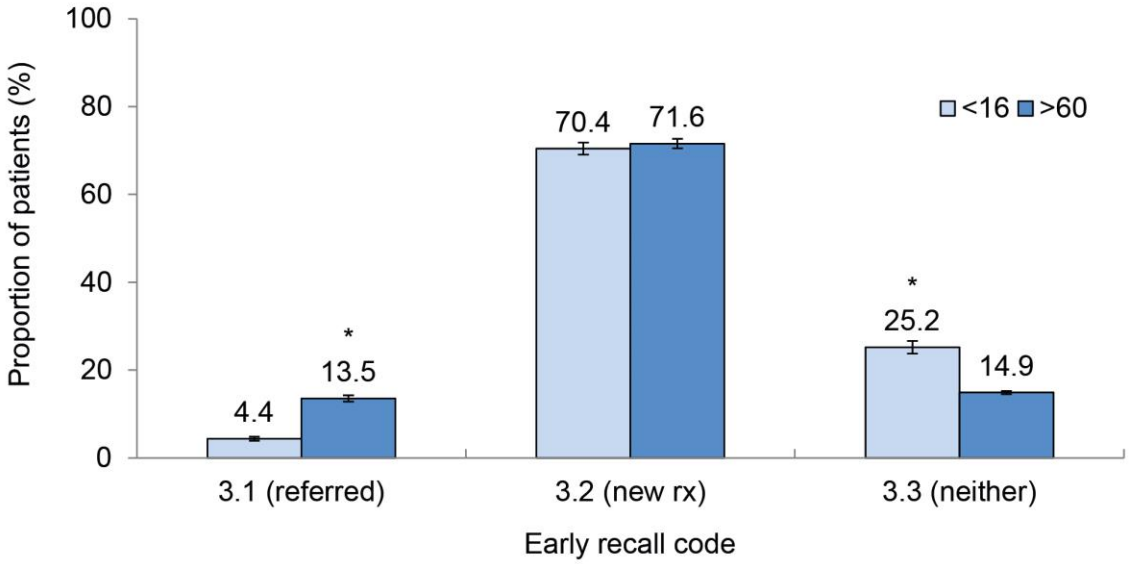

Figure 2.3: The effect of age group on early recall code. Asterisk denotes significant ($p < .05$) increase relative to the other two age groups within each early recall code. I represents 95% confidence intervals.

There was a significant main effect of outcome of early sight test ($F_{(2, 24)} = 8488.66$, $p < .001$, $\eta_p^2 = .99$), and an interaction between age and outcome of early sight test ($F_{(2, 24)} = 185.97$, $p < .001$, $\eta_p^2 = .94$). There was, however, no significant main effect of age ($F_{(1, 24)} < .0005$, $p > .99$, $\eta_p^2 < .001$). Pairwise comparisons, with Bonferroni correction, revealed that patients aged ≥60 years were significantly more likely to present early and require subsequent referral (Early Recall Code 3.1, $p < .001$) and patients aged <16 years were significantly more likely to present early resulting in neither a new prescription nor a referral (Early recall code 3.2, $p < .001$), relative to the other age group. There was, however, no significant difference between mean uptake ratios for patients presenting early for a sight test resulting in a new spectacle prescription being issued (Early recall code 3.3, $p = .12$).

It was also found that IMD has statistically significant associations ($p < .05$) with the outcome of sight tests performed earlier than the recommended interval. However, the differences between the mean and the most/least deprived quintiles are all 3% or less and therefore are unlikely to be clinically significant. Specifically, for patients aged under 16, a chi-square test revealed that IMD had a statistically significant association with early recall code ($\chi^2(8) = 38.46$, p

< .001. Cramer's V = .028). Specifically, relative to the baseline average, those in the least deprived quintile were significantly less likely to present with symptoms requiring a subsequent referral (p = .003, figure 3.3a) and are more likely to present resulting in no change in prescription or referral (p = .033, figure 3.3c). Patients from the most deprived IMD quintile are significantly more likely to present for a sight test and require a new prescription (p = .026 figure 3.3b). In line with this, those patients in quintiles one (p = .049) and two (p = .009) (figure 3.3c) (most deprived) were significantly less likely to present early for an eye test that results in no change to prescription or referral. There were significant associations between IMD and each of the three early recall codes.

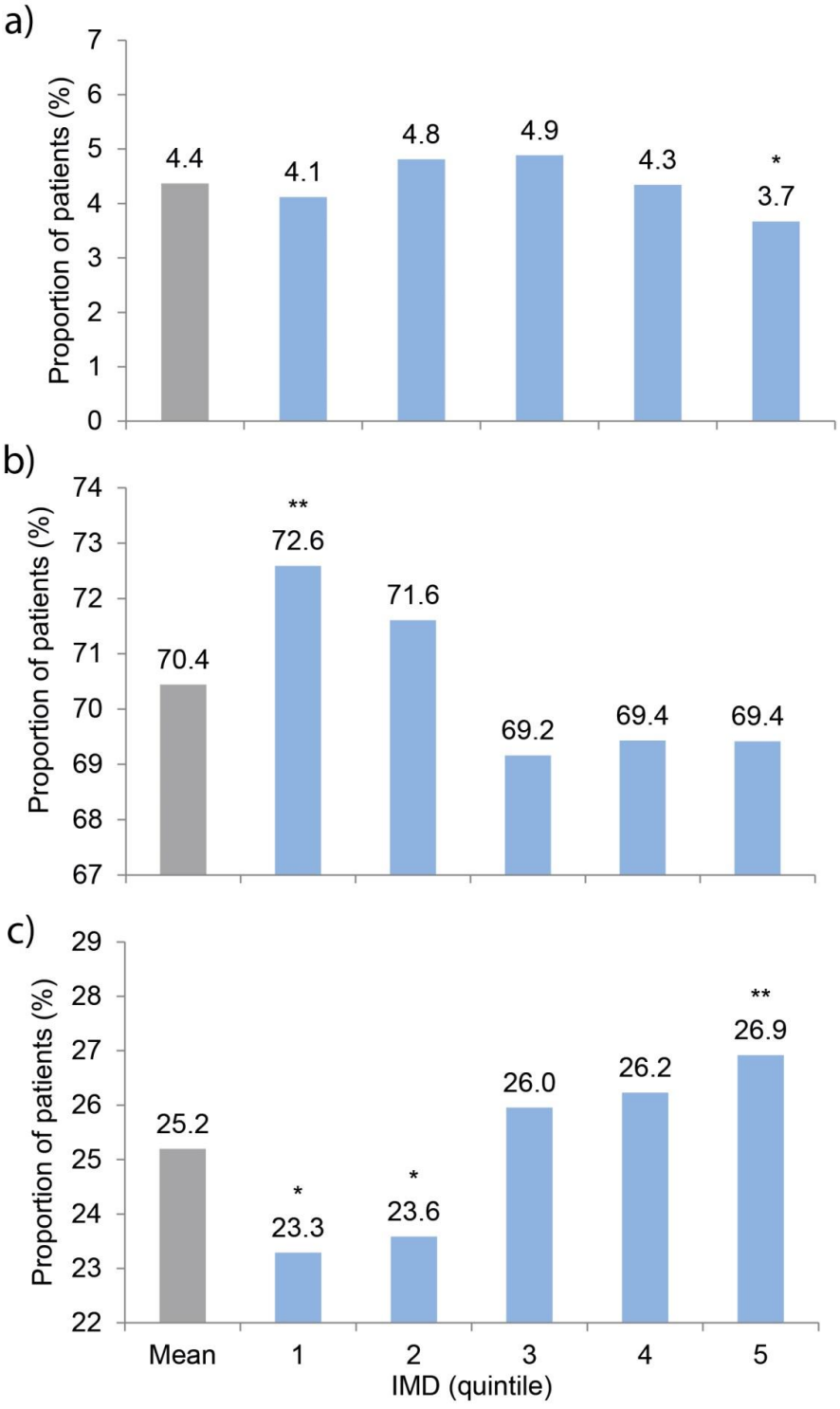

Figure 2.4. The proportion of patients aged under 16 presenting earlier than the recommended interval for a GOS sight test was significantly associated with IMD quintile in which the patient lived. Figure 2.4a. Early recall code 3.1: Patient presented early with symptoms that resulted in a referral. Figure 2.4b. Early recall code 3.2: Patient presented early with symptoms that resulted in a new or changed prescription. Figure 2.4c. Early recall code 3.3: Patient presented early with symptoms that resulted in neither a new prescription, nor a referral. The single asterisk denotes a significant decrease ($p < .05$), relative to the baseline

average (mean, grey bar). The double asterisk denotes a significant increase ($p < .05$), relative to the mean.

In summary, there was a tendency for children living in the more deprived areas to be more likely to present early when requiring a new spectacle prescription. In contrast, patients from less deprived areas were more likely to present early for an examination which resulted in neither a change in spectacle prescription, nor a referral.

For patients aged ≥60 years, IMD had a statistically significant association with early recall code (χ^2 (8) = 37.45, $p < .001$. Cramer's V = .015). Specifically, relative to the baseline average, those in the most deprived quintile were significantly less likely to present requiring a referral ($p = .001$, figure 3.4a) and significantly more likely to present resulting in a changed prescription ($p < .001$, figure 3.4b). Patients from quintile two were significantly more likely to present early resulting in a change in prescription ($p = .026$ figure 3.4b). Those patients from the least deprived IMD quintile, on the other hand were significantly less likely to present for a sight test and require a change in prescription ($p = .039$ figure 3.4b). There was no significant differences between IMD quintile when examining the patients who presented early and required neither a new prescription, nor a referral (figure 3.4c).

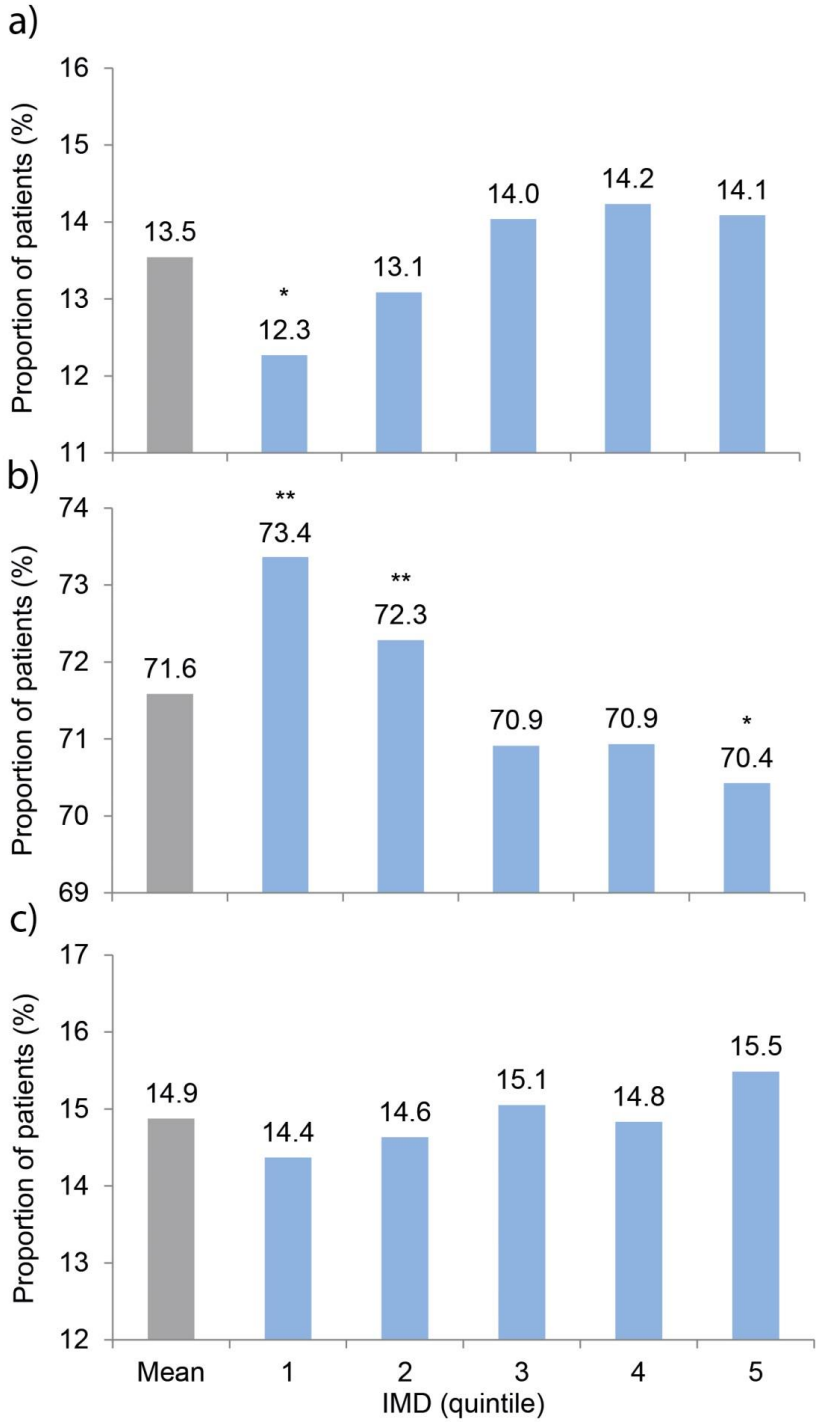

Fig 2.5. The proportions of patients aged over 60 presenting earlier than the recommended interval for a GOS sight test was significantly associated with IMD quintile in which the patient lived. Figure 2.5a. Early recall code 3.1: Patient presented early with symptoms that resulted in a referral. Figure 2.5b. Early recall code 3.2: Patient presented early with symptoms that resulted in a new or changed prescription. Figure 2.5c. Early recall code 3.3: Patient presented early with symptoms that resulted in neither a new prescription, nor a referral. The single asterisk denotes a significant decrease ($p < .05$), relative to the baseline average (mean, grey bar). The double asterisk denotes a significant increase ($p < .05$), relative to the mean.

In summary, patients aged ≥60 years living in the most deprived areas were significantly less likely to present early for a sight test that results in an onwards referral, but were significantly more likely to present early for an examination resulting in a new spectacle prescription, relative to their less deprived counterparts.

2.4. Discussion

The present study found that socio-economic status had a significant (but clinically small) association with the outcome of a GOS sight test (I.e. whether patients had a change in spectacle prescription or were referred). Furthermore, the outcome of tests for patients presenting earlier than the recommended interval for sight tests appeared to be statistically significantly associated with age. GOS sight test uptake was associated with SES (IMD), which concurs with previous research in Essex (Shickle et al. 2017).

2.4.1. Routine GOS sight test outcome

Analysis of GOS sight test outcome revealed that patients living in the least deprived areas of Essex were significantly more likely to require no spectacle prescription (if < 16 years) or an unchanged spectacle prescription (if ≥60 years) relative to their more deprived counterparts. Those living in the least deprived areas were also significantly less likely to receive a new prescription (all ages) and less likely to be referred (<16).

The finding that patients from less deprived areas are more likely to have a sight test (Shickle and Farragher 2014; Shickle et al. 2017) could partially explain why they are less likely to have a changed prescription issued at the end of their sight test; they might be attending for their routinely scheduled test whilst asymptomatic, whereas people who are from more deprived areas might delay having a sight test until they feel that a new spectacle prescription is essential due to fear of the cost (Shickle and Griffin 2014). Those from less deprived areas may also have increased awareness of the preventative health check aspect of a sight test, which is in line with the finding that patients from

more deprived areas, particularly males, can perceive a sight test to be needed only when you're experiencing visual problems (Shickle and Griffin 2014). Further support for the hypothesis that patients from lower SES areas may not be attending sight tests until they are symptomatic can be inferred from differences in prevalence of ametropia among different SES groups. For example, it has been reported that higher socio-economic status is associated with increased astigmatism (Goverdhan et al. 2011) and myopia (Cumberland et al. 2015) whereas, hyperopia is more common amongst patients from lower socio-economic backgrounds (Williams et al. 2008). Potentially, therefore, in contrast to our findings, we would expect that new and unchanged prescriptions would be positively associated with higher SES. Our findings, therefore, that increasing IMD (ffom most, to least deprived) is associated with a significant increase in patients requiring no prescription (<16 years) or a stable prescription (≥60 years) support the view that patients from less deprived areas are presenting asymptomatically for preventative routine sight tests. An alternative explanation might be that practices visited by patients from more deprived areas have smaller profit margins and thus, require more patients to be issued with a new spectacle prescription (i.e. a higher conversion rate) and subsequent NHS subsidised spectacle purchase in order to cover business costs (Shickle et al. 2015b). In summary, the NHS sight test appears to be either: a) resulting in patients from deprived areas to delay attendance at sight tests until they're sufficiently symptomatic and/or b) issuing more new/changed prescriptions to patients from more deprived areas that expected for other reasons.

There is a paucity of literature on sight test outcomes and SES, however, the finding that referrals decrease (<16 years) with an increasing IMD (from most to least deprived) is somewhat in line with studies on GP referral rates. Goddard and Smith (2001) reported that more deprived SES areas have higher rates of referral from GPs. Also, lower parental SES (determined by receipt of means-tested benefits) has been associated with a greater odds of failing childhood visual screening, which is consistent with the increase referral rate associated with that demographic in the present study (O'Colmain et al. 2016; Bruce et al. 2018b). Together, this points to the conclusion that, although uptake is reduced,

the NHS sight test might be meeting the needs of the ocular health of the small percentage of children living in more deprived areas that do attend sight tests.

As increasing age is associated with an increased prevalence of eye disease (Rudnicka et al. 2006; Klein et al. 2007; Chang et al. 2011; Yau et al. 2012; Wong et al. 2014), the effects of IMD on referral rate would be expected to have a larger impact in the over 60 years, relative to the under 16 years, age group. Whilst the present study analysed data in 3 discrete age groups, analysis could have been run to examine the relationship between this effect over age. For example, it is possible that any effect could have increased as patient age increased. This was, however, beyond the scope of the present study. The lack of significant effect of IMD on referral rates in the over 60s, however, is unexpected. For adults, it has been reported that patients from more deprived areas are more likely to have acute angle closure glaucoma (Nessim et al. 2010) and sight threatening diabetic retinopathy (Scanlon et al. 2008; Low et al. 2015). Similarly, patients of lower SES have been found to have an increased self-reported glaucoma diagnosis (Shweikh et al. 2015) and an increased likelihood of previous cataract extraction (Scanlon et al. 2008; Nessim et al. 2010; Yip et al. 2014; Low et al. 2015). These results would point to the conclusion that, in contrast to the findings from the present study, older patients from more deprived areas would be more likely to be referred, relative to their less deprived counterparts. Accordingly, this lack of effect indicates that the ocular health needs of patients living in the most deprived areas may be underserved. This is supported by reports that patients from more deprived backgrounds are associated with an increased risk of late presentation of: neo-vascular age-related macular degeneration (Sharma et al. 2014), advanced glaucomatous visual field loss (Fraser et al. 2001; Sukumar et al. 2009; Ng et al. 2010) and sight threatening diabetic retinopathy (Denniston et al. 2019). Accordingly, the results indirectly support the view that the ocular health needs of these patients are not being met by the current primary eye care system.

The reason behind this could be related to the poor accessibility of eyecare in deprived areas. The barriers to obtaining eye care, such as a lack of understanding of the health aspect of the sight test, fear of cost and having to

travel to optometry practices (Awobem et al. 2009; Shickle and Griffin 2014; Shickle et al. 2014) are likely to disproportionately affect the most, relative to least, deprived. For example, it has been reported that in a small area analysis of Leeds, England, optical practices are rarely located in deprived areas (Day et al. 2010). Moreover, despite patients on means-tested benefits receiving a NHS voucher to subsidise the cost of spectacles, a 2009 study reported that only 59% (44/75) of practices responding to a questionnaire provided spectacles fully covered by the NHS voucher (Jessa et al. 2009). 41%, therefore, did not provide spectacles to patients at no cost. Accordingly, it is likely that as a result of these disproportionate effects, patients from more deprived areas may delay sight tests until they experience severe issues. Patients from higher SES areas, on the other hand, attend more frequently when asymptomatic and receive an earlier diagnosis and referral.

Together our results support the hypothesis that patients from more deprived areas are more likely to delay sight test attendance which is likely to have a negative impact on the prognosis of pathology. As the NHS funded sight test is the primary form of eyecare for those aged 60 years and older, removal of barriers to the obtainment on this eye care is essential to improve outcomes of patients living in more deprived areas.

2.4.2. The outcome of sight tests performed earlier than the recommended interval.

Each of the age categories (<16 years, ≥60 years) has one category of patients that was seen disproportionately more, relative to the other age group. The finding that over 60s have an increased rate of presenting early for a sight test that results in being referred for further investigations/ management, relative to those under 16, is in line with prevalence of ocular disease increasing with age (Rudnicka et al. 2006; Klein et al. 2007; Chang et al. 2011; Yau et al. 2012; Wong et al. 2014). Those aged under 16 years are disproportionately more likely to present early for a sight test which subsequently results in neither a new prescription nor an onwards referral (code 3.3). The reasons for this cannot be explained by the present study; however it could be that a sight test is

indicated in these children as part of a barrage of tests to determine the underlying issue. For example, poor performance at school (Bruce et al. 2018a), headaches of unknown cause (Abel 2009) or a number of other symptoms and behaviours could be attributable to poor eyesight. A sight test, therefore, would be indicated earlier than the recommended interval but could often result in no change in refractive error or pathology. In support of the hypothesis of patients from more deprived areas being more likely to attend sight tests because of visual problems, patients of that demographic who presented early for sight tests were statistically significantly more likely to be given a new spectacle prescription, relative to patients from less deprived areas. Moreover, parents who brought their children earlier than recommended for a sight test who lived in less deprived areas were more likely to do so when the child required neither a prescription nor a referral. This points to the conclusion that awareness of the need for a routine sight test is higher amongst patients from less deprived areas. This is supported by the finding that children from more deprived areas were more likely to present early for a sight test that resulted in a new spectacle prescription. Patients from wealthier areas may be more aware that a sight test could be required for other non-spectacle related issues (i.e. health). An alternative explanation is that there could be an aspect of 'the worried well' (Cochran and Mays 1989). This has been reported to be more present in those from less deprived backgrounds (Hanlon et al. 1995) and could, therefore, partially explain why patients (<16 years) from less deprived areas were more likely to present early for a sight test resulting in neither a new prescription, nor a referral.

In contrast, in Scotland, which has a different funding arrangement of NHS sight tests, it has been reported that practice distribution is not related to the areas deprivation level (Legge et al. 2018). Consequently, it has recently been reported that children living in the most deprived areas of Scotland are not disadvantaged in accessing NHS subsidised spectacles, relative to children living in the least deprived areas (Kearney et al. 2021). Kearney and colleagues reported that in Scotland, application of GOS claims for spectacle issuances in children were similar to reported prevalence of various refractive errors. This study benefits from only including one claim per patient per year – accordingly,

this reduces the impact of patients of differing SES presenting at different intervals. This is not completely eliminated, however, as some children will be reviewed biennially. As detailed in the present study, patients from more deprived areas were more likely to present early for a sight test resulting in a new spectacle prescription (and subsequently spectacles) being issued. Therefore, it could be that the numbers of children accessing NHS subsidised spectacles were differentially lower in the most, relative to least, deprived areas. The effect of this could be that fewer patients than expected from lower socio-economic areas are accessing NHS subsidised spectacles. Further research, however, is required to quantify this.

2.4.3. NHS funded sight test uptake

Previous work has examined the effect of SES on NHS funded sight test uptake and found similar results to those presented in the present study (Shickle and Farragher 2014; Shickle et al. 2017). These studies, however, used 'uptake ratios' which were calculated by the uptake in a given area, relative to what would be expected using the national average from NHS official statistics. Whilst this approach is useful for making national comparisons, it somewhat masks the actual proportion of patients that attend sight tests. Nonetheless, both previous studies have reported that attendance to NHS funded sight tests is associated with IMD; increasing deprivation reduces the likelihood of receiving an NHS funded sight test. The present study expands on this knowledge, utilising data from the whole of Essex and finding that a low proportion of those aged under 16 years, living in the most deprived areas of Essex attend for a sight test in a given year (12.3%). Interestingly, this is approximately half the proportion of patients of the same age who live in the least deprived areas (24.5%). Whilst the present study was not aimed at examining the reasons behind such differences, as previously mentioned, due to the financial model of the NHS sight test in England (Shickle et al. 2015b) practices are rarely located in areas of high deprivation (Shickle and Farragher 2014). In Scotland, however, where the NHS sight test is funded differently, optometry practice location has been reported to be 'relatively balanced' across IMD quintiles. Specifically, 25% of practices were located in the most deprived

quintile, relative to 11% in the least deprived. (Legge et al. 2018) It is unclear, however, whether this distribution itself has resulted in a greater uptake in deprived areas, as, the blanket eligibility for the NHS sight test in Scotland has been reported to increase uptake to a greater extent for those living in the least, relative to most, deprived areas (Dickey et al. 2012; Knight and Lindfield 2015). As previous authors have discussed, solutions to this issue may not be as simple as free sight tests for all (Dickey et al. 2016). Indeed the age groups where everyone currently receives a free sight test show inequalities of access in the present study. Improvements, however, could involve providing spectacles at reduced costs for those socio-economically deprived patients or subsidies for practices locating closer to patients living in these more deprived areas (Shickle et al. 2015b). Moreover, more work is needed to promote the importance of sight tests as health checks rather than to sell spectacles (Shickle and Griffin 2014). Accordingly, further work is required to reduce the barriers to accessing eye care that those living in the most deprived areas face (Shickle and Griffin 2014; Shickle et al. 2014).

2.4.4. Limitations of this study

The present study uses the IMD of the area where an individual lives as a proxy for SES. This undoubtedly is a limitation as there will be a number of people living in areas that don't represent their individual SES. However, given the way of calculating IMD rankings combined with the large sample size, it is likely to be a good approximation of SES.

The outcome of a sight test as determined by boxes ticked on GOS forms may not necessarily reflect the true outcome of the test. For example, whereas one outcome box will need to be ticked to claim the GOS fee, it may be that, in addition to a prescription outcome, the patient was referred but this box was not ticked. This limitation is unavoidable; however there is no reason why this should be biased towards one particular age group or SES category.

The study also suffers from its' retrospective design; the research team did not design the methodology of data collection and were limited to the range of

metrics present on the GOS form which is not designed for research purposes. This limited the analyses and did not allow us to adequately investigate the rationale behind clinical decisions made by the optometrists in this study. In particular, the data were anonymised prior to the research team receiving them. As aforementioned, the figures, therefore, for 'routine' eye tests may include individual patients presenting twice in the study period. For example, a patient aged under 16 may be reviewed annually and therefore be included twice. Accordingly, the percentage of patients who attend for sight tests is likely to be an overestimate of the true proportion.

The present study utilised a large sample size and, as detailed by a recent editorial by Armstrong, (Armstrong 2019) the small R^2 values questions the *clinical* significance of some of these findings (low amounts of variance explained), despite the highly *statistical* significant *p* values.

Another limitation is the way in which this data was captured. It was scanned by optical character recognition. Accordingly some letters and numbers may have been misread by this process which could have possibly affected the analysis.

2.5. Conclusions

This study demonstrates that not only does SES have an impact on the likelihood of having sight tests, but also the outcome of a sight test. This may be partially explained by the lack of awareness of the healthcare aspect of a sight test, and the lower uptake by those living in more deprived areas, which is attributable to the financial model behind primary eye care in England. In summary, these differences support the conclusion that the NHS sight test may not adequately address the ocular health care needs of patients living in more deprived areas in England (Hirji and Myers 2014; Shickle et al. 2015a).

Chapter 3

3. Exploring the effect of optometrist practice type on NHS funded sight test outcome

The work in this chapter has been published, in Journal of Optometry (Swystun and Davey 2021a) and is freely available at: https://doi.org/10.1016/j.optom.2020.03.008

3.1. Introduction

The National Screening Committee, a group that advises the UK government and NHS about population screening, recommends that all children *should* receive a sight check between the ages of 4 and 5 by an orthoptist, usually within schools (Public Health England 2019). This is not as comprehensive as a sight test as it does not contain a check of ocular health. Unfortunately, this screening is only a recommendation and commissioning of school screening varies depending on the local authority. It has been reported that only 55% of local authorities commission this service and where this isn't performed a NHS sight test is indicated (NHS 2019a). Whilst Public Health England recommend school screening, a national screening committee commissioned report found that there is little-to-no evidence on the clinical or cost effectiveness of such screening strategies (Solebo 2019). None-the-less, the age of children's first eye test, therefore, is an important metric to consider. The aim of testing children's eyesight is to detect common ocular abnormalities such as uncorrected refractive error or amblyopia ('lazy eye') that may hinder the child's progression either socially, or academically (Saunders 2010; Bruce et al. 2018a). As treatment aimed at correcting amblyopia is typically more successful when conducted before the age of 7 (Holmes et al. 2011; Stewart et al. 2011), the earlier a child has his/her sight tested, the greater the probability that the condition will be detected, and managed effectively.

In the UK, there are national chain opticians ('multiples') that have numerous practices distributed across the country, and 'independent' opticians that have

either one, or a small number of practices across a region. Previous research has reported that independents typically charge more for a private sight test and spent longer performing the eye test, relative to multiples (Shah et al. 2008). Shah and colleagues also reported that multiples delegated more tasks to auxiliary staff (e.g. trained optical assistants or dispensing opticians) and, moreover, patients felt independent opticians addressed their presenting symptom significantly better than multiples. Similarly, it has been reported that multiple chain optometrists are typically less experienced than their independent counterparts (Davey et al. 2016). These findings suggest that optometrists working in different practices may perform systematically different to each other despite both business types employing optometrists trained to the same standard.

The prerequisites to obtain a NHS sight testing contract are independent of the optometrist's place of work. Given this, it might be expected that there would be little difference in sight test outcome depending on which type of optometric practice a patient attends. However, given differences in business models, tests performed (Shah et al. 2008) and false positive referrals (Davey et al. 2016) we hypothesise that differences in NHS sight test outcomes will also exist.

The aim of the present study was to assess a) whether NHS sight test outcome is related to practice type (independent or multiple), b) whether socio-economic status is associated with practice type and c) what age patients' have their first NHS sight test. As the previous research has found that independent practices typically charge more for their services and employ more experienced staff, we hypothesise that patients living in more deprived areas would be less likely to attend an independent practice.

3.2. Method

The present chapter contains some of the same data as described in the previous chapter. For the present study, however, we use data from all age groups (664,480) of which 39,392 (5.93%) were first eye tests. First eye tests were determined by 'date of last eye test' on the GOS form, typically, there was

either the date of the previous eye test or the word ‘first’ to indicate that the child’s parents or guardian stated that the child had never received an eye test (either privately or NHS) prior to that visit. Due to differing eligibility of NHS sight tests to different ages, ages were grouped as follows: under 16’s (free sight tests for all), those aged 16 to 59 (free sight tests only for those on means-tested benefits, or some at-risk groups) and 60 and above (free sight tests for all). Practices were separated into national chain opticians (multiples; Asda, Boots (Including D&A), Costco, Optical Express, Scrivens, Specsavers, Tesco and Vision Express) and independent opticians. This methodology would be problematic going forward. Many independents are currently being purchased by a single large group. Whilst they may retain the original ‘independent name’ they are now part of a national chain. Similarly, a number of independents may have more than a single practice. Accordingly, they could be defined as a multiple. For our definition, only the multiples aforementioned were grouped into ‘multiple’.

3.3. Results

Breakdowns of patients’ age and sight test outcome are given in table 3.1 and a breakdown of sight tests by optical practice type (independent and multiple) are given in table 3.2.

Table 3.1. A breakdown of patient ages and sight test outcome found in the present study (Percentages are greater than 100 as patients can be referred and given a prescription (refractive) outcome or referred and not given a prescription outcome).

Age group	Number of sight tests	Mean age ± SD (years)	New (or changed) Prescription	Unchanged prescription	No prescription	Referred	% of total Essex population
< 16	178,645	9.4 ± 3.5	80,198 (44.9%)	14,002 (7.8%)	82,010 (45.9%)	3,330 (1.9%)	34.4
16-59	136,212	39.3 ± 14.8	105,979 (77.8%)	17,127 (12.6%)	11,135 (8.2%)	3,871 (2.8%)	9.3
≥ 60	349,623	72.7 ± 8.2	261,564 (74.8%)	72,062 (20.6%)	1,783 (0.5%)	26,901 (7.7%)	59.3

Table 3.2. A breakdown of the number of optical practices and how many sight tests are performed in each subtype.

Practice Type	Number of practices	Sight tests	First sight tests
Multiple	65 (33.2%)	416,763 (62.7%)	25,656 (65.1%)
Independent	131 (66.8%)	247,717 (37.3%)	13,736 (34.9%)

There was no clinically significant difference in ages that visited multiples, relative to independents. Specifically, medians and SD's for each age group are detailed in table 3.3.

Table 3.3. The median age and interquartile range (in years) for patients visiting independent and multiple optical practices.

	Under 16's	16's to 59's	Over 60's
Independents	9 (6 – 12)	44 (20 – 52)	73 (67 – 80)
Multiple	10 (7 -12)	44 (25 – 52)	71 (66 – 78)

3.3.1. Practice type

As IMD quintile increases from most to least deprived, the proportion of people presenting to independent, relative to multiple, increases (figure 3.1).

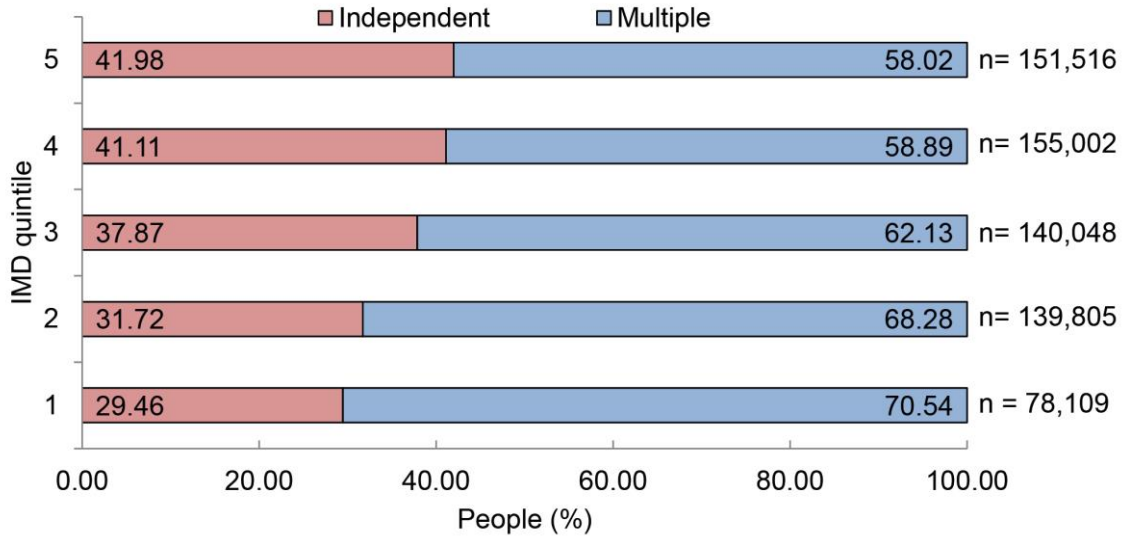

Figure 3.1. The relationship between IMD quintile and optometric practice type that patients' visit. The number of people visiting independent optometrists (red bars) increases going from most (bottom) to least deprived (top).

A binary logistic regression indicated that there was a significant association between IMD quintile (one to five) and choice of optometric practice (independent or multiple) (χ^2 (3) = 482.76, p< .001). Specifically, as IMD increased by one quintile, patients were 1.16 times more likely to visit an independent practice (table 3.4), so that patients in the least deprived quintile were 1.81 more likely to visit an independent practice than those in the most deprived.

Table 3.4. The effect of IMD on the likelihood of a patient visiting an independent, relative to multiple, practice.

Practice Type	β (S.E)	EXP(β) (*p*)	95% CI for odds ratio (lower-upper)
	χ2 (3) = 482.76, p< .001, R^2 = .012		
IMD	0.148 (0.002)	1.159 (*p* < .001)	1.155-1.164

β: Coefficient for the constant, S.E: standard error, Exp (β): odds ratio, CI: Confidence Intervals; IMD: Index of Multiple Deprivation.

3.3.2. First eye test

39,392 patients presented for their first eye test. Due to varying eligibility criteria of differing age groups, only those under 16 (n = 30,777) were included for these analyses (figure 3.2).

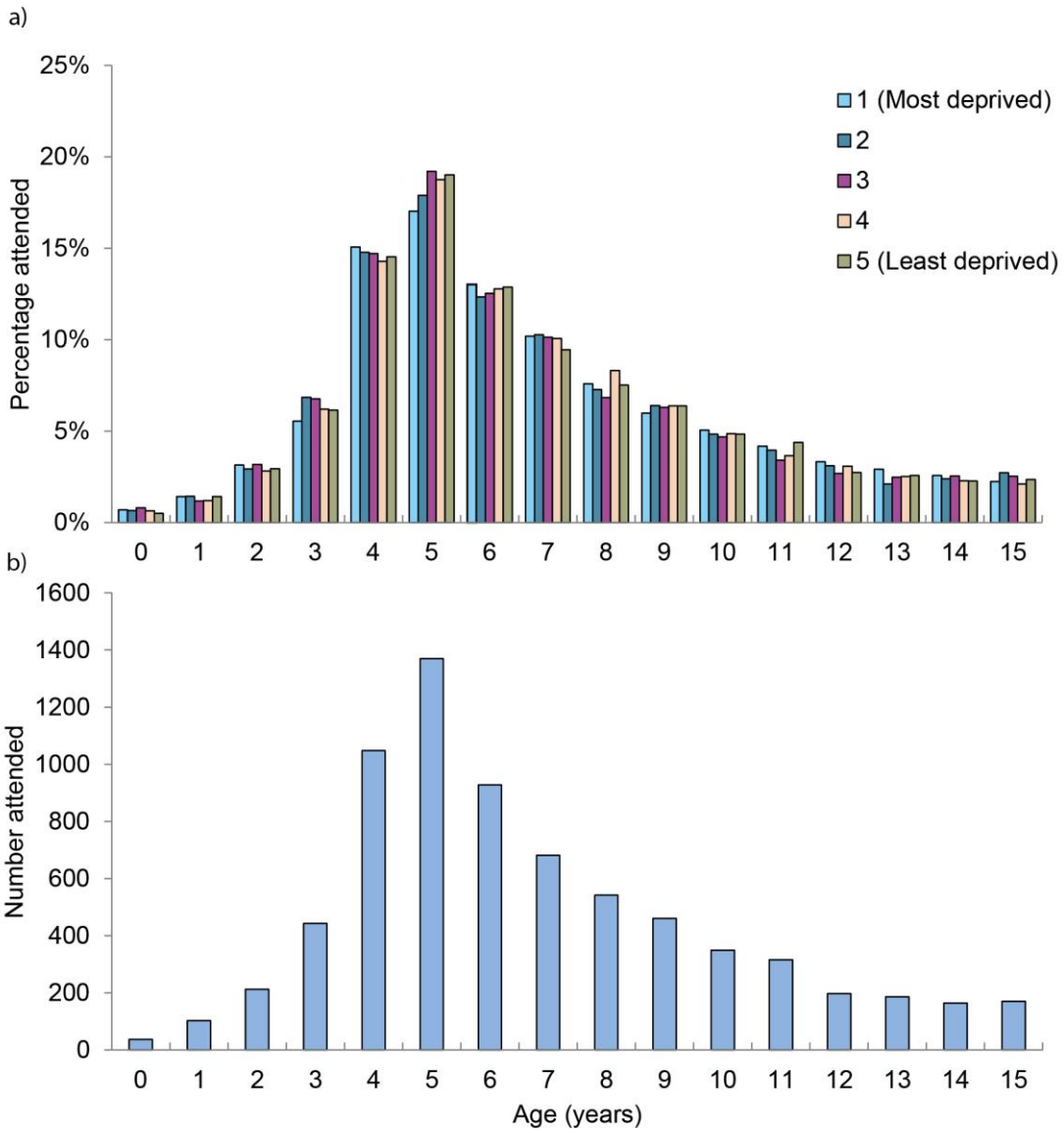

Figure 3.2. Ages of patients presenting for their first eye test. Figure 3.2a. The percentage of patients presenting for their first eye test at each age in each IMD quintile. Figure 3.2b. The number of first eye tests at each age after combining all IMD quintiles together. In both graphs each age represents the whole year. For example, an age of 1 represents all people from one year to less than two years.

The mean age for those presenting for their first sight test was 6 years and 254 days. This ranged from 6 years and 285 days (IMD quintile 1) to 6 years and 229 days (IMD quintile 3). The median age for a first sight test was 6 in all five IMD quintiles. Table 3.5 details the outcomes of first sight tests. The majority of first sight tests resulted in neither a referral nor issuing of a spectacle prescription (67.7%).

Table 3.5. The number and percentage of each sight test outcome for patients aged under 16 attending their first sight test (numbers add up to greater than 100% as patients who are referred may or may not additionally receive an outcome for their prescription).

Outcome	New prescription	No prescription	Unchanged prescription	Refer	Blank
Number (%)	8,634 (28.1)	20,835 (67.7)	451 (1.5)	998 (3.2)	67 (0.2)

3.3.3. Practice type vs sight test outcome

To examine whether the practice type (multiple or independent) had any effect on sight test outcome (new prescription, unchanged prescription or no prescription), separate multinomial logistic regression analyses were performed for each age group. IMD quintile (one to five) in which the patient lives was used as a co-variate to account for the effects of SES on sight test outcome (table 3.6).

Table 3.6. The effect of practice type on sight test outcome. All outcomes are relative to a patient being issued with no prescription at a multiple, relative to an independent.

Age Group / Variable			
Under 16	$\chi^2(3) = 3401.36$, $p < .001$, $R^2 = .026$		
	β (S.E)	Exp(β) (*p*)	95% CI for odds ratio (lower-upper)
New or changed	0.343 (0.010)	1.409 ($p < .001$)	1.381-1.438
Unchanged	0.186 (0.019)	1.204 ($p < .001$)	1.161-1.250
IMD	-0.164 (0.004)	0.849 ($p < .001$)	0.843-0.855
16 to 59	$\chi^2(3) = 1593.84$, $p < .001$, $R^2 = .017$		
	β (S.E)	Exp(β)	95% CI for odds ratio (lower-upper)
New or changed	0.537 (0.021)	1.711 ($p < .001$)	1.644-1.782
Unchanged	0.298 (0.025)	1.347 ($p < .001$)	1.281-1.415
IMD	-0.121 (0.004)	0.886 ($p < .001$)	0.878-0.894
60 and above	$\chi^2(3) = 2628.40$, $p < .001$, $R^2 = .011$		
	β (S.E)	Exp(β)	95% CI for odds ratio (lower-upper)
New or changed	0.310 (0.048)	1.363 ($p < .001$)	1.241-1.498
Unchanged	0.057 (0.048)	1.058 ($p = .241$)	0.963-1.163
IMD	-0.115 (0.003)	0.891 ($p < .001$)	0.887-0.896

β: Coefficient for the constant, S.E: standard error, Exp (β): odds ratio, CI: Confidence Intervals; IMD: Index of Multiple Deprivation.

For the under 16 category, there was a significant effect of practice type on NHS sight test outcome ($\chi^2(3) = 3401.36$, $p < .001$, $R^2 = .026$). Specifically, the odds of a patient who attended a multiple receiving a 'new or changed prescription' rather than 'no prescription' was 1.41 times (I.e. 41%) more likely than the odds for a patient who attended an independent practice. Similarly, the

odds of a patient receiving an ‘unchanged’ prescription, rather than ‘ no prescription’ at a multiple was 1.20 times that of the odds of a patient attending who attended an independent (*p*’s < .001).

For the 16 to 59 category, there was a significant effect of practice type on NHS sight test outcome ($\chi^2(3) = 1593.84$, $p < .001$, $R^2 = .017$). Specifically, the odds of a patient who attended a multiple receiving a ‘new or changed prescription’ rather than ‘no prescription’ was 1.71 times (71%) more likely than the odds for a patient who attended an independent practice. Similarly, the odds of a patient receiving an ‘unchanged’ prescription, rather than ‘no prescription’ at a multiple was 1.35 times that of the odds of a patient who attended an independent (*p*’s < .001).

For the 60 and older category, there was a significant effect of practice type on NHS sight test outcome ($\chi^2(3) = 2628.40$, $p < .001$, $R^2 = .011$). Specifically, the odds of a patient who attended a multiple receiving a ‘new or changed prescription’ rather than ‘no prescription’ was 1.36 times more likely than the odds for a patient who attended an independent practice ($p < .001$). The odds of a patient receiving an ‘unchanged’ prescription, rather than ‘no prescription’ at a multiple was similar to a patient attending an independent and was not significant (odds ratio = 1.06, $p = .24$).

As an alternative, or addition, to patients being given a refractive outcome, the patient may be referred. Separate binary logistic regressions were used for each age group (under 16, 16 to 59 and 60 and above) to examine the effect of practice type (multiple and independent) on whether the patient is referred. For each age group, age, deprivation quintile (one to five) and referral outcome (referred or not) were used as predictor variables for practice type (table 3.7).

Table 3.7. The results of the binomial logistic regression analysis with the effect of practice type, age and level of socio-economic status (IMD) on the likelihood of a patient being referred following an NHS sight test.

Age Group / Variable			
Under 16	$\chi^2(3) = 756.40$, $p < .001$, $R^2 = .025$		
	β (S.E)	Exp(β) (*p*)	95% CI for odds ratio (lower-upper)
Practice Type	0.188 (0.037)	1.207 (*p* < .001)	1.123-1.297
Age	-0.137 (0.005)	0.872 (*p* < .001)	0.863-0.881
IMD	-0.064 (0.013)	0.938 (*p* < .001)	0.915-0.962
16 to 59	$\chi^2(3) = 352.60$, $p < .001$, $R^2 = .011$		
	β (S.E)	Exp(β) (*p*)	95% CI for odds ratio (lower-upper)
Practice Type	-0.111 (0.035)	0.895 (*p* = .002)	0.835-0.959
Age	0.022 (0.001)	1.022 (*p* < .001)	1.019-1.024
IMD	-0.020 (0.012)	0.980 (*p* = .10)	0.958-1.004
60 and above	$\chi^2(3) = 2597.39$, $p < .001$, $R^2 = .018$		
	β (S.E)	EXP(β) (*p*)	95% CI for odds ratio (lower-upper)
Practice Type	0.036 (0.013)	1.037 (*p* = .006)	1.011-1.064
Age	0.039 (0.001)	1.040 (*p* < .001)	1.038-1.041
IMD	0.011 (0.005)	1.011 (*p* = .032)	1.001-1.021

β: Coefficient for the constant, S.E: standard error, Exp (β): odds ratio, CI: Confidence Intervals; IMD: Index of Multiple Deprivation.

Specifically, patients that attended multiples who were aged under 16 (1.21 times) and 60 and above (1.04 times) were more likely to be referred, relative to patients that attended independent practices. In contrast, those aged 16 to 59 who attended multiples were less likely to be referred (0.90 times), relative to those in the same age group that attended independent practices.

3.4. Discussion

The present study found that NHS sight test outcome varies with practice type (multiple or independent) and patient choice of practice is dependent on the deprivation level of the area in which the patient lives. The present study also found that the age at which a child presents for their first eye test is clinically independent of the deprivation level of the area that they live. Together these findings support the view that there are differences in sight tests between optometrists working in different practices. Importantly, this isn't intended to suggest one practice type is superior to the other rather, simply, that differences do exist. Further work is required to explain the reasons for these differences. Indeed, Shah and colleagues (Shah et al. 2008) conducted a study assessing how optometrists performed a sight test on a young myopic patient who presented with headaches. The authors reported that although there may be some differences between optometrists in multiples, relative to independents, there were no significant differences between the two groups when comparing which of the required tests (as judged by a 'gold-standard' reference group) were performed.

3.4.1. Practice type and routine NHS sight test outcome

Across all age groups, patients attending multiples were significantly more likely to receive a 'new or changed prescription' relative to 'no prescription' compared to those patients that attended independent opticians (36-71% more likely). Although the exact reasoning for this are unclear, it could be that patients who think that they might require new spectacles choose to visit a multiple, or, alternatively, optometrists may be systematically performing differently or both. For example, the optometrists working in a multiple may have a smaller threshold for what they consider a 'new prescription', relative to an independent optometrist. Further work, therefore, is required to examine this. The finding that patients presenting to multiples are also more likely to receive an unchanged prescription, relative to no prescription, in both the under 16's and 16-59 age

groups points to the conclusion that those attending multiples are more likely to wear spectacles, relative to patients visiting an independent. In line with patients reporting they're recommended spectacles that they don't need (Shickle and Griffin 2014): an alternative explanation could be due to differing commercial pressures between the two practice types; optometrists working in multiples may be under more pressure to recommend spectacles, thus, accounting for the differences found in the present study. It is possible that independent opticians are less likely to exist close to deprived areas therefore they are less likely to be frequented by patients in these areas or It could also be that multiples and independent practices have significant differences in price of spectacles. There is, however, a lack of published evidence examining this. There is currently a paucity of research examining sight test outcome, and the large amount of electronically captured data that was analysed in the present study offered us the opportunity to examine this. However, given the retrospective design of this study, we are unable to draw definite reasoning for the differences found between practice types.

There was also a significant effect of practice type on whether patients were referred. The reasons for this are unclear. It has been reported that optometrists who are recently qualified may tend to refer more than their more experienced colleagues (Davey et al. 2016; Parkins et al. 2018). It could, therefore be that, as reported in Bradford (Davey et al. 2016), multiples in Essex tend to employ more newly qualified optometrists. Furthermore, it has been reported that multiples tend to produce a greater number of false positive referrals, even when accounting for the effects of optometrist experience. (Davey et al. 2016) There is a paucity of published evidence examining this and it is unclear why this effect would be the opposite for those aged under 16 compared those aged 16 to 59. For those aged 60 or older, the effect is small and is unlikely to be clinically significant.

3.4.2. Practice type and first eye test

Across all levels of deprivation, multiple practices conduct the majority of sight tests, however as hypothesised, the present study found that as IMD quintile

increases by 1, a patient is 16% (odds ratio 1.16) more likely to visit an independent optometrist compared to a multiple. One possible explanation for this finding could be that more multiples could be established in deprived areas. A study examining areas of deprivation and optometry practices in Leeds, UK, however, showed that it is rare for any practice (multiple or independent) to be within a LSOA that is from the most deprived IMD decile. Moreover, when these practices are situated within a deprived area, they are typically on the border with a less deprived area (Day et al. 2010). Mapping of practice type and IMD quintile was beyond the scope of the present study, but given the business requirements of the optometric business model, (Shickle et al. 2015b) it is likely that optometrists (multiple and independent) in Essex are also predominately situated in less deprived areas (Shickle et al. 2015a).

The age at which a child presented for their first eye test ranged by 56 days from 6.63 to 6.78 years depending on IMD quintile (median 6 years in all quintiles). This difference is unlikely to be *clinically* significant. This average age of first eye test, however, is conservative as all those that received their first eye test at 16 years or older (n = 8,615) were removed from analysis. Our finding that children are over six and a half years old before their first eye test could be cause for concern. Firstly, this age is considerably later than the 4 or 5 years of age that the NHS recommends for a first vision test (NHS 2019a). This leaves children with potential eyesight issues such as amblyopia going undetected close to the level at which treating becomes significantly more difficult (7 years) (Holmes et al. 2011; Stewart et al. 2011). Moreover, in the UK schooling system, children will have typically had two or three years of education before their first sight test. If children are unable to see through this period, it would be expected that this could have an impact on their engagement and ability with education (Bruce et al. 2018a) Although, at present, a recent freedom of information request (July 2019) has revealed 96% of children in Essex aged 4-5 now attend school vision screening (Essex County Council 2019). This school screening scheme existed in a different format in the years that the present study examined (2015 to 2016) and the proportion of children receiving school screenings at that time is unknown. All patients aged under 16, regardless of their socio-economic status are entitled to a NHS sight test at no cost to the

patient (NHS 2017). The present study, therefore, supports the view that further work is required to promote the importance of children's sight tests across all socio-economic classes. Reduced visual acuity, that could be detected as part of a sight test, has been shown to be associated with reduced proficiency of reading and writing (Bruce et al. 2016). Accordingly, lack of access to sight tests could be affecting more than just the child's ocular health. As part of a school vision screening, the child's parents receive a letter detailing the outcome; this may be a good opportunity to educate patient's families about the importance of regular eye examinations with optometrists.

Interestingly, the majority (67.7%) of children presenting for their first eye test neither required spectacles nor a referral to a doctor (General Practitioner or hospital eye department). This indicates that of the children in Essex that did attend their first sight test, the majority do so despite having no ocular problems. This could be that certain subsets of the population have awareness of the importance of sight tests despite no apparent symptoms (NHS 2019a). Although this is positive, the finding that only 34.4% of the Essex population aged under 16 received a NHS sight test, within the county in the 18 months the present study examined, suggests that more work is needed to promote the importance of sight tests.

3.4.3. Limitations of this study

The limitations of the data set are described in the previous chapter. In addition, the age of sight test on the data set we used was given as a whole number. For example, patients aged 6 years and 11 months were recorded as 6 years old. Therefore, the exact ages for mean age of first eye test can only be used as an approximation. The metrics recorded: for example, age and whether it is the patient's first eye test, relied on patient's information. This is not verified before the practice submits the GOS claim form. Accordingly, there may be some potential of patient's parents or guardians inaccurately recalling if the patient has had a prior eye test. This is unlikely to be an issue in the under 16 age-group as the time between the last eye test to the present visit would be relatively small. Patients 16 and over, however, were not included in the

analyses of first eye tests and therefore, the effect on the results should be minimal. Similarly, the data relies on the optometrist selecting the correct box on the GOS1 form, as this does not form part of the clinical record, this might not be the case.

3.5. Conclusion

This study demonstrates that SES is associated with the type of optometry practice (independent or multiple) that a patient visits. Moreover, we demonstrate that the type of practice that a patient visits is associated with the likelihood of being prescribed glasses: patients attending multiples were 36-71% more likely to receive a new, relative to no prescription compared to patients attending independent practice. This points to the conclusion that patient care may differ between different modalities of practice type. Further work is required, however, to explore these differences and the underlying cause. We also find that patients in Essex typically present for a sight test at a later age, relative to what is recommended. This highlights that further work is required to increase the uptake of children's sight tests at an earlier age.

Chapter 4

4. Impact of the coronavirus disease 2019 UK lockdown on the ocular health of patients with diabetes and suspect glaucoma.

4.1. Introduction

COVID-19 resulted in the suspension of both routine sight testing and diabetic retinal screening (DRS) throughout the United Kingdom. The purpose of the present study was to investigate what impact this suspension had on the detection of open angle glaucoma and diabetic retinopathy. We examine the effects of the nationally commissioned NHS sight test on a national level and the locally commissioned diabetic retinal screening programme on a local level.

4.1.1. Suspension of sight testing

Different countries within the United Kingdom operated at different speeds in the suspension and reinstating of routine sight testing (table 4.1).

Table 4.1. The date that the NHS funded sight test service was suspended in each country of the UK.

Country	Suspension date	Recommencement date
England	1st April 2020 [i]	17th June 2020 [i]
Scotland	23rd March 2020 [ii]	3rd August 2020 [iii]
Wales	17th March 2020 [iv]	22nd June 2020 [v]
Northern Ireland	24th March 2020 [vi]	29th June 2020 [vii]

[i] (Neligan and Sharma 2020) [ii] (Campbell 2020) [iii] (Ferris 2020) [iv] (Welsh Government 2020c) [v] (Welsh Government 2020a) [vi] (Curran 2020) [vii] (Health and Social Care Board 2020).

Across the UK, once routine eye care was suspended, provisions were made for the continuation of emergency eye care by a number of support packages by the respective NHS of each country. Typically, this included continuing to pay primary care optical practices, that remained open for essential and emergency

care, their average NHS claim per month based on historic levels. Accordingly, the aim was to ensure that patients at risk of vision loss who experience acute symptoms could still have access to primary care optometrists in the form of urgent and/or emergency sight tests, reducing the burden of eye disease on secondary care and, ultimately, reducing unnecessary visual loss as a result. Patients, who were asymptomatic, however, were not considered to be an essential or emergency sight test. Accordingly, pathology in this cohort of patients would have gone undetected. Notwithstanding the possibility of a number of potentially sight threatening conditions presenting asymptomatically (i.e. in a non-dominant or amblyopic eye), the most common condition referred from community optometrists to a hospital ophthalmology department that can result in permanent irreversible visual loss, is glaucoma (Davey et al. 2011; Evans et al. 2020). Glaucoma, therefore, would be the most frequently encountered condition at risk of going undiagnosed as a result of suspension of routine sight testing.

As detailed in sections 1.1 and 1.3, primary eye care system varies across the UK. In Scotland, all residents are eligible to receive an NHS funded sight test at least every two years. In England and Northern Ireland, however, only those aged under 16 years, 60 years and older and those in a limited number of at risk groups or in receipt of means tested benefits (and those receiving a war pension in Northern Ireland) are eligible to receive an NHS funded sight test. Wales, on the other hand, has a unique structure. Specifically, in addition to the forementioned groups, patients at an increased risk of sight loss (e.g. certain races) are also eligible for a NHS funded sight test.

In each UK country, however, there are systems running parallel to the NHS funded sight test for patients with acute onset eye problems. These are nationally commissioned across Scotland, Wales and Northern Ireland. Specifically, in Wales, the Eye Health Examination Wales (EHEW) provides urgent eye care to anyone experiencing acute eye problems and an enhanced test for certain at risk groups (band one), referral refinement (band two) and follow ups (band three) (McAlinden et al. 2016). Throughout the suspension of routine sight testing, the EHEW for enhanced sight testing of at risk groups was

also suspended. PEARS (acute eye problem) appointments, however, were unaffected (Welsh Government 2020c). In Northern Ireland, the nationally commissioned PEARS scheme continued throughout the suspension, whilst in Scotland, urgent eye care was included in the nationally commissioned NHS eye examination. England, however, has a piecemeal system of a number of different variations of urgent eye care schemes (MECS/PEARS/COVID Urgent Eyecare Service) in some areas, and no provision for primary care urgent eye care in others. As these urgent eye care services remained accessible, the current review focuses on the effect of suspension of routine sight testing through the COVID-19 suspension.

4.1.2. The suspension of diabetic retinal screening

The diabetic retinal screening programme is a national initiative that is commissioned on a regional basis. Therefore, although each region may operate slightly different services, the overarching aim and regulations are consistent (National Institute for Health and Care Excellence 2016a; National Institute for Health and Care Excellence 2019). In brief, prior to COVID-19, patients with a diagnosis of diabetes who are aged over 12 were invited for a yearly screening examination (Routine Digital Screening, RDS) where two 45 degree wide photographs per eye are taken through dilated pupils. One image is centred on the optic disc the other on the macula. For those patients who have retinopathy or maculopathy, a decision is made as to whether these patients should be monitored more frequently (Digital Surveillance, DS). This decision is agreed on a local basis between the provider of the diabetic eye screening service and the local hospital eye service ophthalmology departments. Across the UK, the only group that is consistently seen more frequently in DS are those who have pre-existing diabetes and become pregnant (not gestational diabetes). This cohort is seen in line with NICE recommendations. Specifically, those who are pregnant should be offered a retinal screening after their first antenatal appointment. Should any diabetic retinal pathology be found at that screening, patients should be offered another retinal screening between 16 and 20 weeks. Regardless of the outcome of the

first appointment, patients should be offered a follow up at 28 weeks (National Institute for Health and Care Excellence 2015). If the photo taken in DS or RDS is not of sufficient quality to examine diabetic retinopathy status (e.g. cataract), the patient is invited for a dilated slit lamp bio-microscopy examination (SLB). Throughout the pandemic, those at high risk of sight loss and those who are pregnant, were able to attend diabetic screening. The routine eye screenings, however, ceased. Accordingly, we hypothesise that a number of patients would have developed new, sight threatening diabetic eye pathology, which would not have been detected. The diabetic screening in the present study was suspended for one month.

The 5-year incidence of open angle glaucoma in Amsterdam (de Voogd et al. 2005) and Australia , was approximately 3.5% of those aged ≥55 years an 1.1.% of those aged ≥40 years (Mukesh et al. 2002) respectively and that approximately half of these cases are undiagnosed. Accordingly, using population estimates from the Office of National Statistics (Office for National Statistics 2020), we hypothesised that in a 1 year period, between 36,980 and 71,876 people would be diagnosed with open angle glaucoma in the UK each year. As not all patients with glaucoma would be diagnosed through sight testing, we hypothesised that the total number would be lower than this.

The aims of the present study were: 1) To predict the effect of the suspension of routine sight testing with regards to number of patients with undiagnosed primary open angle glaucoma. 2) Determine, on a local level, the effect of the suspension of routine diabetic screening on the ocular health of known patients with diabetes. As sight-threatening diabetic retinopathy is rare, relative to non-sight threatening (Thomas et al. 2015), we hypothesised there would be a potentially large impact of delayed screening on a small number of patients.

4.2. Method

4.2.1. Sight testing

A literature review was conducted using CINAHL, MEDLINE and EMBASE to provide information relating to a) the number of sight tests that result in referral (search terms: ((sight OR eye) AND (test OR exam*)) AND (Optician* OR Optom*) AND (Refer*)), b) the proportion of referrals that are for suspect glaucoma (search terms: ((sight OR eye) AND (test OR exam*)) AND (Optician* OR Optom*) AND (Refer*)) and c) the true positive rate of these glaucoma referrals (search terms: ((sight OR eye) AND (test OR exam*)) AND (Optician* OR Optom*) AND (Refer*)). In order to keep the data as up to date as possible, we limit the search to studies published from 2010 to the date of extraction (August 4th, 2020). Hand searching was used to capture any studies that were published after the data of the systematic search. For studies in England, data must have been collected post NICE guidance issued in 2009 relating to glaucoma (National Institute for Health and Clinical Excellence 2009) (Table 6.2).

NHS statistics were used to estimate the number of sight tests that would have been performed in the year 19/20 assuming an increase from 18/19 in line with previous years. The predicted number of patients that would have been diagnosed with glaucoma was then applied to the number of sight tests performed in each country of the UK. This allowed calculation of the number of patients that would have been referred for, and subsequently diagnosed with glaucoma across the UK per month.

4.2.2. Diabetic Retinal Screening

Northgate Public Services (https://www.northgateps.com/) was the provider of the diabetic eye screening programme for patients registered with a GP in the CCG areas of Bradford and Craven, Calderdale and Greater Huddersfield in 2020. As of 16th July 2020 Northgate Public Services covered a population of 73,201 people with diabetes. Northgate Public Services were contacted to provide data on the numbers of patients that attended each type of diabetic retinal screening (RDS, DS and SLB) and their appointment outcome. Patients were graded according to the following scale: R0: no retinopathy; R1: Background retinopathy; R2: Pre-proliferative retinopathy; R3A: Active

proliferative retinopathy; R3S: Stable/ treated proliferative retinopathy; M0: No maculopathy; M1 clinically significant macular oedema (Scanlon 2017). This information was then used to quantify the number of patients that were expected to be seen in the service that would have resulted in new pathology being detected. Rates of progression to sight loss due to diabetic retinopathy and maculopathy was then be used predict the expected loss of vision as a result of cancelled screening.

4.3. Result

4.3.1. Glaucoma

The results of the literature searches that were conducted in order to estimate the number of patients that are diagnosed with open angle glaucoma as a result of routine sight testing each year in the UK is given in table 4.2.

Table 4.2. The results on the literature searches for a) the number of sight tests that result in referral, b) the proportion of referrals that are for suspected glaucoma and c) the referrals for suspected glaucoma that result in the diagnosis of glaucoma.

	Proportion of sight tests resulting in referral	Proportion of referrals for suspected glaucoma	Proportion of glaucoma referrals that are true positives
Total articles	4,989	754	754
Duplicates removed	3,459	546	546
Since 2010	2,136	354	354
Full text read	35	20	42
Hand searching	1	0	0
Final	5	3	10

4.3.1.1. Number of sight tests

Whilst estimates of the number of NHS funded sight tests are published in each country, these data are not collected for private sight tests. Two estimates, however, have been provided. A survey in Northern Ireland reported that 72.3% of all sight tests were NHS funded (Health and Social Care in Northern Ireland 2020) and an earlier survey across Great Britain reported that 68.5% of all sight tests were NHS funded (The Infomation Centre 2006). Importantly, since the earlier survey, all residents of Scotland are entitled to a NHS funded sight test. Accordingly, we would expect the number of *private* sight tests to be minimal. The number of NHS sight tests reported in each country are detailed in table 4.2

Table 4.3. The number of NHS funded sight tests and eye examinations per country since the financial year 2014/2015.

Country		14/15	15/16	16/17	17/18	18/19	19/20
England [i]		12,764,485	12,979,762	12,995,512	13,032,582	13,255,755	13,355,060
Scotland [ii]		2,039,845	2,109,947	2,198,390	2,213,781	2,343,604	2,182,534
Wales	GOS [iii]	750,244	769,380	776,827	790,140	795,188	806,839
	EHEW (band 1) [iv]	n/a	81,428	93,566	102,963	109,275	120,532
Northern Ireland [v]		453,714	468,117	476,423	464,466	470,429	468,813

i (NHS Digital 2020) ii (Public Health Scotland 2020b) iii (Welsh Government 2020b) iv (Welsh Government 2020d) v (Health and Social Care Business Services Organisation 2020). Underlined figures indicate data not released at time of writing, so was estimated based on increase from previous years. Also important to note that 19/20s figures will be under-estimates as countries of the UK suspended routine sight testing prior to the end of the financial year.

Using estimations that in England and Northern Ireland 72.3% of all sight tests are NHS funded, we can make assumptions about the number of private sight tests. In Scotland, as everyone is entitled to a NHS funded eye examination, we use the number of NHS eye examinations as the total number. We acknowledge that there will be a small number of patients that may pay privately. This number, however, is difficult to quantify. For Wales, we estimate that the number of individuals who attend for GOS and EHEW (excluding acute eye problems/ GP referrals) combined will account for 72.3% of eye examinations. We also use the value that 25.8% of band one were for routine eye care (Welsh Government 2020d) (table 4.4)

Table 4.4. The estimations of the number of sight tests performed in each country in the UK for the year April 2019 to March 2020.

Country		NHS sight tests	Private sight tests	Total sight tests
England		13,355,060	5,116,669	18,471,729
Scotland		2,182,534		2,182,534
Wales	GOS	806,839	321,035	1,158,971
	EHEW	31,097		
Northern Ireland		468,813	179,614	648,427
Total		16,844,343	5,617,318	**22,461,661**

Accordingly, the total number of sight tests performed across the UK in the year April 2019 to March 2020 was estimated to be 22,461,661. Therefore, ≈1,871,805 sight tests were performed per month on average if seasonal variations in uptake are ignored. Underlined figures indicate data not released at the time of writing, so is estimated based on increase from previous years.

4.3.1.2. Percentage of sight tests that result in referral

The literature search for the proportion of sight tests that result in referral revealed four studies and is detailed in table 4.5 (McAlinden et al. 2016; Wright et al. 2020; El-Abiary et al. 2021; Swystun and Davey 2021a). In addition, one study was published since then (Evans et al. 2020).

Table 4.5. Studies published using data since 2010 that detail the number of patients that are referred from various optometric primary eye care examinations.

1st Author	Year	Country	Age	Sample size	Sample Population	% referred	Refer to
McAlinden	2016	Wales	All	511	EHEW (Excluding PEARS)	12.9	GP or HES
El-Abiary	2020	Scotland	All	2,343,604	GOS eye examination (all eligible)	4.1	HES
Swystun	2020	England	All	664,478	GOS eligible	5.1	GP or HES
Wright	2020	Northern Ireland	≥60	311,999	GOS eligible	4.7	GP or HES
Evans	2020	England	All	8,327	GOS and Private sight tests	5.5 / 4.9	All / HES only

EHEW: Eye Health Examination Wales; PEARS: Primary Eyecare Acute Referral Scheme; GP: General Practitioner; HES: Hospital Eye Service; GOS: General Ophthalmic Services

El-Abiary and colleagues results come directly from the nationally reported NHS statistics (ISD Scotland 2019). These statistics detail that 1.4% and 4.1% of

sight tests result in referral to the GP and HES, respectively. Similarly, for the Welsh EHEW, 2.7% of encounters result in a GP referral and 10.2% resulted in a HES referral (McAlinden et al. 2016),but this uses only those patients attending EHEW appointments which are predominantly at-risk groups. Therefore, this referral rate will be larger and not representative of all Welsh sight tests and was removed from further analysis. In line with this, the study by Wright and colleagues uses only those aged 60 years or older, who are more likely to be referred, relative to those aged under 60 years (Swystun and Davey 2021a) and cannot be used to generalise to all age groups. The study by Swystun and Davey uses only *NHS* funded sight tests in one county of England and, therefore, is not necessarily representative of *private* sight tests or the remainder of England. Therefore, for the purposes of the present study, we will use the figure calculated from Evans and colleagues (4.9%) for referral rates for England, Wales and Northern Ireland. Reassuringly, this is very similar to the 4.7% and 5.1% given in the excluded studies (Wright et al. 2020; Swystun and Davey 2021a).

4.3.1.3. Percentage of referrals that are for suspected glaucoma.

The literature review conducted to find studies that contain information relating to the proportion of sight test referrals that are for suspect glaucoma revealed three studies (Davey et al. 2011; Khan et al. 2015; Fung et al. 2016) and is detailed in table 4.6

Table 4.6. Results of the literature search for studies examining proportion of referrals to the hospital for suspected glaucoma.

1st Author	Year	Sample Size	% of referrals for glaucoma
Davey	2011	433	20
Khan	2015	346	11
Fung	2016	569	21.5

The study by Fung and colleagues reported that patients were referred for: IOP>21mmHg (14%), Primary Open Angle Glaucoma (POAG) suspect (7.5%),

abnormal/suspicious disc (6%) and abnormal visual field (5%). As there was no response from contacting the author, we assume that, as POAG suspect has its own section, the abnormal optic nerve head and visual field sections are not relating to glaucoma. The study by Khan and colleagues was conducted in Scotland and is markedly different from the other two studies. Accordingly, we take the 11% as the value for Scotland and the average of the Davey and Fung studies for the remainder of the UK, which suggests that approximately 20.75% of all optometrist's referrals are for suspected glaucoma.

4.3.1.4. Percentage of glaucoma referrals that are true positives

The literature search on this topic revealed ten studies (Shah and Murdoch 2011; Khan et al. 2012; de Silva et al. 2013; Ratnarajan et al. 2013c; Bobat et al. 2015; Jeganathan et al. 2015; Kotecha et al. 2017; Annoh et al. 2019; Gunn et al. 2019; Sii et al. 2019) and is detailed in table 4.7.

Table 4.7. The results of the literature search evaluating the true positive rate of glaucoma referrals.

1st Author	Year	Country	Time period	Sample size	Mode	Diagnosis (% excluding DNA)
Shah	2011	England	Nov 2009 – Dec 2009	110	ST to HES, Pre NG81	G (or S): 24.5%, O:15.5%, N: 60.0%
Khan	2012	England	Jan 2011 – Feb 2011	102	ST to HES, Pre NG81	G: 16.7%, N: 29.4%,S: 17.6%, AC: 11.8%, O: 24.5%
De Silva	2013	England	2010	895	ST to HES, Pre NG81	G: 12.6%, O: 16.1%,S: 9.7%, N: 61.6%
Ratnarajan	2013	England (Nottingham)	Mar 2011 – Apr 2011	269	ST to HES, Pre NG81	FVDR: 53.7
		England (Huntingdon)	Mar 2011 – Apr 2011	434	ST to HES, Pre NG81	FVDR: 38.3
Bobat	2015	England	No date	200	ST to GRR to HES, Pre NG81	PPV (ST): 0.16,PPV (GRR): 0.80
Jeganathan	2015	Scotland	No date	100	ST to HES	G: 84%
Kotecha	2017	England	Mar 2014 – Mar 2016	1380	ST to Virtual HES, Pre NG81	FVDR: 62%,FN: 20%
Annoh	2019	Scotland	Jun 2016 –Nov 2016	715	ST to HES, Pre	FVDR (open angles): 25%

					S144	FVDR: (Suspect AC): 12%
Gunn	2019	England	Oct 2014 - Aug 2016	1404	ST to GRR, Pre NG81	Discharge: 53.6%,FN: 10.7% G: 0.0%,S: 3.8%,O: 2.3%,AC: 4.6%
				283	GRR to HES, Pre NG81	G: 16.2%, S: 47.5%,O: 11.2%, ACS: 9.4%, N: 15.8%
Sii	2019	Scotland	Oct 2014 – Nov 2014	337	ST to HES, Pre S144	FVDR: 29.2%, G: 28.9%, S/O: 32.8%, AC: 8.7%, N 29.6%
			Sep 2016 - Oct 2016	357	ST to HES, Post S144	FVDR: 19.4%,G: 29.9%,S/O: 36.5%, AC: 12.9%,N: 20.8%

G, Glaucoma; S, Suspect; O, Ocular Hypertension; N, Normal; AC, Angle Closure; ACS, Angle Closure Suspect; FVDR, First Visit Discharge Rate; PPV, Positive Predicted Value; NG81, National Institute for Health and Care Excellence Glaucoma Guidelines 81; S144: Scottish Intercollegiate Guidelines Network 144

To the date of the literature search (August 12th 2020), there have been no studies examining the true positive rates of referrals since the updated NICE guidance in 2017 (National Institute for Health and Care Excellence 2017). The intention of this, however, was to reduce false-positive referrals without a significant impact on true positives. The study by Jeganathan and colleagues was removed from analysis due to bias in the study population; it includes only patients who had received a diagnosis of glaucoma or suspect glaucoma (El-Medany et al. 2017). The study by Bobat and colleagues was removed from analysis as it is a conference abstract and does not provide sufficient data (Bobat et al. 2015). The study by Gunn and colleagues was removed from analysis due to the enhanced referral pathway creating an additional variable (i.e. sight test to referral refinement to hospital.

This leaves three studies that provide measures of first visit discharge rates (FVDR), three studies that provide the proportion of patients' diagnoses at their hospital visit and one study that provides both proportions and FVDR. FVDR is perhaps the least useful measurement for the purpose of the present study as we are interested in the proportion diagnosed with glaucoma and not those discharged. Accordingly, we are left with four studies (Shah and Murdoch 2011; Khan et al. 2012; de Silva et al. 2013; Sii et al. 2019) of which two provide sufficient breakdown of patients diagnoses (i.e. open angle / closed angle / suspect and OHT) (Khan et al. 2012; Sii et al. 2019). Specifically, Khan and colleagues (2012) report that 16.7% of glaucoma related referrals in England result in an open angle glaucoma diagnosis. In Scotland, Sii and colleagues (2019) report a higher value of 29.9%.

For the purpose of the present study we hypothesise that the true positive rate in England is similar to that of Wales and Northern Ireland. The true positive rate for Scotland, on the other hand, is higher (Sii et al. 2019) likely due to the more in depth nature of the Scottish *eye examination*, relative to the rest of the UK's *sight test*. The summary of this section is provided in table 6.7

Table 4.8: The estimation of patients diagnosed with glaucoma in each country of the UK in a given year.

Country	Number of Sight tests	Sight tests referred (%)	Referrals for Glaucoma (%)	Referrals diagnosed with open angle glaucoma (%)	Patients diagnosed with open angle glaucoma
England	18,471,729	4.9	20.8	16.7	31,440
Scotland	2,182,534	4.1	11.0	29.9	2,943
Wales	1,158,971	4.9	20.8	16.7	1,973
Northern Ireland	648,427	4.9	20.8	16.7	1,104
Total	**22,705,491**				**37,459**

In summary, we estimate that, across the UK, 37,459 people are diagnosed with open angle glaucoma in recent years as a consequence of routine sight testing.

4.3.2. Diabetic eye disease

The outcomes for routine diabetic screening in Bradford, Craven, Calderdale and Huddersfield are displayed in table 4.9.

On average, each year within Routine Diabetic Retinal Screening (RDS), 262 and 74 patients are referred routinely and urgently respectively, to the HES for diabetic related eye disease. Another 44 and 89 patients are referred routinely and urgently respectively, to the HES for non-diabetic related eye disease. Similarly, on average, each year within Digital Surveillance (DS), 520 and 98 patients are referred routinely and urgently respectively, to the HES for diabetic related eye disease. Another 8 and 13 patients are referred routinely and urgently respectively, to the HES for non-diabetic related eye disease. Within Slit lamp Bio-microscopy Diabetic Screening (SLB), a further 243 and 20 patients are referred routinely and urgently respectively, to the HES for diabetic

related eye disease. Another 15 and 10 patients are referred routinely and urgently respectively, to the HES for non-diabetic related eye disease (table 4.9).

Table 4.9. The diagnoses and outcomes for patients attending the diabetic eye screening programme in Bradford, Craven, Calderdale and Huddersfield in the years 2018 and 2019.

Grading	2018			2019		
	RDS	DS	SLB	RDS	DS	SLB
R0M0	36,013	600	2,156	36,591	562	2,128
R1M0	9,693	682	506	9,730	766	525
R1M1	1,351	2,669	106	1,109	3,966	115
R2M0	127	181	20	122	317	18
R2M1	152	347	11	92	463	5
R3SM0	19	153	26	9	210	33
R3SM1	8	82	6	8	130	10
R3AM0	34	25	7	33	25	10
R3AM1	43	59	3	33	59	5
Ungradable	1,303	152	296	1,301	202	259
Outcome						
12/12 Recall	45,539	66	2,295	46,119	2	2,347
9/12 Recall	n/a	42	n/a	n/a	146	n/a

6/12 Recall	n/a	2,788	139	n/a	3,340	181
3/12 Recall	n/a	220	n/a	n/a	1,362	n/a
Return to RDS		1,079	343		1,040	263
Refer to DS	1,776		60	1,417		42
Refer to SLB	918	109		1,086	177	
Refer to HES (routine)	309	529	251	215	510	235
Refer to HES (Urgent)	78	96	18	69	99	21
Refer to HES (non-DR, routine)	67	11	21	21	4	9
Refer to HES (non-DR, urgent)	75	10	10	103	16	10
Exclude from screening	1	0	0	0	0	0

DR: Diabetic Retinopathy; R0: No retinopathy; R1: background retinopathy; R2: Pre-proliferative retinopathy; R3S: Uncertain progression of proliferative retinopathy; R3A: Active proliferative retinopathy; M0: No maculopathy; M1: Clinically significant maculopathy. RDS: Routine diabetic screening; DS: Digital surveillance; SLB: Slit lamp bio-microscopy; HES: Hospital eye service

In summary, in an average year (based on the previous 2 years), the diabetic retinal screening service from the present study refers 1025 patients routinely and 192 patients urgently to the HES for diabetic eye disease. Additionally, another 67 patients are referred routinely and 112 patients are referred urgently for non-diabetic related eye pathology.

Throughout April 2020, two patients were seen in RDS (R0M0) and were put onto an annual recall, nine patients were seen in DS (6 R0M0, 3 R1M0) of which six were retained in DS and three were returned to RDS and none were seen in SLB. Accordingly, essentially, the diabetic retinal screening service used in the present study temporarily shut for April 2020. The referral urgency of diabetic eye disease (table 6.9) and non-diabetes related eye disease (table 4.10) are shown below.

Table 4.10. Urgency of referral for each stage of DR in the Northgate Public Services screening programme.

DR status	Referral urgency
R0	No referral
R1	No referral
R2	Routine
R3S	No referral
R3S (uncertain)	Urgent
R3A	Urgent
M0	No referral
M1 (Exudates area <1/2 DD)	No referral
M1 (Exudates area <1/2 DD)	Routine

DR: Diabetic Retinopathy; R0: No retinopathy; R1: background retinopathy; R2: Pre-proliferative retinopathy; R3S: Uncertain progression of proliferative retinopathy; R3A: Active proliferative retinopathy; M0: No maculopathy; M1: Clinically significant maculopathy.

On average, therefore, over the previous two years, 168 patients with R3A and 24 patients with uncertain R3S receive an urgent referral per year. Similarly, 928 patients with R2 and 97 patients with M1 receive a routine referral into the

hospital ophthalmology department per year. Accordingly on an average month, the DRS programme detected 14 R3A, 2 R3S, 77 R2 and 8 R1M1 patients pathology that required the attention of ophthalmology. In addition, the diabetic eye screening programme refers a smaller number of patients for a variety of suspected non-diabetic related eye pathologies (table 4.11).

Table 4.11 Non-diabetic reasons for referral from the diabetic eye screening programme, and urgency.

Condition (Non Diabetic Related)	Referral urgency
Vitreous Haemorrhage	Urgent
Retinal Detachment	Urgent
Branch Retinal Vein Occlusion involving the macula	Urgent
Central Retinal Vein Occlusion involving the macula	Urgent
New or changed Wet AMD:	Urgent
Optic Disc Swelling- New	Urgent
Macular Hole (new)	Routine
Postoperative Capsular Opacification	Routine
Branch Retinal Vein Occlusion (No Macula involvement)	Routine
Optic disc haemorrhage	Routine
Optic disc cupping / pallor	Routine
Corneal / anterior segment disorder (new)	Routine
Dry AMD – If >2-line reduction in visual acuity	Routine
Longstanding retinal vein occlusion (If no previous images) or collaterals	Routine
Eyelid disorders such as entropion	Routine

Although an exact breakdown per condition is not available, the diabetic retinal screening programme refers 112 patients each year for a mix of vitreous haemorrhages, retinal detachments, central and branch retinal vein occlusions (macula involvement), wet AMD and new optic nerve head swelling.

4.4. Discussion

On an average month, we estimate that 3,122 patients get diagnosed with glaucoma across the UK as a result of routine sight testing. At 37,459 patients per year, this is similar to the lower end of the hypothesised number (36,980). As forementioned, as not all cases would be diagnosed through sight testing (i.e. patients seeing GP, or already under the care of ophthalmology for co-existing conditions), the number of patients diagnosed through sight testing is in line with incidence figures diagnosed primary open angle glaucoma in similar countries. Furthermore, in a small area with a high prevalence of diabetes in England (Allen 2015), 116 patients get referred from the diabetic retinal screening programme. Specifically, per month of suspension of DRS, 14, 2, 77 and 8 patients with R3A, R3S, R2 and M1 respectively have been failed to be detected and referred appropriately. Similarly, 9 patients each month with serious non-diabetic related eye pathologies requiring an urgent ophthalmology appointment are typically detected through retinal screening of patients with diabetes.

When considering the effect that suspension of routine sight testing has on the ocular health and vision of patients with primary open angle glaucoma, it is important to consider at what stage of the disease process these patients typically have at presentation to hospital ophthalmology departments and the rate of progression to sight loss. It has been reported that patients with glaucoma in England, typically have early stage glaucoma at their first presentation (Jones et al. 2020). Jones and colleagues reported that 14% of patients present with visual field loss in the worst eye of ≤ −12.01dB. However, this study used data from 1989 to 2012 and does not appear to make comment about the visual field loss severity changes over time which have been decreasing (Boodhna and Crabb 2015). Accordingly, it is likely that, given changes in referral criteria for suspected glaucoma (e.g. National Institute for Health and Care Excellence 2017) and increasing use of equipment such as tonometry, visual field analysers and modern imaging techniques (Dabasia et al. 2014) disease severity at first presentation is now less severe.

It has been reported that progression of visual field loss in early glaucoma is slow but with a wide range (Heijl et al. 2013; Ha et al. 2018). Specifically, the early manifest glaucoma trial recruited participants with glaucoma and followed them for a median period of 6 years. The authors found that visual field progression among patients who received no treatment was at a rate of -0.05 ± 0.07dB per month (Heijl et al. 2013). Progression of glaucoma has been reported to be faster in patients with increased age or IOP (Gordon et al. 2002; Leske et al. 2003; Heijl et al. 2013), worse mean deviation (Leske et al. 2003), thinner central corneal thickness, greater pattern standard deviation and larger cup-to-disc ratios (Gordon et al. 2002). Accordingly, the majority of patients with little-to-no visual field defect and early glaucoma are unlikely to progress significantly towards visual field loss with a three-month delay to routine sight testing. In order to accurately determine the effect of a suspension of routine sight testing in modern times, a study investigating the current severity of glaucoma at first presentation is required. However, assuming 14% of the 3,249 patients per month present with already advanced/severe visual field loss which has been shown to be a predictor of faster visual field progression, this equates to a potentially sight threatening delay for 455 patients per month in the UK. This is an important aspect to consider when balancing the risks of allowing the continuation of care versus the risks of undiagnosed disease progression. It might be that ‘routine’ face to face care could be safely suspended for those with a recent sight test (e.g. within the last 3 years) which revealed nothing of remark. Conversely, in order to minimise sight loss from undiagnosed glaucoma, patients without a recent sight test, or those who required more frequent examination could be advised that they can still attend their sight test appointment despite being asymptomatic. For example, routine sight testing of patients with high IOP (21-23mmHg) that wasn’t indicated for referral (National Institute for Health and Care Excellence 2017), who have a family history of glaucoma or who’s optometrist recommended a review more frequent than the biennially recommended interval should not be suspended.

Although the present study was examining the effect of sight test suspension primarily regarding the number of patients referred for, and subsequently diagnosed with, primary open angle glaucoma it’s also important to mention the

impact on patient's general health. As detailed in table 6.4, 0.6% of patients are referred to their GP for management of general health related conditions (Evans et al. 2020). It is not currently known what proportions of these referrals are for GP diagnosis (e.g. blood pressure / diabetes checks) or solely for management (e.g. prescribing drops at the request of the optometrist). However, it's important to consider that 0.6% of all sight tests is 136,233 patients per year. A proportion of which will have underlying health issues going un-diagnosed and, therefore, not managed as a direct result of suspension of routine sight testing. Outcomes of optometric referrals to General Practitioners have not yet been examined.

As with glaucoma, when considering the impact of the suspension of diabetic retinal screening on the ocular health of patients with diabetes, disease prognosis needs to be considered. In our small area sample, 14 patients per month were diagnosed with proliferative diabetic retinopathy that was not present at their previous screening. Without treatment these patients are at a risk of subsequent retinal detachment and/or pre-retinal haemorrhages which increases the risk of permanent visual impairment (Klein et al. 1984a; Fong et al. 1999). However, a small delay in time (up to "several weeks") from detection of proliferative retinopathy to treatment has been reported to have no statistically significant effect on the final visual acuity in patients with proliferative retinopathy (Negretti et al. 2016). Therefore, it would be expected that a similar delay to the referral of patients with pre-proliferative retinopathy would have minimal long term effect. Negretti and colleagues did report however, that 3 out of 28 patients who had a delay in their referral time resulted in a permanent reduction of visual acuity thought to be directly attributable to the delay. Therefore, although a small delay may not have statistical significance, it could have a disproportionate clinical significance to a small number of patients.

In addition to potential sight loss from diabetic retinopathy, it is important to consider the delay of treatment for patients with diabetic macular oedema (Tan et al. 2017). These patients are typically referred routinely, which in the present setting results in an ophthalmology appointment within approximately 3 months. Studies that evaluate the prognosis for visual function in patients with diabetic

macular oedema typically initiate treatment shortly after diagnosis (Blinder et al. 2017). It has been reported, however, that patients with diabetic macular oedema are less likely to experience permanent vision loss relating to delayed treatment, relative to other macular pathologies (Korobelnik et al. 2020). Accordingly, the UK's Royal College of Ophthalmologists recommended that as a result of the COVID-19 pandemic, new patients with diabetic macular oedema can be deferred for a period of 6 months (The Royal College of Ophthalmologists 2020). In this case, screening for diabetic maculopathy is arguably important to be continued: the delay in detection is in addition to the delay in treatment.

Of the potential reasons for a non-diabetic related urgent referral into ophthalmology, these conditions appear to be mainly symptom causing and therefore, patients should be made aware that primary care optometric services (e.g. sight tests and acute eye care schemes) remained open for symptomatic individuals on an urgent and emergency basis. However, it appears that the public were not adequately made aware that primary and secondary eye care remained open. Specifically, it has been reported that new presentations into wet age related macular degeneration (AMD) clinics significantly declined following lockdown (Schimansky et al. 2020; Wickham et al. 2020). Similarly, the number of retinal detachments presenting to hospital ophthalmology departments in Scotland has significantly reduced (Shams et al. 2020). The reduction in patients attending macula and retinal clinics suggests patients were not aware of what NHS services were open during the first national lockdown and/or that some felt the risk of contracting COVID-19 was a greater problem for them than possible vision/ eye problems. Regardless, in the event of future suspensions of routine health care services, clear communications about what health services remain open is essential.

4.5. Conclusion

In conclusion, the authors expect that the COVID-19 related temporary cessation of primary eye care services for asymptomatic individuals should have had a minimal impact on the ocular health of patients with diabetes (<1

month suspension) and undiagnosed glaucoma (<3 months suspension). This is with the caveat that patients are appropriately made aware that should they experience symptoms or concerns, primary eye care is open for their urgent and emergency ocular needs.

4.6. Limitations

Actual patient numbers referred with each stage of diabetic retinopathy were not provided. These however, can be calculated. Specifically, the diabetic eye screening programme protocol states that R2 and M1 are referred routinely and R3A and uncertain R3S are referred urgently. The numbers of R3A and R2 and the total number of diabetic eye disease related routine and urgent referrals were provided by Northgate Public services enabling calculation of patients referred with R2 and R3A. Similarly, the present study made no attempt to account for any false-positive diagnoses.

Similarly, the number of patient's screenings is not equal to the number of individual patients seen as some of the patients who are on a 3-month recall may have been screened 4 times in a given year. This limitation, however, is unlikely to have impact on the number of patients referred.

Furthermore, the effect of the cessation of screening may have had less of an impact than the general restrictions that applied at the time. Changes in routine, exercise and eating is likely to have a greater impact that a temporary suspension of retinal screening. Similarly, there have been no studies examining the effect of the latest NICE guidance on optometry referrals for suspected glaucoma. Whilst this may impact referrals, it is unlikely to affect the number of patients diagnosed with glaucoma.

Another Limitation is the search strategy. In a *systematic* review two authors independently screen abstracts and titles. The present study uses a systematic review type method without the screening of two authors – this could lead to relevant studies being inadvertently removed from analysis.

Chapter 5

5. A Needs Assessment for a minor eye conditions service in Leeds, Bradford and Airedale, UK

5.1. Introduction

The work in this chapter has been published in *BMC Health Services Research* (Swystun and Davey 2019) and is freely available at: https://bmchealthservres.biomedcentral.com/articles/10.1186/s12913-019-4448-8.

As mentioned in section 1.2.1, MECS, (also known as PEARS) have been commissioned by Clinical Commissioning Groups (CCGs) in some areas of the United Kingdom. These enhanced optical services are commissioned at a local level to enable appropriate use of community resources to manage minor eye problems within routine optometric practice.

Optometrists in the UK are required to complete a university degree and a College of Optometrist accredited scheme for registration (General Optical Council 2019). As part of this training programme competence in the detection and management of certain eye diseases is attained. However, in order to perform MECS appointments, commissioners often require optometrists to become accredited through online training (Konstantakopoulou et al. 2014). After this is completed, optometrists are eligible to offer NHS funded eye care beyond the scope of a general ophthalmic service (GOS) sight test in the form of a MECS appointment. Specifically, LOCSU state that MECS are commissioned with the purpose of offering rapid access to professional eye care, which would thereby reduce unnecessary referrals into hospital ophthalmology departments. In turn, this would be expected to reduce referral-related patient anxiety and should change the case-mix of patients seen in overburdened ophthalmology departments to be more appropriate to secondary care (Brewer et al. 2007; Davey et al. 2013; Konstantakopoulou et al. 2014; Konstantakopoulou et al. 2018; LOCSU 2018). For example, taking patients out

of hospital ophthalmology services who could be safely and effectively dealt with by a community optometrist results in more patients who require the specialist level of care of an ophthalmologist to receive it and, receive it more promptly.

Elderly patients make up the largest proportion of users of health care systems, (Rice and Fineman 2004). This, combined with the UK's ageing population, is increasing the demand on hospital services and ophthalmology departments are no exception (Chalk and Smith 2013; Kotecha et al. 2015). There have been several reports that have concluded that the overburdening of secondary care eye services directly results in a negative impact on patient safety and treatment (Gulland 2003; National Patient Safety Agency 2009; Tatham and Murdoch 2012; Malik et al. 2013b; Boyce. 2014; Kotecha et al. 2015; Foot and MacEwen 2017). Specifically, the National Patient Safety Agency stated that patients have been negatively harmed, with outcomes including complete loss of vision, as a result of delayed follow-up appointments for patients that have glaucoma (National Patient Safety Agency 2009). Beyond patient safety, issues of accessibility, sustainability and convenience require the current practice of delivering eye care within a hospital setting to be reviewed. For example, Potamitis et al. (1994) reported that 7.7% of patients who failed to attend hospital ophthalmology appointments was due to transport. This occurs even when transport is arranged by the hospital. In comparison, transport was not an issue raised for patients who did not attend an ophthalmology clinic in New Zealand (Koppens et al. 2005).

As mentioned in section 1.2 in order to reduce demand on overburdened ophthalmology clinics, optometrists employed by hospitals are increasing in scope of practice. This, however, does not alter the demand on hospital ophthalmology departments and the costs to the NHS remain unchanged. Although there are a limited number of studies evaluating MECS in different regions, it is typically reported that after a MECS consultation approximately 20% of patients require a hospital ophthalmology appointment and 9% of patients require an appointment with a GP (Sheen et al. 2009; Greenwood L. 2013; McCracken M. 2013; Cottier 2015; Konstantakopoulou et al. 2016). It has

been reported that this results in a reduction in GP and ophthalmology outpatient appointments (Sheen et al. 2009; Mason et al. 2017), relative to when MECS are not commissioned. This reduction in unnecessary appointments results in a greater number of patients who require specialist care to receive it. Furthermore, two studies (Hau et al. 2008; Wasfi et al. 2008) have shown that approximately 25% of patients who attended ophthalmology specific A&E departments could have been successfully managed by an optometrist. These studies point to the conclusion that redirection of these patients to an optometrist could reduce the number of patients presenting to A&E with ocular issues.

According to 'Annex A: The national prices and national tariff workbook of the National tariff payment system 2017/18 and 2018/19', the February 2019 initial outpatient attendance fee for a single profession ophthalmology appointment was £139 with a follow up fee of £53. Similarly, a visit to A&E involving investigation started from £93 (NHS Improvement and NHS England 2017). In contrast to these secondary care costs, the remuneration per MECS appointment in regions neighbouring the area of the present study were £40 (Wakefield), £44 (Harrogate) and £46 (Huddersfield) at the time writing (February 2019). Reflecting the lower cost of a primary care, relative to secondary care, medical appointment, a GP appointment costs the NHS approximately £30 (NHS England 2019c). Given the figures aforementioned, successful management of eye issues within primary care could reduce the costs associated with managing this cohort of patients. This depends, however, on the numbers of additional patients that would subsequently access a service that is more accessible and conveniently located. Specifically, the unmet demand increase of MECS is not currently known.

Although the financial cost of a GP appointment is lower than the typical cost of a MECS assessment, as mentioned in section 1.2. GPs typically do not possess the necessary equipment and/or skills for investigation and intervention of ophthalmic problems. Specifically, it has been reported that GPs, on average, received eight days of ophthalmology training at undergraduate level (Baylis et al. 2011; Welch and Eckstein 2011). Beyond undergraduate level, 96% of GPs

received no further ophthalmological training (Kilduff and Lois 2016), The end result is that, in one survey, 78% of general practitioners felt that their training on ophthalmology was inadequate (Shuttleworth and Marsh 1997).

Also as mentioned in section 1.2, NHS ‘red flags’ exist to aid GPs with management of patients that present with suspected ophthalmological problems. Specifically, if a patient presents with any of the following acute signs or symptoms: sudden appearance of flashes or floaters, abnormal pupil reactions, moderate to severe pain or photophobia, marked redness of one eye, reduced visual acuity, reduced visual field, haloes around lights or foreign bodies, an urgent referral into the ophthalmology department is recommended (Kilduff and Lois 2016; National Institute for Health and Care Excellence 2016b; Robinson 2017). It is expected that after examination by an optometrist, a lower number of patients would be referred, relative to when based solely upon presenting symptoms.

At the time of writing (February 2019), there were no Minor Eye Condition Services in Bradford, Airedale or Leeds. As such, two local optical committees (LOCs) had commissioned this survey to investigate the need for a MECS scheme in the locality.

5.2. Method

Bradford and Leeds LOC’s contacted their databases of local optometrists with details regarding the needs assessment and invited them to participate. The study in Bradford lasted for a six-week period from 29/5/18 to 9/7/18. The Leeds study commenced on 15/02/18 and lasted for a period of six weeks and three days until 31/03/18. 6 weeks was chosen as a convenience sample for those participating.

The inclusion criteria were defined as any patient attending the participating optometric practice whose reason for visiting was due to symptoms indicative of a problem that could not be corrected by spectacles/contact lenses. This definition was based on advice from the Association of Optometrists.

Specifically, “Patients presenting with clear ocular medical concerns requesting a sight test for reasons (such as sticky red eye, foreign bodies and requests for a procedure, for example, if a patient’s doctor has advised a visual field check for driving) should be told that a GOS sight test is inappropriate and that they should be either treated privately in your practice or directed to hospital eye services or their GP as appropriate” (Association of Optometrists 2015). Thus a sight test is indicated only in instances where the patients presenting symptoms are likely to be correctable by refractive correction. The present study includes patients who were redirected before seeing the optometrist. For example, patients who presented to the practice but were informed by the reception staff that a sight test was inappropriate. At that stage, if the patient refused to pay, the optometrist could either have: a) seen the patients free of charge, b) redirect to free of charge care (e.g. GP/ A&E/ Pharmacy)

The results from both areas were submitted anonymously. Practitioners in Leeds submitted results through a Microsoft Excel document with drop down boxes, whereas results from Bradford were submitted utilising a Google form (an Excel spreadsheet was offered). Identical questions and response options were provided in both areas and a free text box was provided for optometrists to record any additional information they deemed appropriate.

According to the ethical checklist at the University of Bradford, this retrospective evaluation did not require ethical review. Importantly, however, the audit did comply with the tenets of the Declaration of Helsinki and participating optometrists gave informed consent.

5.3. Results

Responses from 105 patient encounters from 12 optometry practices within Leeds and 184 patient encounters from 34 optometrists within Bradford were received through the duration of the study.

Following the optometrist’s consultation, 75% (n=183) of patients were managed by the optometrist. 16% (n=39) of patients were subsequently

referred into a hospital ophthalmology department and 9% (n=22) were required to see their GP (Figure 5.1).

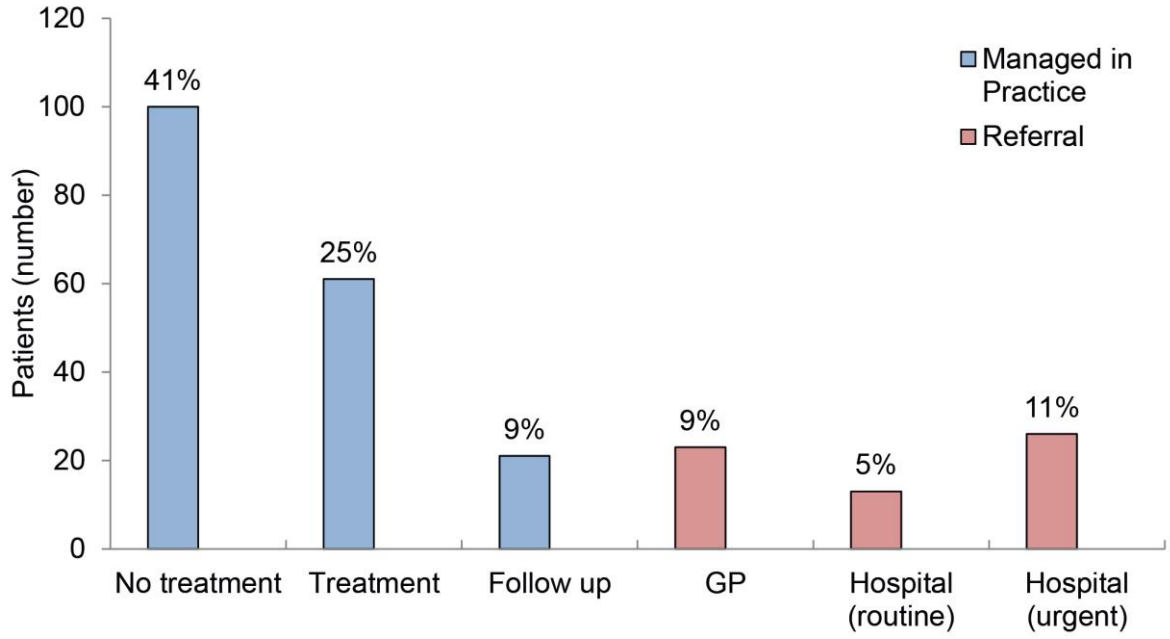

Figure 5.1. Appointment outcome. Most of patients were managed in practice (blue bars). 25% of patients required an onward referral (red bars) (n =244).

Optometric practice dealt with a range of acute eye problems. Figure 5.2 details the presenting complaints(s).

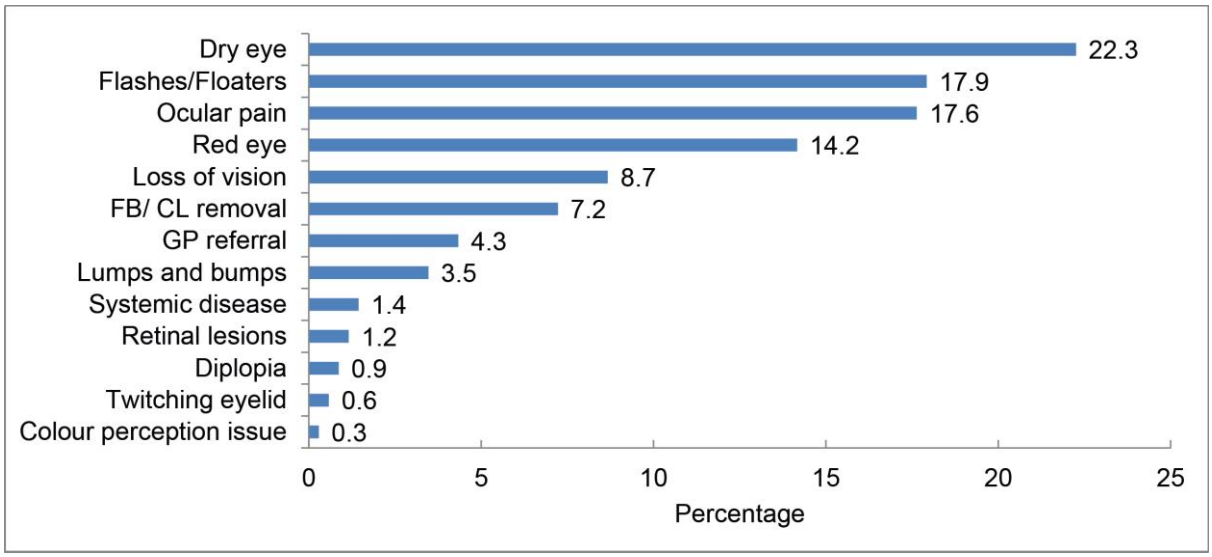

Figure 5.2. Reasons for obtaining an appointment. Patients could have presented with more than one symptom (n=346). (FB = Foreign body, CL = Contact lens, GP = General practitioner).

Patients typically presented to their optometrist with symptoms of an anterior eye problem (48%), potential posterior eye issues were relatively less common (19%). The remainder of presentations (33%) were ambiguous as to the location prior to seeing the optometrist (e.g. GP referral).

In most cases, the patient paid a fee to access the optometrists' service (53%). A number were seen at no charge to the patient, either as optometrist good-will (19%) or using a GOS claim (9%). The remainder of patients declined an appointment (19%) and were subsequently redirected to their GP (13%), A&E (4%), another optometrist (1%) or a pharmacy (1%) (Figure 5.3).

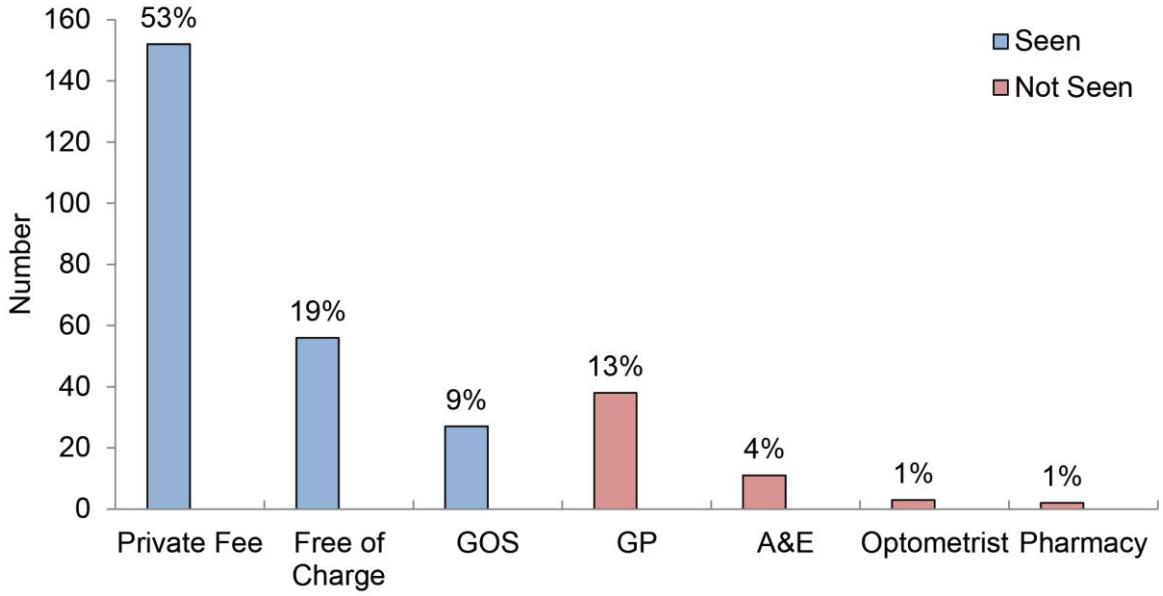

Figure 5.3. How the consultation was funded. The blue bars represent patients that were seen by the optometrist and were either charged a private free, no fee or under GOS. The red bars represent patients that weren't seen by the optometrist and were redirected to the GP, A+E, another optometrist or a pharmacy (n=289).

Only six patient encounters specifically recorded the reason for the patient not receiving a consultation. Although only a small number, this was typically due to unwillingness to pay (4/6).

Perhaps unsurprisingly, the majority of patients presenting with an acute eye problem would have sought alternative treatment if they were unable to obtain an appointment with the optometrist (96%). Unmet demand is categorised as

patients who have accessed a specific service that would not have accessed any alternative service. In the present study this could be classed as the proportion of patients that accessed an appointment with an optometrist that would not have otherwise sought professional advice and/or treatment (4%) (Figure 5.4).

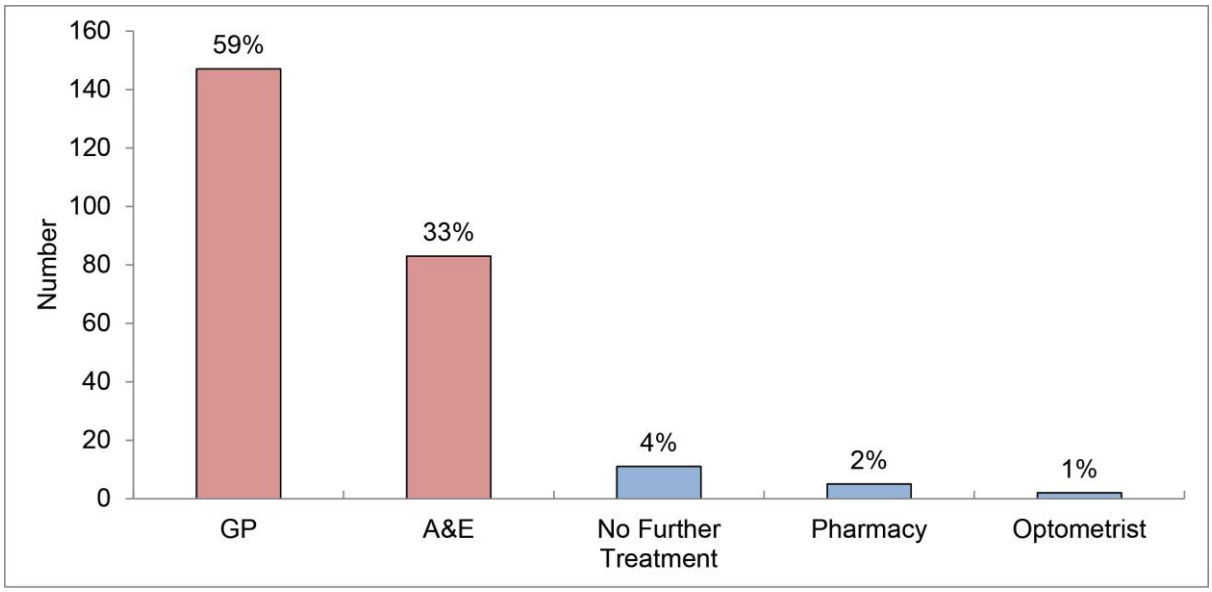

Figure 5.4. Alternative source of treatment if the optometrist was unable to see the patient. Red bars represent an alternative provider that costs would incur significant costs to the NHS. Blue bars represent alternative providers that do not incur significant costs the NHS (n=248).

62% of patients presenting in the present study either had GP red flags (Kilduff and Lois 2016; National Institute for Health and Care Excellence 2016b; Robinson 2017) or were referred to an optometrist by the GP for a second opinion. If there was no community optometric service for seeing these patients, this large cohort of patients would have required the GP to refer into a hospital ophthalmology department; in many cases this would have been unnecessary. The results of this are particularly apparent when examining patients presenting with symptoms of flashing lights and/or floaters. Of the 55 patients presenting with flashing lights and floaters that were provided with a private optometric consultation, a GP would have be advised to refer 100% urgently into ophthalmology (Kilduff and Lois 2016; Robinson 2017). In the present study, after optometric examination it was found that 78% of these patients did not require ophthalmological intervention and were subsequently discharged with advice. Only 22% had signs of an underlying pathology requiring referral into

hospital ophthalmology departments. 81 patients presented to the optometrist with red flag symptoms excluding flashing lights and/or floaters (total red flag patients = 135). 9 further patients were referred to the optometrist by the GP for unspecified red flags or a second opinion. The presenting symptoms and outcome are detailed in Table 5.1.

Table 5.1. How patients presenting with 'red flags' were managed.

Presenting Reason	Number Seen	Number Referred to Ophthalmology
Ocular Pain	30	3
Combinations [a]	17	3
Foreign Body/ CL removal	14	1
Vision Loss	14	8
GP Referral	9	0
Marked Red Eye	6	2
Total	90	17

[a] *'Combinations' refers to more than one presenting reason. For example, a patient presenting with both a marked red eye and vision loss.*

Of the 55 red flag patients in the present study who would have sought the advice of the GP as an alternative to the optometrist, the optometrists referred 9 (16%) for an ophthalmological opinion. This details that a number of patients would have been referred to secondary care unnecessarily.

Patient satisfaction with the private MECS services was generally high (88%). From the patients who experienced dissatisfaction with the service (5%, n=12), this most commonly occurred in instances where the patient had not received an appointment and were redirected (n=7). The remainder of patients were indifferent about the level of service provided (8%) (Figure 5.5).

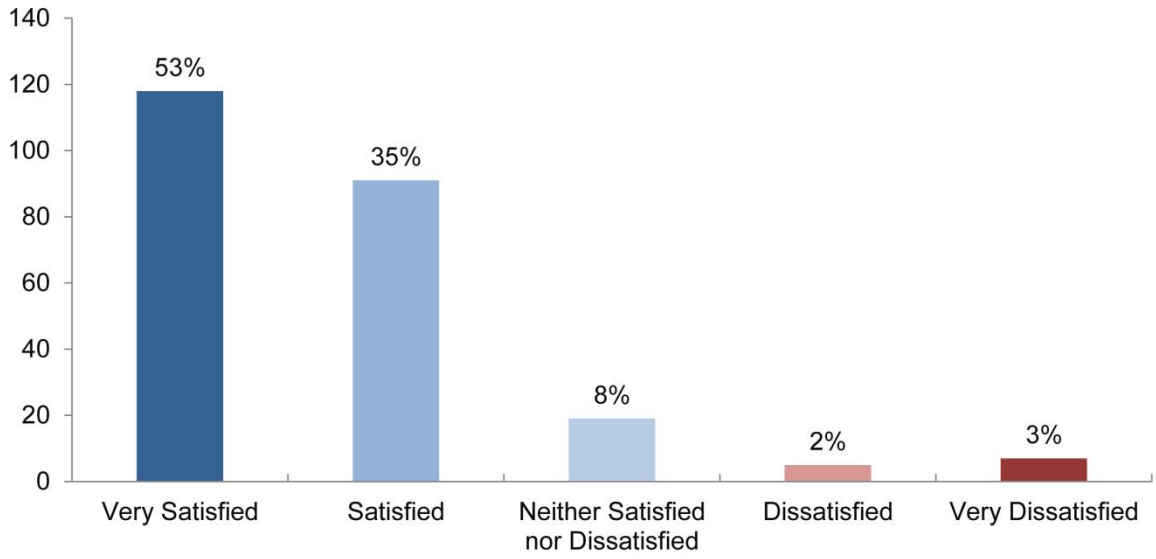

Figure 5.5. Satisfaction level with the service provided (n=239).

5.3.1. Cost Analysis

For this cost analysis, of the 289 patient responses that were recorded, those that did not receive an appointment with the optometrist are excluded (n = 54). Furthermore, those who were seen, but had incomplete data (i.e. alternative source of treatment not filled in) were also excluded (n = 20). This leaves 215 patients of which, 133 presented with symptoms that are considered red flags. For this cohort of patients it is recommended that they will be referred into a hospital ophthalmology department (Kilduff and Lois 2016; National Institute for Health and Care Excellence 2016b; Robinson 2017). For the present calculation, we will assume that 100% of these patients received this referral from their GP. Although A&E doctors are likely to follow the same protocol as GPs for red flag symptoms, the present cost analysis adopts a conservative approach by assuming that the A&E doctor seeing these patients was an eye specialist and successfully managed these patients at first visit. Appointment costs are based on those mentioned earlier and a visit to the pharmacy is assumed to cost £0 and a figure of £46 is assumed for optometric reimbursement to reflect the highest cost of the scheme in neighbouring regions. All costs are per appointment, irrespective of time taken (Table 5.2).

Table 5.2. Cost analysis of the present study.

N= 215	With Scheme	Without Scheme
Not Seen/ Pharmacy	0 x £0[i] = £0.00	14 x £0 = £0.00
GP	15 x £30[ii] = £450.00	123 x £30 = £3,690.00
A&E	0 x £93[iii] = £0.00	76 x £93 = £7,068
Ophthalmology Referral	35 x £139[iv] = £4,865.00	55 x £139 = £7,645.00
Optometrist	215 x £46[v] = £9,890.00	2 x £0 = £0.00
Total	**£15,205.00**	**£18,403.00**

[i] The cost to the NHS of seeing a community pharmacist, or if the patient doesn't see anyone, is assumed to be £0. [ii] A GP visit is costed at £30 (NHS England 2019c). [iii] An A&E visit costs £93 (NHS Improvement and NHS England 2017). [iv] The cost of a first ophthalmology appointment is £139 (NHS Improvement and NHS England 2017). [v] The cost of a MECS appointment is presumed to be £46 which represents the highest first visit cost in neighbouring areas.

The results of the present study show that in the 6-week timescale, with a relatively small number of participating optometrists there was a theoretical cost saving to the NHS of £13,088 as optometrists were seeing the patients and not redirecting them to GPs or A&E. In this example, a MECS scheme costing £46 per episode would have resulted in a theoretical cost saving of £3,198 to the NHS. In this instance, optometric remuneration of less than £85.60 per MECS appointment would have resulted in a cost-saving. In reality, due to over demand for GP and secondary care resources, a MECS scheme may not reduce costs to the CCG, but does, however, result in a more appropriate case mix in secondary care that is cost-effective. Reduced costs may also be achieved by patients seeing an optometrist, nurse or other health care professional in place of an ophthalmologist within the hospital ophthalmology departments. However, with the present secondary care funding structure this could still be classed as an 'ophthalmology led' service and would not result in any decrease in costs to the CCGs. Furthermore, whilst this section looked at costs to the NHS, costs to patients have not been considered. As has been reported for patients attending community, or hospital based clinics for

glaucoma care (Sharma et al. 2012),It might be that costs to the patient of attending a local high street optometry practice with a flexible appointment system would also be less than the cost for the patient to attend a GP, A+E or hospital ophthalmology department. Studies that have looked into costs for the health care provider have found, however, that providing care in the community is more expensive than that of hospital care (Gillam et al. 1995; Sharma et al. 2012).

5.4. Discussion

At the time of writing (February 2019), Bradford, Leeds and Airedale did not have a MECS commissioned. The results from this study indicated that a MECS scheme would receive high patient satisfaction, while concurrently reducing the number of unnecessary presentations of eye conditions to GPs and secondary care. Furthermore, community management of minor eye conditions appears cost effective. Although important, cost is not the sole factor in determining viability of local enhanced services. Patient safety, satisfaction and service efficiency must be considered.

Getting it right first time is proposed to reduce waiting times, provide cost savings and improve the patient journey (Briggs 2012; MacEwen et al. 2017; NHS Providers 2018). The present study supports this statement by demonstrating that a number of patients who would have seen the GP and subsequently been referred to ophthalmology did not require any treatment (84%). This result is perhaps unsurprising given the small amount of ophthalmological training UK GPs receive (Shuttleworth and Marsh 1997; Baylis et al. 2011; Welch and Eckstein 2011; Kilduff and Lois 2016). In line with this, a recent study on stakeholder attitudes towards MECS in Lewisham and Lambeth report that GPs support MECS, stating that ‘MECS would improve care and the patient journey’ (Konstantakopoulou et al. 2014).

As detailed in section 1.2.1, reports of the absolute cost savings of MECS are inconclusive. Whilst the PEARS in Wales incurs an increase in costs of approximately £12 per episode (Sheen et al. 2009), reviews of the MECS in Lambeth and Lewisham found that cost savings were 0.6% and 16.9% respectively, relative to a control region in close proximity (Southwark) that didn't have a MECS service (Mason et al. 2017). Whereas the data from the PEARS covers the whole of Wales, the data from England is limited to two areas with differing service specifications (Mason et al. 2017). More importantly, the study by Mason and colleagues (2017) use the number of outpatient appointments in three areas – two with, and one without a MECS. As mentioned in the general introduction, it is unclear if the results reported could have been a result of a change in staffing levels allowing for an increase/decrease in outpatient appointment availability over the time period. Furthermore, the differing results between these two areas highlight the dangers in generalising across the whole of England due to varying demographics, workforce and service specifications. Importantly, however, it has been reported that MECS have been found to be cost-effective, irrespective of absolute cost savings (Sheen et al. 2009; Baker et al. 2016; Mason et al. 2017).

In the present study, after receiving a privately funded appointment, 25% of patients required a further appointment from a healthcare professional (GP or ophthalmologist). In contrast, prior to the MECS appointment 93% of patients would have presented to the GP or A&E. Whilst there are very few studies on the unmet need of ophthalmology services (The Royal College of Ophthalmologists 2017a), the amount of patients that would not have sought an alternative form of treatment in the present study was low (4%). This figure is unsurprising given that there was no publicised scheme offering a free optometric eye service; the patients that attended the optometrist were likely to be those that expected to have to pay. Whilst meeting unmet need might be seen as unnecessary expense, it's important to consider that improving access to health care (therefore increasing demand) is likely to result in detection of previously undiagnosed disease. Importantly, however, performing health checks and giving reassurance to patients whose symptoms would eventually

self-resolve is reassuring the patient and likely to cause a benefit in terms of anxiety.

The findings of the present study support the premise that MECS would reduce unnecessary referrals into hospital ophthalmology departments. Specifically, for patients presenting with symptoms of flashing lights and/or floaters, 78% of these were retained in primary care optometry: 22% were referred onto hospital ophthalmology. This figure in line with several studies citing the prevalence of retinal tear/breaks/detachment or other conditions requiring ophthalmological opinion being present in 9.4 – 27.1% of patients presenting with flashing lights and/or floaters (Posterior Vitreous Detachment (PVD) (Diamond 1992; Hikichi and Trempe 1994; Dayan et al. 1996; Hollands et al. 2009; Khandhadia et al. 2009; Seider et al. 2021). As unnecessary (false-positive) referrals to hospital departments have been reported to cause negative psychological consequences to the patients (Tymstra 1986; Brewer et al. 2007; Davey et al. 2013), reducing the number of false-positive referrals into secondary care is expected to reduce the amount of referral-associated anxiety. An advantage of providing enhanced eye care within the community allows patients to have care closer-to-home with a more flexible appointment booking system. Beyond the financial sustainability, as in the UK there are significantly greater numbers of optometrists (The College of Optometrists 2016), relative to ophthalmologists (The Royal College of Ophthalmologists 2016), it is also expected that care by optometrists in the community would be more sustainable for the workforce. In addition, in areas of the UK where distance to the hospital ophthalmology department is large, a visit to the patient's local optometry practice could be significantly more convenient and provide economical savings, for example, by reducing time taken off work to attend a health assessment.

Although a small number of patients presented with their only symptom being loss of vision (n=14), they were typically referred to either ophthalmology (n=8) or to their GP (n=1). Only 5 of these patients could be successfully managed in optometric practice. This indicates that there could be certain conditions that should bypass the optometrist and be directed directly to secondary care. Further work, however, is needed to explore this.

The present study supports previous findings demonstrating that cost is a factor influencing whether a patient will present to an optometrist (Hayden 2012; Leamon et al. 2014). Although only a small number of optometrists explicitly recorded the reason when a patient declined an appointment, the majority (4/6) recorded that the patient declined due to the fee. In these instances the patient was redirected to free-to-access health care (A&E, GP, and Pharmacy). Although this number is too small to draw any conclusions, it is in line with the core principles and values of the NHS: Specifically, that health care will be provided free at the point of delivery and not based on the ability to pay (National Health Service 2018). Furthermore, previous research has indicated that optometrist participation in these enhanced optometric schemes partially depends on financial remuneration (Konstantakopoulou et al. 2014). For the reasons aforementioned, to ensure widespread optometrist participation and public engagement it is important that any MECS is appropriately funded. The cost analysis of the present study reveals that community eye care could be an effective use of the finite resources of the NHS.

The present study, despite auditing patient episodes beyond the scope of a GOS sight test, revealed that 9% of patients were seen under the GOS sight test. This is despite this being in contradiction to the legal advice of the UK's Association of Optometrists (Association of Optometrists 2015). This demonstrates that a significant proportion of practices were not clear on what constitutes a NHS funded sight test, and what does not. Further work is required to understand optometrists understanding on this.

5.4.1. Limitations

A limitation of the present study is that only a sample of optometrists in the area participated which increases the likelihood of a self-selection bias being present in these data. This, however, could be mirrored by the self-selection of those optometrists who decide to participate in enhanced community services like MECS. Attempts were made to quantify how many optometrists in total were practising in the area however these data were not available from either Local

Optical Committees or NHS Primary Care Support England. The geographical location, optometrist experience or practice type may also result in bias in the clinical decision making (Davey et al. 2016; Parkins et al. 2018).

In the present study, as participating optometrists knew that their results would be closely audited, this may have influenced their clinical decision making resulting in an observer effect. The impact of this may be considerable given that participating optometrists also knew that these results could influence whether or not a MECS would be commissioned in these areas. Regular and continuing audit, therefore, is essential to assess long term effectiveness and efficiency of any enhanced scheme. Optometrists did not also record how much they attempted to charge the patient for a private consultation. This could have been more than the cost of a sight test as subsequent spectacle purchases subsidise the cost of the sight test, which wouldn't have occurred for an appointment to manage an acute eye problem.

A further limitation of the present study is that the false-negative outcome of the patients managed by primary care optometrists was not measured. Although the results of the present study were broadly similar between Leeds, Bradford and Airedale, further work is needed to assess the impact that a MECS would have in other areas of the UK, due to varying local referral guidelines and demographics.

It is likely that a number of patients will not have presented to participating optometrist with their eye problems in the time period of the present study. The total number of expected patient numbers that such a commissioned service might serve, therefore, cannot be accurately drawn from the present study

5.5. Conclusion

The present study supports the view that improvements in primary eye care could be made by using optometry based enhanced services for the management of acute eye problems. It would be expected that this service would alter the case mix of referrals into hospital ophthalmology departments

making it more appropriate to secondary care. Furthermore, this study provides support for the notion that a MECS in Bradford, Leeds and Airedale would contribute towards efficient use of finite NHS resources while retaining high levels of patient satisfaction.

Chapter 6

6. Analysis of Minor Eye Condition Services (MECS) across England, UK.

6.1. Introduction

As detailed in sections 1.2.1 and 2.1, MECS aim to provide rapid access to professional eye care (LOCSU 2018). They are typically commissioned, and subsequently audited, at a local level. The content, quality and frequency of data collection is currently unknown. It could be that the data collected only contains details of the numbers of patients seen through these schemes in order to provide payment to optical practices. Alternatively, although unlikely, it could be that data collected contains information on false-positive onward referrals. The limited numbers of published studies on MECS demonstrate that they are cost-effective (Sheen et al. 2009; Konstantakopoulou et al. 2014; Chaturvedi et al. 2015; Cottier 2015; Konstantakopoulou et al. 2016; McAlinden et al. 2016; Mason et al. 2017; Konstantakopoulou et al. 2018). These studies, however, are limited to single locations and due to varying demographics and service specifications cannot be used to generalise to other areas. Wales, in contrast to England, has a national scheme (PEARS) that has the same aims as the English MECS. It has been reported that PEARS in Wales are cost effective and clinically safe (Sheen et al. 2009). As such, the aim of this chapter is to collect and combine the data from MECS across England, to provide an evidence base for, or against, the commissioning of MECS schemes.

Furthermore, our research in the previous chapter found that there may be certain presenting complaints which are more likely to result in a referral onto GP/Hospital care. If this is the case, the patient journey could be improved by bypassing the optometrist. Accordingly we aim to examine this on a national level.

Specifically, we aim to examine 1) the outcomes of the appointments. 2) The demographics of patients accessing these services (whether there is an effect

of socio-economic status). 3) Whether these schemes are generalizable across different areas. 4) Whether there are any presenting symptoms which are more likely than not, to result in an onwards referral to a medical professional. We hypothesised that the overall results would be similar to that of previously reported services. For example, that approximately 17-19% of patients are subsequently referred to hospital ophthalmology departments (Konstantakopoulou et al. 2016; McAlinden et al. 2016). We also hypothesised that given the results of chapter 5, patients with acute loss of vision would be referred to secondary care in more cases than not.

6.2. Methods

CCGs and LOCs typically commission schemes with the aid of LOCSU (https://www.locsu.co.uk/). LOCs themselves cannot hold contracts, therefore, a number of LOCs use Primary Eyecare Companies to place bids for enhanced optical services contracts on their behalf. At the time of the study, the largest Primary eye care company in England (PEC Services, now known as Primary Eyecare https://primaryeyecare.co.uk/) routinely used software (OptoManager) to capture metrics for audit purposes. LOCSU is the overarching organisation that supports all PECs in England. Accordingly, the authors contacted LOCSU in an attempt to obtain this data. Some other LOCs, however, have MECS commissioned through CCGs to individual practices or other PECs. For these areas, the authors used the LOCSU's website (https://www.loc-net.org.uk/loc-net/alphabetical-list/) to find contact details for all LOC's in England (25/01/2019). LOC's / Eye care companies were initially contacted by email, followed by a follow up email. In cases where there was no reply to the second email request, a further email was sent. If no contact details were available or no response was received, other LOCs might be able to provide information on whether schemes exist in those areas and so were contacted. The authors requested information on whether MECS (also known as PEARS) schemes were commissioned in any of the areas that the LOC represented. If there were commissioned schemes, we asked for any anonymised data that they may hold. If the scheme was managed through a separate company, the company was contacted directly and each LOC that the company provides services for wasn't

contacted. For example, if four LOCs provided a MECS through a particular Primary eyecare company, the eyecare company was contacted directly rather than all of the individual LOCs.

Ethical approval was granted by the Chair of the Biomedical, Natural, Physical and Health Sciences Research Ethics Panel at the University of Bradford on 03/01/2019 (EC25364).

6.3. Results

Due to the overarching organisation (LOCSU) being unable to provide any data, LOCs and PECs were contacted between 25/01/2019 and 15/05/2020. Data collection was paused whilst in contact with LOCSU, which accounts for the large time difference between first contacts with some LOCs, when compared to others. Information was gathered from 76 out of 78 LOCs. Three LOCs had no contact details available on the website and thus, were unable to be contacted, although information on one area was obtained from other LOCs. In total, 48 LOCs were contacted which provided information on the 76 LOC areas.
Nine LOCs directed us to LOCSU and 25 directed us to Primary Eyecare Services who subsequently directed us to LOCSU. Four LOCs were covered by Primary Eye Care North Yorkshire and Humber. The MECS commissioned by Primary Eyecare North Yorkshire and Humber, at the time of response, was undergoing significant alterations and, therefore, was significantly different to a 'typical' MECS and is not included here further but is discussed in the following chapter. Eight LOCs directed us to JCL consulting (http://www.jclconsulting.co.uk/index.php), who responded and attempted to gather data from respective CCGs. One CCG was able to provide some data (Somerset). Two LOCs had services commissioned through Community Health and Eye Care Ltd. who responded positively, but ultimately, did not provide any data. Three LOCs had services commissioned through Evolutio Care Innovations Ltd. who also responded positively, but ultimately did not provide any data. 17 LOCs did not currently have a MECS/PEARS commissioned. Three LOCs stated that they have MECS commissioned, but did not have access to any data. Two LOCs responded positively and were able to provide

data (Bradford and Devon). N.b. Bradford CCG commissioned a MECS after the audit of the previous chapter. Two LOCs did not respond and no information was able to be gathered on whether schemes exist in these areas. Two LOCs had no contact details and information was not able to be gathered. One LOC agreed to send data but ultimately didn't (table 6.1).

Table 6.1. The outcome of contacting all LOCs in England.PENYH: Primary Eyecare North Yorkshire and Humber; CHEC: Community Health and Eyecare; MECS: Minor Eye Condition Services

Number of LOCs	Outcome	Data
25	Commission through Primary eyecare Services	No data
17	No MECS	No data
9	Contact LOCSU	No data
8	Contact JCL Consulting	Data from 1 area
4	Commission through PENYH	Not typical MECS
3	Commission through Evolutio	No data
3	Have MECS	No data
2	Commission through CHEC	No data
2	Have MECS	Sent data
2	No contact details	No data
2	No response	No data
1	Have MECS - agreed to, but didn't send, data	No data

In summary, data was obtained from three LOC areas: Bradford, Devon and Somerset.

Somerset CCG could only provide a basic overview of their service. Specifically, it was reported that for the 18 months March 2018 to August 2019, 17,627 appointments were conducted of which 2,408 were for follow up visits. The reasons for presenting to the initial appointments are detailed in table (7.2).

Table 6.2. The conditions that patients presented with to the Somerset urgent eye care service (n = 20,389). N is greater than sample size due to the way Somerset recorded patients presenting with more than one condition.

Condition/symptom	Number	% of total
Ocular pain or discomfort	7086	34.8
Red eye/s	4057	19.9
Flashes and/or Floaters	3542	17.4
Sudden or recent change in vision	2509	12.3
Other	1551	7.6
Suspected foreign body	1004	4.9
FB / Trauma	301	1.5
Recent onset diplopia	183	0.9
Significant recent discharge	156	0.8

Similarly, Devon LOC could provide some details on presenting reasons (table 6.3) and further detail such as how the patients were managed (table 6.4). In total, 2831 patients accessed the service between October 2018 and May 2019, of which, one patients presenting reason was not recorded. For Bradford, data were received covering June 2019 to February 2020 and presenting reasons are displayed in table 6.3

Table 6.3. The conditions that patients presented with to the Devon (n=2830) and Bradford (n=4806) urgent eye care services.

Condition/symptom	Devon		Bradford		Combined[+]	
	n	%	n	%	n	%
Flashes and/or Floaters	729	25.8	751	15.6	1397	19.7
Ocular pain or discomfort	610	21.6	691	14.4	1224	17.2
Red eye/s	408	14.4	1076	22.4	1364	19.2
Eye and lid Lumps and Bumps	255	9	186	3.9	420	5.9
Recent change or distortion in vision	246	8.7	172	3.6	399	5.6
Dry, gritty or itchy eye	222	7.8	301	6.3	490	6.9
FB / Trauma	217	7.7	130	2.7	333	4.7
Sticky and/or watery eye	126	4.5	383	8	466	6.6
Other	17	0.6	1116*	23.2	1009	14.2

** 'Other' for Bradford includes patients that presented with multiple symptoms, for example, a red, watery, sticky eye that was uncomfortable. [+]adjusted for differing time periods (Devon = 8 months, Bradford = 9 months)*

Overall, the most common presenting reasons were flashing lights and/or floaters (19.7%), red eye(s) (19.2% and painful eyes (17.2%). The outcomes of patients presenting in Devon and Bradford are displayed in table 6.4

Table 6.4 The outcome of patients presenting to the MECS in Devon (n = 2831) and Bradford (n = 4806) (% not equal to 100, due to rounding).

Outcome	Devon		Bradford		Combined[+]	
	n	%	n	%	n	%
Discharged	1864	65.8	3846	80.0	5283	74.4
Refer to Hospital	509	18.0	584	12.2	1028	14.5
Follow up in practice	207	7.3	118	2.5	312	4.4
Refer to GP	132	4.7	255	5.3	359	5.0
Refer to Pharmacy	119	4.2	3	0.1	122	1.7

[+]adjusted for differing time periods (Devon = 8 months, Bradford = 9 months)

In summary, in Devon 73.1% of patients were retained in optometric practice, 8.9% in another provider of primary care health care and 18.0% were referred

onto secondary care. Similarly, in Bradford, 82.5% of patients were retained in optometric practice, 5.4% in another provider of primary care health care and 12.2% were referred onto secondary care. Overall, 78.8% of patients were retained in optometric practice, with 14.5% being referred to hospital ophthalmology departments and 6.7% to other primary care providers (GP/Pharmacy).

The data from Bradford also gave information regarding what patients would have done, should the MECS not have been available (table 6.5).

Table 6.5. The alternate providers of care that patients would have attended to, should there not have been a MECS commissioned (n= 4806).

Alternate Provider	Number	% of total
GP	3644	75.8
A+E	724	15.1
Pharmacy	105	2.2
See Optometrist	230	4.8
Self-managed	64	1.3
Unknown	21	0.4
111	18	0.4

GP: General practitioner; A+E: Accident and Emergency

Overall, 93.4% of patients would have tried to find an alternate source of health care mainly in the form of their GP (75.8%) or A+E (15.1%). Only 1.3% would have tried to manage their condition without professional help or advice. Additionally, Bradford also provided data on satisfaction levels, which is displayed in figure 6.1. A large majority of patients were very Patients were satisfied (85.6%) or satisfied (13.5%) with the Bradford MECS (99.1%).

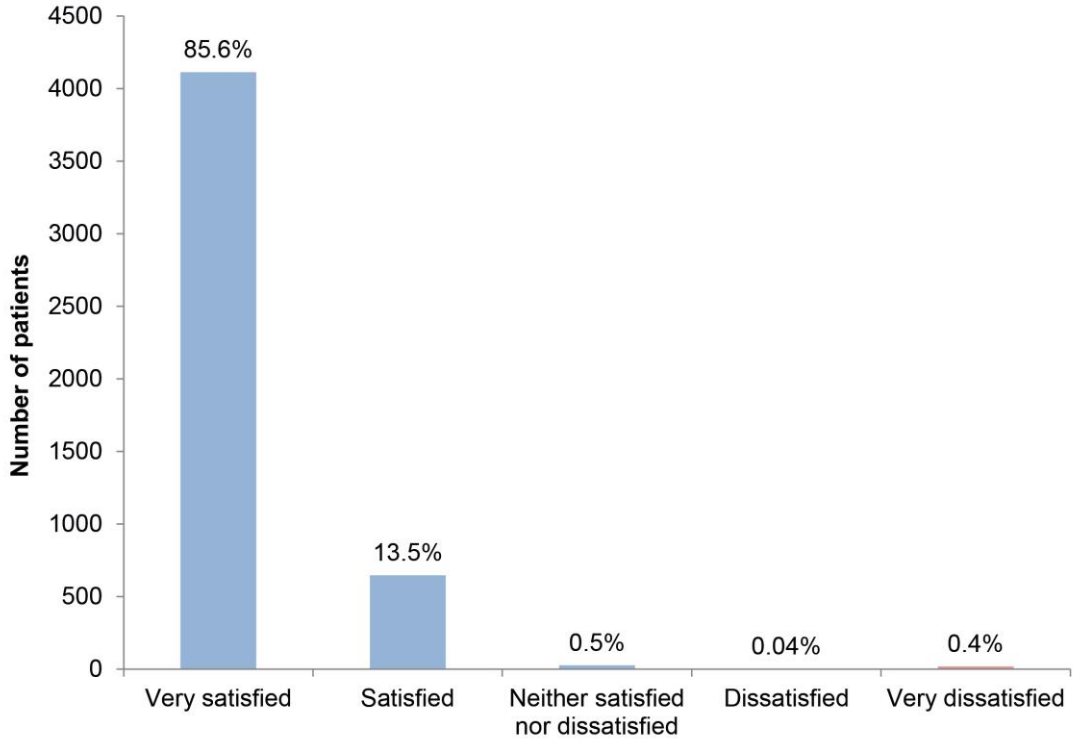

Figure 6.1. Satisfaction levels for the MECS service in Bradford (n = 4806).

The data from Bradford were not of sufficient quality to be able to examine which conditions were referred to the hospital. The data from Devon, however, were (table 6.6).

Table 6.6. A breakdown of the presenting symptoms of patients in Devon that subsequently receive an onward referral to their general practitioner (GP), Hospital Eye Service (HES) and Pharmacy.

Presenting symptom	Total (n)	Referred (n)			Referred (%)
		GP	HES	Pharmacy	
Flashes and/or Floaters	729	12	98	1	15.2
Ocular pain or discomfort	610	32	129	29	31.1
Red eye/s	408	15	68	26	26.7
Eye and lid lumps and bumps	255	23	31	14	26.7
Recent change or distortion in vision	246	29	118	1	60.2
Dry, gritty or itchy eye	222	12	14	14	18.0
Foreign Body / Trauma	217	1	34	10	20.7
Sticky and/or watery eye	126	6	12	24	33.3
Other	17	2	5	0	41.2

GP: General practitioner; HES: Hospital Eye Service

In line with the findings of the previous chapter, patients who present with symptoms of acute onset loss of vision are typically referred onwards to hospital ophthalmology departments.

6.4. Discussion

There is a paucity of published evidence compared to the number of MECS in operation. Additionally, there does not seem to be ongoing robust data collection regarding MECS type services. Only 3 out of 76 LOC areas had MECS data that they were able to share with the research team. These data, however, were very basic and mainly provided information regarding patient numbers. Two of the three areas also routinely captured the outcome of the MECS (whether or not the patient was referred onto another provider of health care). No areas, however, collected data on true or false positives or negatives. Accordingly, the safety of minor-eye condition services is unknown. In line with previous studies, and our hypothesis, approximately 14.5% of acute eye consultations resulted in a referral to hospital ophthalmology departments. Importantly, this study supports our hypothesis that there might be some presenting symptoms that could be more appropriately managed by medical professionals (e.g. GP/Ophthalmologists), rather than optometrists.

As detailed in the thesis introduction, MECS have been reported to be a cost effective method of managing patients with eye problems (Sheen et al. 2009; Konstantakopoulou et al. 2016). It is unknown whether patients are being appropriately managed in most services, however, the national PEARS in Wales however, has been reported to be clinically safe, utilising a methodology of phoning patients after their appointment to find out what happened (Sheen et al. 2009). On the other hand, in England, the only evaluation looking at safety of MECS has examined whether the referrals to the hospital eye service were appropriate (Konstantakopoulou et al. 2018). Whilst false-positive referrals can help with an indication of a services cost-effectiveness, it neglects the aspect of patient care that is arguable more important clinically – false-negatives. When looking at the impact on an individual level, the patient that is incorrectly-referred to the hospital, despite experiencing increased anxiety (Davey et al. 2013), is unlikely to suffer irreversible damage to eye health as a result. For patients incorrectly not referred however, this is a considerable possibility.

The present study demonstrates that although MECS are commissioned across a large proportion of England, whether the schemes are cost or clinically effective is unknown, even to those who fund such schemes. As mentioned earlier, given that these services are funded and commissioned with differences between areas, current evidence on a small scale cannot be used to generalise to different areas. Accordingly, this could potentially support the view that services need to be commissioned over a geographically large area with consistency of data collection and reporting conforming to a minimum dataset (Davey et al. 2017). If data collection is consistent, this will subsequently allow for future research to successfully examine whether it is in the patients', or health care systems best interests. The data currently collected appears to be based mainly around patient numbers. This is unsurprising: without knowing how many patients go through the service, participating practices would not get paid and commissioners would not be able to budget accordingly. What is surprising, however, is that it does not appear that the data from these services are able to adequately describe the quality of the service.

Interestingly In our previous study examining the need for a MECS in Bradford, we reported that the data suggested that there could be a subset of patients who, based on presenting reason, might benefit from bypassing the optometrist and instead be directed to the hospital ophthalmology department. The present study found that 60% of patients with symptoms of loss of vision were referred onto either the patients' GP, or direct to ophthalmology. This is in line with the 64% found in the previous chapter and highlights that future work is needed to examine the possible consequences on ocular health that a potential delay in the delivering of care might result in. For example, it might be that patients who originally present to their GP with acute onset loss of vision could be directly referred to the hospital, rather than an optometrist in community. It has been reported that the most likely reason for a patient over 30 experiencing sudden onset, painless loss of vision is a central retinal artery occlusion. Accordingly, delays in delivering of care, could be life threatening and should therefore be minimised (Georgalas et al. 2014; Weymouth and Pedersen 2019). In contrast, it might be that the visit to the optometrist provides additional information to the patients onwards referral that enables effective triage. Accordingly, the 'delay' in

service might be of benefit. The additional information combined with 40% of patients not being unnecessarily referred to the hospital or GP could have benefits that outweigh the potentially small time delay. Future work is required to quantify this.

The case mix found in the present study is consistent with the previously published literature (Konstantakopoulou et al. 2018). Specifically, the 3 main reasons for patients attending an urgent eye care appointment were flashing lights and/or floaters, red eyes and painful eyes. Although Konstantakopoulou reported a higher percentage of patients attending for 'red eyes' (36.7%), than in the present study (19.2%), these differences may be partially explained by differences in the collection of data. There is no consistent reporting of MECS and audits are conducted differently in different areas. Accordingly, optometrists selecting 'other', in Bradford to record a combination of conditions would reduce the percentage correctly listed with red eyes. An alternative explanation could be differing prevalence's of eye conditions in different parts of the country. The prevalence of different eye conditions presenting for the MECS could in part be explained by the urgent eye care schemes being at different stages. For example, whilst the MECS in Bradford was a new scheme, the scheme in Devon had been running for a number of years. Accordingly, it might be that the self-limiting, or minor conditions that patients present with early on in a schemes course may not represent at later years due to patient education (e.g. dry eye type symptoms). Patient presenting with flashing lights and floaters, for example, may increase as the years go by, due to an aging population and education that these symptoms require urgent investigation. Future research could utilise a standardised reporting with a minimum data set (Davey et al. 2017) to elucidate this issue.

In conclusion, in order to ensure patient safety is maintained, clinical data from health services should be routinely collected to robustly examine clinical safety. Specifically, this should include the planning of research to quantify the number of patients who came to harm, despite accessing the service (e.g. false negatives). The present study supported the view that there may be certain

presenting symptoms that should be directed to a medical professional (ophthalmologist) rather than visiting an optometrist.

6.4.1. Limitations

The main limitation of the present study was the poor response rate. Despite data collection taking place over a large period of time, most responders either did not collect data or they were unwilling to share the data. This small sample size has limited the useful analysis of the data: data from two areas is unlikely to be generalizable to the rest of the country.

A further limitation of this study is that there is also no assessment of these schemes safety: no area reported numbers of true/false positives/negatives. It appears that these schemes are assumed to be safe with no ongoing evaluation.

Chapter 7

7. Evaluation of the clinical safety of a COVID Urgent Eyecare Service.

7.1. Introduction

The work in this chapter has been published in *Ophthalmic and Physiological Optics (Swystun and Davey 2021b)* and is available at: https://onlinelibrary.wiley.com/doi/epdf/10.1111/opo.12916

COVID-19 altered the way that health care was provided. In particular, emphasis was placed on managing patients remotely, where possible (Nagra et al. 2020). This was an area novel to optometrists working in the UK, who typically managed patients in person and the College of Optometrists rapidly issued guidance on this (The College of Optometrists 2020c). Although telephone triaging may have been used to determine the criteria for how soon the patient needed seeing, there were no virtual appointments offered and optometrists typically had received no training on conducting remote consultations.

Unlike in neighbouring Scotland and Wales, the provision and commissioning of eye care in England is fragmented. As detailed in section 1.1, sight tests performed for symptoms that are refractive in nature are covered and commissioned nationally, whereas all other services (e.g. automated visual field tests, repeated tonometry and acute eye problem consultations) are provided either at a cost to the patient, the practice, or in some areas, covered by local NHS teams known as clinical commissioning groups (CCGs) (Association of Optometrists 2018b). This lack of consistent commissioning across the country leads to local variations in service provision and patient care. Therefore, whilst some countries of the UK already had national provision of emergency eye care in the community (e.g. Wales, Scotland and Northern Ireland), England did not. Some areas of England, such as those in the present study had existing Minor Eye Condition Schemes (MECS, also known as Primary Eyecare Acute Referral

Scheme: PEARS), examples of which have been previously reported (Konstantakopoulou et al. 2018). In these services patients could self-present to, or be referred to an accredited optometrist who was funded to provide an assessment beyond the scope of a sight test at no charge to the patient (Association of Optometrists 2015). Accordingly, the existing minor eye condition scheme (MECS) across the areas of the present study (Hull, East Riding of Yorkshire, Harrogate, Bedfordshire and Luton CCG areas) were required to be altered by each of the respective CCGs. Specifically, in March 2020 the contract of the MECS was altered, instead of offering a cost per episode, the payment structure was changed to a block contract on a month-to-month basis and an initial telephone triage was added to the patient journey. This adapted service (COVID Urgent Eyecare Service, CUES) commenced across Hull, East Riding of Yorkshire and Harrogate CCG areas from April 17th 2020 and was provided by Primary Eyecare North Yorkshire and Humber. Subsequently Bedfordshire and Luton CCGs opted to provide CUES, commissioned through Ocular Outcomes (a private company directed by some of the staff involved in Primary Eyecare North Yorkshire and Humber). Some of the aims of CUES are similar to that of MECS: to reduce unnecessary presentations to secondary care. CUES, however, provided care beyond that seen in a typical MECS by enabling the addition of remote (e.g. telephone based) consultation that could provide care for those clinically vulnerable or unable to visit an optometrist in person. Additionally, instead of offering a payment structure of cost per patient episode, the payment structure was changed to a block contract on a month-to-month basis which provides a budget for the service to operate in and a more accurate financial forecast. This could, however, impact on patient care. Specifically, a company could reduce the quality of care (I.e. less consultations) in order to (a) maximise profit and/or (b) meet the finite budget set. Overall the amendments of the MECS were to: a) reduce unnecessary traveling and encounters between people in the COVID-19 pandemic b) reduce costs to the CCGs (delivering care F2F is more expensive than over the phone).

The design of CUES has been published elsewhere (Harper et al. 2021). Briefly, routine F2F sight testing was suspended in England from April 1st to

June 17th 2020 (Neligan and Sharma 2020). This meant that in areas without previously locally commissioned urgent eye care services, patients with an acute eye problem had to either contact their GP, or hospital in order to receive NHS funded eye care. In order to alleviate unnecessary demands on ophthalmology doctors who were required to be redeployed to other overburdened hospital departments (Attzs and Lakhani 2020; Lim et al. 2020), the COVID-19 Urgent Eye Care specification was published (The College of Optometrists 2020a). This was not intended to replace existing services, but to be an option in areas without currently commissioned services. Accordingly, in part, due to local commissioning, the CUES in the current scheme had some variations from the previously described scheme. In the present study, patients were initially required to telephone a free of charge central phone number (0800) where the patient becomes registered on a custom built system designed by the eye care company (Primary Eyecare North Yorkshire and Humber or OcularOutcomes) ran by PharmOutcomes (Pinncacle Health, https://www.phpartnership.com). As CUES is commissioned on a local level, the service is only available for patients with a GP registered within the area of the CCG. Accordingly, this first step is required to ensure that the patient was registered with a GP in the area and data were verified, where possible, using national database of patient demographic information (Personal Demographic Service) which was extracted from the National Health Service (NHS) spine. Once the patient had registered and their eligibility confirmed, their details and presenting symptoms were taken and this was sent electronically to an optometrist who would then triage the patients as appropriate and subsequently called the patient for a tele-consultation. Optometrists were able to use photos, video calling as well as telephone to aid their consultation at their discretion. As the phone line was a central service, the optometrist would not have any access to the patient's clinical records. This is in contrast to a service where the teleconsultations were provided by the patient's regular practice. However, as patients were freely able to move between optometrists, it was not necessarily the case that a patient would visit their usual optometrist in the event of an acute eye problem. The possible outcomes of the optometrist's tele-consultation were: patient self-management (e.g. over-the-counter medication), a referral direct to alternate care (hospital ophthalmology department, A&E, GP)

or a F2F appointment with the patient's typical optometrist (e.g. high street practice). Patients had free choice of which practice they visited and if their first choice of practice did not have an appointment available, the triaging optometrist found an optometric practice that had availability within the specified timescale.

Optometrists for the telephone consultation service were either known to the directors of the companies or recruited via word-of-mouth and had experience of providing MECS type services. Where possible, these optometrists did not work in the same area that they provide tele-consultations for in order to reduce the likelihood of directing patients to their own practice / place of work. Optometrists did not require any specific a priori local knowledge (I.e. of other locally commissioned services) as the outcome options of the consultation were contained within the service and referrals to F2F providers were made within PharmOutcomes (Bedfordshire Local Optical Committee 2020).

The present study aimed to determine the patient reported clinical safety and effectiveness of the scheme, specifically aiming to identify instances of patients whose problem was incorrectly managed. As previous literature has suggested that urgent eye care schemes (e.g. welsh PEARS) are clinically safe(Sheen et al. 2009), we hypothesised that the present scheme would have low levels of false negatives. Similarly, as optometrists have been reported to be cautious when managing patients with glaucoma (Wright and Diamond 2015), we hypothesise that, for patients presenting with acute eye consultations, optometrists would work 'on the side of caution', and recommend a large amount of F2F consultations and subsequently, refer on to the hospital a large amount of patients unnecessarily.

7.2. Method

In order to examine the effects of more than one categorical predictor variables on a dependent variable with more than two sub-groups, multinomial logistic regression should be utilised (Kwak and Clayton-Matthews 2002; Starkweather and Moske 2011).

In order to estimate a sample size, we need to know: the number of independent variables, the nature of the independent variables (e.g. categorical, ordinal, interval) and the number of levels of each categorical independent variable. In addition, we needed to estimate the number of events in the least frequently occurring level of the dependent variable (de Jong et al. 2019). A priori, our expected category of the dependent variable with the minimum number of events was false negatives. We expected that a greater number of patients were either: correctly referred, correctly not referred, or incorrectly referred, relative to incorrectly not referred. That is, we assume that telephone optometrists would make their decision 'on the side of caution' given the potentially serious nature of conditions that can present to optometric practice. Previous research examining referrals of patients with suspected glaucoma report that of patients that are not referred, approximately, 12% (Gunn et al. 2019) to 15% (Bourne et al. 2010; Ratnarajan et al. 2015) should have been referred. The authors, therefore report overall false negative rates of 4.2% (Ratnarajan et al. 2015), 4.4% (Bourne et al. 2010) and 5.7% (Gunn et al. 2019). There are currently no studies examining false negative rates of MECS/PEARS services. Accordingly, we based our estimate of minimum group membership from false negative rates of the studies examining glaucoma referrals as forementioned. It's worthwhile to note, however, that it is likely that false negative referrals of an asymptomatic disease are not likely to be representative of symptomatic pathologies: acute-onset symptoms are unlikely to have no cause.

De Jong and colleagues provide a detailed description of how to improve the fit of the multinomial logistic regression model (de Jong et al. 2019). Specifically, if the levels of the dependent variable are equal in relative frequency, there are too many independent variables and the sample size is small, the model is likely to over-fit the data. Accordingly, an erroneously high R^2 may be found that represents random noise, rather than the independent variables. In other words, the model will over-estimate the effect to which the independent (predictor) variables predict the dependent (outcome) variable. To combat this effect, the authors propose that a minimum multinomial event per variable ratio of 10 and a

large total sample size is required to avoid model miscalibration (de Jong et al. 2019).

Multinomial event per ratio is defined as the frequency of events in the least occurring outcome (dependent variable) category (nEventMin) divided by the effective number of regression coefficients (excluding intercepts, nERC, equation 1).

$$EPVm = \frac{nEventMin}{nERC}$$

Equation 1. Calculating multinomial event per ratio using the number of events in the least occurring category of dependent variable (nEventMin) and the effective number of regression coefficients (nERC).

De Jong and colleagues define nERC as the number levels of the dependent variable (J) less one all multiplied by the number of independent variables (predictors, R).

$$nERC = (J - 1)R$$

Equation 2. Calculating the effect number of regression coefficients using the number of categories within the dependent variable (J) and the number of independent variables (R)

For categorical Independent variables with G sub groups, the nERC per independent variable is defined as the number of levels of each independent variable (J) less one, multiplied by the number of levels of that independent variable (G) less one.

$$nERC = (J - 1)(G - 1)$$

Equation 3. The number of regression coefficients for categorical independent variables are defined as the number of levels of the independent variable less one, multiplied by the number of levels in the dependent variable less one. In a given multinomial model, nERC is the sum of this value for all independent variables.

In the model of the present study, we have independent variables as follows: Age (continuous), Sex (binary), SES (10 levels), optometrist (9 levels), location (3 levels) and company (2 levels). Accordingly, for the categorical predictors, our nERC (for the dependent variable outcome with 4 levels) is 66 (2x3 + 9x3 8x3 + 2x3 + 1x3). In addition, we have one continuous variable which adds another 3 ((4-1)x1)) to our nERC count.

Therefore, with a minimum EPVm of 10, our required sample size of the lowest group membership would be 690 [(66+3) x 10]. As this group represents 4.2-5.7% of the sample, our total sample size would be required to be 12,105 to 16,429. Given the provider reports receiving between 1,000-2,000 patients per month, due to limitations of time, finance and practicality, this sample size was not viable.

Instead, as we were specifically interested in cases of disease misdiagnosis we could make the dependent variable dichotomous (e.g. misdiagnosis or correct diagnosis) and perform binomial logistic regression.

It has previously been reported that a minimum Event Per Variable of 10 is required. Event per variable in binomial logistic regression is defined, similarly to EPVm, as the ratio of the number of events in the least frequently occurring dependent variable group to the number of regression coefficients excluding intercepts (independent variables) (Peduzzi et al. 1996). More recently, however, this has been questioned (van Smeden et al. 2016). Van Smeden and colleagues performed a Monte Carlo simulation study and reported that when separation of the dependent variable occurs (when one or a combination of independent variables can separate events from non-events),or the total sample size is small, an EVP of greater than 10 may be required. Subsequently, Bujang and colleagues have proposed guidelines for the minimal sample size required for binary logistic regression (Bujang et al. 2018). Bujang and colleagues propose that in order for the logistic regression model to be representative of the population, a minimum sample size of 500 is required. In a validation study of a large, real life population, the authors found that there are two ‘rules of

thumb' that can be used to determine required sample size. These are either an Event per variable of 50 or, n = 100 + 50(i), where i is an integer representing the number of independent variables.

For our study, with six independent variables, (Px Gender, Px age, SES, optometrist, area, company) we needed a minimum sample size of 100 + (50x6) = 400. As this is less than the minimum sample size of 500, we aimed to collect a minimum of 500 responses.

The next step was to take into account response rate. Our study required the patient to consent on two occasions: once at the initial telephone appointment (when they ring the telephone triage line), and once more when they were contacted by the research team. Previous research that has conducted studies in a similar manner reported that 90% (Neese et al. 2003), and 80% (Kiezebrink et al. 2009) of patients who originally consent for a phone survey, subsequently complete the phone survey. Similarly, when conducting telephone research, Bernardi and colleagues (2018) found that between 81 and 91% of patients consent. In contrast to the study by Neese and colleagues, Kiezebrink and colleagues originally gained consent using an 'opt out' method, where lack of not consenting was taken as consenting. This may partially explain why this has a lower response rate. In the studies forementioned, those that the research teams were unable to collect data for are defined as either people that either decline to participate, or those who are unable to be contacted.

For the present study, attempts to contact patients were made a maximum of three times at differing times of day, on different days (O'Toole et al. 2008). Although previous research has suggested that evening and weekend calls give a higher response rate (Weeks et al. 1987; Brick et al. 2007), we did not specifically targeting calls on these times. Instead, those patients that were unable to be contacted during weekday (Monday to Friday, 10:30 – 18:30) were called at the weekend (Saturday or Sunday 10:30 – 18:30) and subsequently on a weekday evening (18:31 – 21:00). The call was made from a mobile number (not withheld) and the researcher introduced themselves at the beginning of the call as recommended (Arfken and Balon 2011).

Given an expected minimum response rate of 80% at the stage of telephone survey, we aimed to have 625 participants consent at the original appointment. When patients have given oral consent for a research team to contact them, it has been reported that 64% of patients consent (Nelson et al. 2002). Accordingly, estimating that 60% of patients consent originally, we aim to run data collection for 1042 patients. As the providers estimate between 1000 and 2000 patients call the service per month, to ensure minimum sample size requirements, the study ran from 01/11/2020 to 24/12/2020 (54 days) in Luton and Bedford and from 30/11/2020 to 22/01/2021 (54 days) in Harrogate, East Riding and Hull. At the time of data collection, optometric practices were considered essential services and remained open to provide F2F care to patients. Patient data for patients who consented were extracted from PharmOutcomes and sent via an encrypted Microsoft Excel spreadsheet to the research team who subsequently attempted to contact the participants. Optometrists were not explicitly made aware that the patients they managed would be contacted for the evaluation.

At the time of the patient's initial phone contact with the free phone numbers of administrative staff, the patient was asked if they would consent to a member of the evaluation team ringing them approximately four weeks after their telephone appointment for a follow up. Clinical and demographic data were extracted from PharmOutcomes. For patients who did not consent for their identifiable data to be used, anonymised data were used.

Approximately four weeks after the patients last appointment (phone or F2F), a member of the research team (AS) phoned all consenting patients to determine: a) Whether the patient could recall the appointment, b) the patients understanding of the treatment, c) whether the treatment resolved the patients issue, d) whether the patient presented to another health care provider to get the issue resolved and e) whether the patient was satisfied with the service. Prior to conducting the short phone survey, informed consent was once again gained.

For the purpose of the present study, we define the schemes effectiveness at resolving patients eye problems (correct/ incorrect decisions) with respect to the definitions displayed in figure 7.1a (tele-consultations) and 7.1b (F2F)

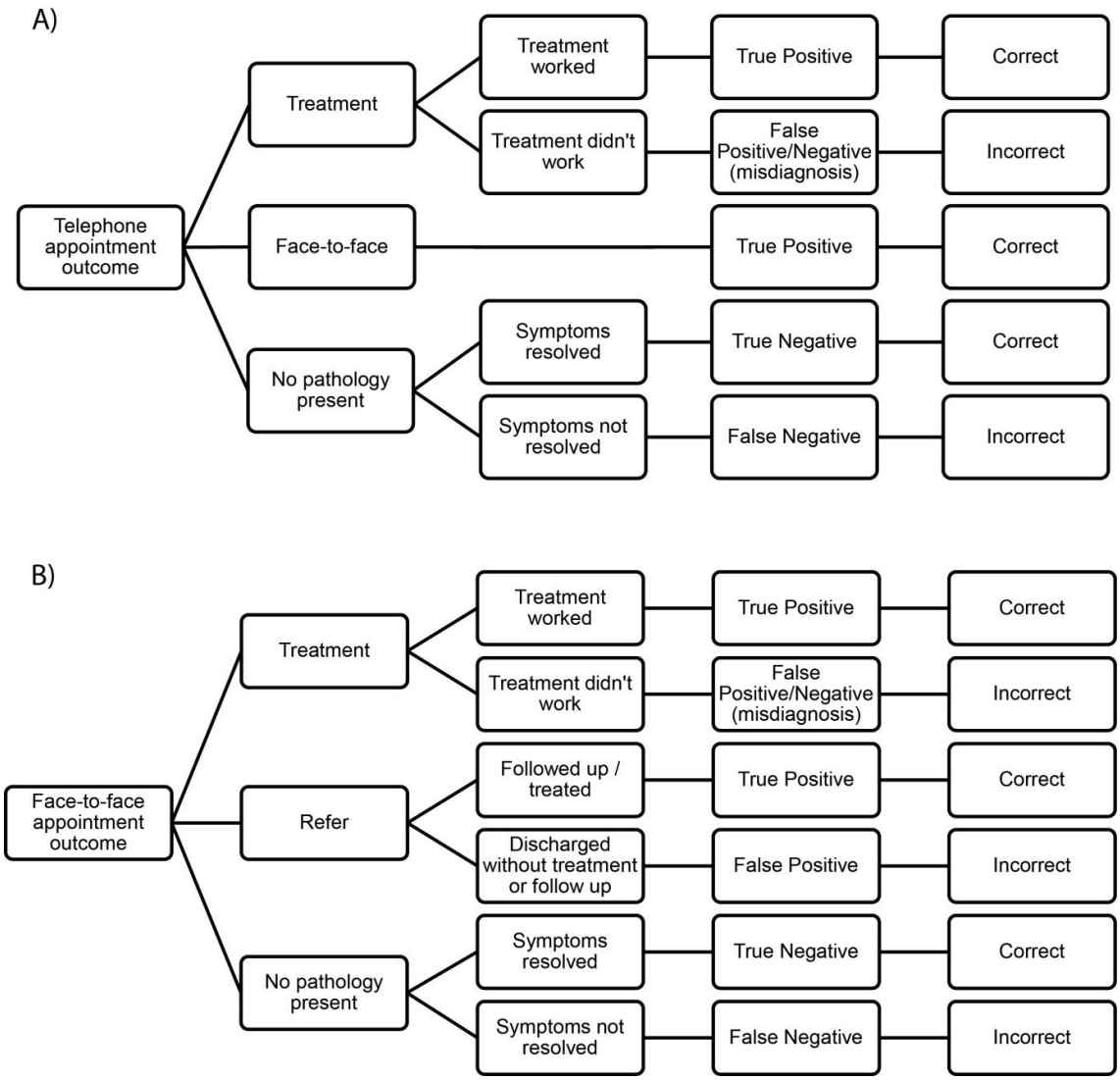

Figure 7.1. The diagnosis decision tree for consultations. Figure 1A: How correct/ incorrect outcomes were determined for telephone consultations. Figure 1B: The decision tree for face-to-face consultations. In order to receive a face-to-face consultation, patients had to pass through the telephone consultation.

For the telephone consultations we expected only patients with ocular symptoms would phone and have an appointment with the telephone optometrist so that there was little opportunity for the evaluation of true / false negatives. This is more likely to occur for the F2F consultations where eye problems may have self-resolved by the time of the appointment.

For the analysis of the schemes safety, as an increased number of appointments for an individual patient were likely to eventually lead to the correct outcome, we included only the outcome of the patient's first appointment. We acknowledge that even the most qualified and experienced professionals may not make the correct treatment decision on one visit. Therefore, for one patient who had two appointments, where the second was an optometrist initiated follow up (i.e. the tele-optometrist phoned the patient to check up on symptoms) the final outcome was included as the outcome for that single case. All cases where the outcome was categorically correct (e.g. optometrist recommended 'xyz' and it resolved the problem) were marked as correct outcome (true positives) by one author (AS). For all patients where the outcome was not categorically correct, the outcome was assessed by two authors (AS/CD) until agreement was reached on the outcome classification. Importantly, due to the study relying on patients informing the research team of whether the recommendation led to the resolving the presenting symptoms, this classification was an over-estimate of the proportion of patients correctly managed. For example, a patient who was recommended treatment for a self-limiting condition would be classified as receiving a correct treatment.

Incorrect diagnoses were categorised into: recommendation didn't work, unnecessary referrals, incorrect diagnosis and major errors. Major errors were defined as an error or omission (as judged by the authors AS and CD) that resulted in a problem that the patient identified, and is likely to have had or could have resulted in harm. 'Major' is differentiated from when the optometrist made a recommendation that didn't work by the nature of the symptom and the patient's report of how the condition deteriorated. For example, a patient who was recommended warm compresses which didn't resolve symptoms of bilateral itchy eyes would be categorised as: 'recommendation that didn't work', rather than 'major error'. If, on the other hand, the patient was subsequently diagnosed with scleritis, this would be classified as a major error. Incorrect diagnoses were able to be determined by the patients account. For example, an incorrect diagnosis was determined to have occurred when: a) the treatment partially solved the patients symptoms, b) the patient used a different treatment

to what the optometrist recommended (which resolved the issue) c) the patient didn't use the optometrist recommended treatment and the condition self-resolved, d) the patient was referred to the hospital and reported that what the optometrist had suggested was incorrect and e) where the patient reported the condition resolved with the treatment but became apparent it was not what the optometrist had described.

For analysis of socioeconomic status, data were analysed by English Lower-Layer Super Output Areas (LSOAs). These are areas in England which have an average population size of 1500 (Ministry of Housing Communities and Local Government 2018). Socioeconomic status (SES) was determined using the Index of Multiple Deprivation (IMD), which is the ranking of LSOAs in order from most to least deprived (i.e. one to ten), nationally based upon weights of various deprivation measurements. LSOAs in decile one, therefore, are in the top 10% of socio-economically deprived LSOAs in the UK (i.e. most deprived). This study utilised data from the Ministry of Housing, communities and Local Government to convert postcodes to IMD deciles (Ministry of Housing Communities and Local Government 2019). Regression analyses were performed using SPSS (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp).

Ethics approval was granted by the Chair of the Biomedical, Natural, Physical and Health Sciences Research Ethics Panel Research Ethics Panel at the University of Bradford on 21/09/20.

7.3. Results

7.3.1. Consenting participants

In total, 2372 patients were asked to participate in the present study. Of these, 1358 (57.3%) consented at the initial stage (when the patient originally contacted the telephone line). Of the 1358 patients who originally consented, 1107 (81.4%) patients comprised the final analysis. 187 patients did not answer the phone, 33 could not remember the appointment, 21 declined to participate,

and 10 were removed for other reasons. Other reasons included the appointment in study period being a follow up call (n = 2), being deceased (n = 1), patient cancelling the appointment before telephone optometrist called (n = 1), the patient being out of the study area (n = 1), number not in use (n = 1), the person answering the phone refusing to let researcher speak to the patient in question (n = 1), incomplete data (n=1) phone number being GP practice, care home or hospital switchboard (n = 3). The total N for Luton / Bedford and East Riding / Hull could not be calculated independently as the anonymous data for the number of patients did not include individual area. In total, data for 1106 patients were included (table 7.1).

Table 7.1. A breakdown of consent rate of patients in each area and the reasons for removing patients from the data analysis. DNA: did not attend.

Area	Total, n	1st consent		Reasons for removal (n)				2nd consent	
		n	%	DNA	Decline	Memory	Other	n	%
Luton	1252	124	53.2	20	3	3	0	98	79.0
Bedford		542		84	5	17	5	431	79.5
Harrogate	346	220	63.6	31	3	6	1	179	81.4
East Riding	766	348	61.6	39	6	6	3	294	84.5
Hull		124		13	4	1	2	104	83.9
Total	2364	**1358**	**57.4**	187	21	33	11	**1106**	**81.4**

DNA: Did not answer

Overall, 1106 patients had 1188 appointments included in the present study. 1036 patients had one teleconsultation, 58 had two appointments and 12 had three appointments.

Ages (in years) were available for all three groups: 1) Those who didn't consent at stage one (when the patient rang the telephone line) 2) Those that originally gave consent, but then withdrew from the study (DNA/ Declined/ Memory/ Other/ incomplete data) and 3) those included in the final analysis (consented at both stages). The median age of each group was 56 (Declined 1st), 53 (Declined 2nd) and 57 (Consented). This data was presented in the ridge plot in figure 2. These data are presented in the box and whisker plot in figure 7.2 and the ridge plot in figure 7.3.

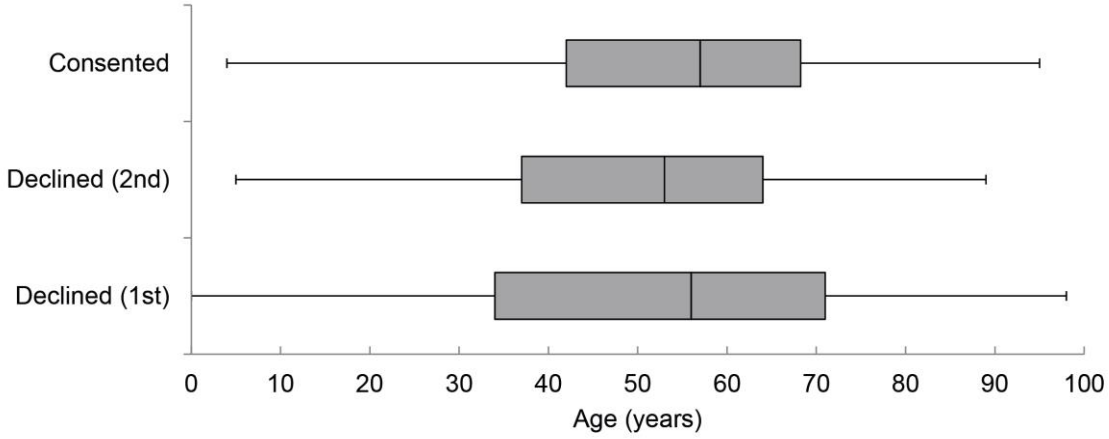

Figure 7.2. Box and whisker plot for patients in the present study. This includes patients who consented at both stages of the study (top bar, median age = 57), those that originally gave consents and subsequently withdrew (middle bar, median age = 53) and those that did not consent (bottom row, median age 56).

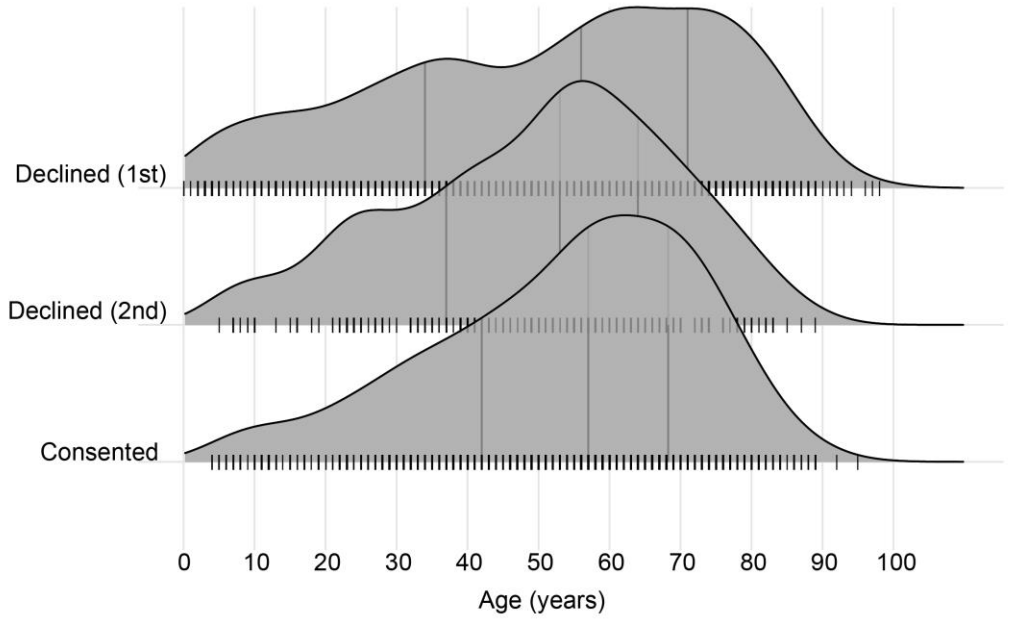

Figure 7.3 Ridge plot showing the distribution of the ages of the patients in each consent group. The median is depicted by the middle long line in each ridge and

the two lines either side represent the end of the 1st (left) and 3rd (right) quartiles. Accordingly, the interquartile range is the area between the left most and rightmost long vertical lines. The height of the ridge indicates the relative frequency of each age and the short bars at the base of each ridge indicate the ages of each patient included in the distribution.

A Kruskal-Wallis H test showed that there was a statistically significant difference in age between the different consent groups, $X^2(2) = 9.59$, $p = 0.01$, and pairwise comparisons, with Bonferroni correction, revealed that the Consent/ No Consent group had a statistically significantly lower age, relative to the Consent/ Consent group ($p = .01$). There were no other statistically significant differences between the ages of the groups. There were no significant difference, however, between the group that originally didn't consent, and the final consent group.

Similarly, a Chi-Square test was used to examine differences in consent rate between the different areas (East Riding/Hull, Harrogate/ Luton/Bedford). Area, was statistically significantly associated with consent rate: $X(4) = 24.25$, $p < .001$. Cramers V = .07. Specifically, pairwise comparisons, with Bonferroni correction, revealed that in East Riding/ Hull significantly more patients consented originally ($p = .04$) and at the second stage ($p = .01$), relative to patients from Harrogate. Similarly, in Luton/Bedford less people consented at either stage (p's < .001), relative to consenting at both stages compared to patients from Harrogate.

The other data available to compare between groups was the SES (as determined by IMD) of groups 2 (Consent / No Consent) and 3 (Consent / Consent). A Mann-Whitney U test revealed no significant differences in IMD between the two groups: ($z = -.257$, $p = .80$).

For 26 patients, the overall outcome could not be determined – for example, the patient was referred routinely from a F2F consultation and hadn't been seen yet or the telephone optometrist recommended some treatment but the patient was unable/unwilling to adhere to the regime and was, therefore still suffering with the same problem (e.g. recommended warm compress but the patient has not

done this). To a lack of date of birth and four further records were removed for not identifying the optometrist. Accordingly, unless otherwise indicated, subsequent analysis was based on 1074 first encounters.

7.3.2. Optometrists

Characteristics of the optometrists involved in the scheme are detailed in table 7.2. There were 11 optometrists involved in delivering consultations (8 male, 3 female). Data were available for 9 of these optometrist: they had a range of experience from 4 to 47 years post qualification (median = 18 years, interquartile range 5-24.5 years), had additional qualifications ranging from none to diplomas in independent prescribing and had worked in a range of settings from Universities to secondary care.

Table 7.2. The number of optometrists with each post-graduate qualification.

Further qualification	Number
None	1
WOPEC MECS level 1	8
WOPEC MECS level 2	6
WOPEC Glaucoma level 1	3
WOPEC Glaucoma level 2	3
WOPEC Cataract	1
WOPEC Learning Disabilities	1
Professional Certificate in Glaucoma	2
Diploma in Diabetic Retinal Screening	1
Diploma in Independent Prescribing	1

WOPEC: Welsh Optometric Postgraduate Education Centre; MECS: Minor Eye Condition Service

Regarding practice setting, of the 9 optometrists, none were currently working in a University although 1 had prior experience of this. 1 was currently delivering eye care in a hospital and a further 2 optometrists had previous experience of hospital optometry. 4 were currently working in a multiple (e.g. national chains)

practice and a further 3 had experience working there. Finally, 5 optometrists were working in independent practice with a further 2 having experience of this. In total, optometrists worked between 24 and 65 hours per week (median = 44 hours, interquartile range 34-48 hours).

7.3.3. Scheme Safety

The number of patients managed by each optometrist (telephone consultations) is given in table 7.3. Due to the small number of patients cared for by optometrists 8, 9, 10 and 11, these are grouped together as 'other' in future analysis.

Table 7.3. The number of appointments both correctly and incorrectly managed by each optometrist involved in the service. 'Other' is optometrists 8 to 11.

Management provided by	Number of patients	Correct (N)	Incorrect (N)	Incorrect (%)
Optometrist 1	199	141	58	29
Optometrist 2	25	19	6	24
Optometrist 3	75	53	22	29
Optometrist 4	55	44	11	20
Optometrist 5	28	16	12	43
Optometrist 6	99	70	29	29
Optometrist 7	125	99	26	21
Other optometrists	23	17	6	26
Teleconsultation Total	629	459	170	27
F2F optometrist	445	417	28	6.3
Total	1074	876	198	18.4

Overall, 18.4% of patients phoning the service were incorrectly managed. For the patients who were solely managed by a telephone optometrist, 27.0% of patients were incorrectly managed. Telephone optometrists attempted to manage 46.9% to 72.4% of their patients solely by telephone with 27.6% to 53.1% being referred for a F2F appointment. For patients that saw an

optometrist in person, on the other hand, only 6.3% patients were incorrectly managed.

A binary logistic regression was used to assess the effect of area [Luton, Bedford, Harrogate, East Riding, Hull], Optometrist [1, 2, 3, 4, 5, 6, 7, other], source of referral to service [optometrist, GP, other] patient age [in years], SES [IMD deciles 1-10], and whether the patient was seen in person [yes, no] on the outcome of the consultation [Correct / incorrect]. Due to multicollinearity between variables of company and area, only area was used a variable. The following equation was significant: $\chi^2 (24) = 114.09$, $p < .001$, $R^2 = .16$ and the results are displayed in table 7.4

Table 7.4. The results of the binomial logistic regression analysis examining predictors of whether a patient was correctly managed. Significant predictors are displayed in ***bold***

Variable	Compared to	β	S.E.	Wald	df	Sig.	Exp(β)	95% C.I.for EXP(β)	
								Lower	Upper
Area				9.39	4	.052			
East Riding	Bedford	0.51	0.26	3.85	1	.05	1.66	1.00	2.75
Harrogate		0.06	0.27	0.05	1	.82	1.07	0.63	1.81
Hull		-0.13	0.37	0.12	1	.73	0.88	0.43	1.82
Luton		0.77	0.36	4.60	1	.03	2.15	1.07	4.34
IMD Decile				10.40	9	.32			
2	1	-0.20	0.55	0.13	1	.72	0.82	0.28	2.40
3		-0.12	0.54	0.05	1	.83	0.89	0.31	2.54
4		-0.57	0.50	1.30	1	.26	0.57	0.21	1.51
5		-0.31	0.51	0.37	1	.54	0.73	0.27	1.99
6		-0.29	0.50	0.33	1	.57	0.75	0.28	1.99
7		0.16	0.50	0.10	1	.75	1.17	0.44	3.10
8		0.07	0.49	0.02	1	.88	1.08	0.41	2.84
9		0.44	0.50	0.77	1	.38	1.56	0.58	4.18
10		-0.21	0.49	0.18	1	.67	0.81	0.32	2.10
Optometrist				7.86	7	.35			
Optometrist 2	Optometrist 1	-0.10	0.42	0.05	1	.82	0.91	0.40	2.08
Optometrist 3		-0.08	0.30	0.07	1	.80	0.93	0.52	1.66
Optometrist 4		0.33	0.39	0.72	1	.40	1.39	0.65	2.95
Optometrist 5		-0.78	0.40	3.76	1	.052	0.46	0.21	1.01
Optometrist 6		-0.13	0.27	0.23	1	.63	0.88	0.52	1.48
Optometrist 7		0.20	0.27	0.52	1	.47	1.22	0.71	2.08
Other Optometrists		-0.07	0.45	0.03	1	.87	0.93	0.39	2.23

Source of Referral				1.08	2	.58			
Optometrist	GP	-0.01	0.18	0.004	1	.95	0.99	0.69	1.42
Other		0.41	0.41	0.96	1	.33	1.50	0.67	3.37
F2F	**Telephone**	**1.73**	**0.23**	**59.06**	**1**	**<.001**	**5.66**	**3.64**	**8.80**
Age		0.01	0.01	1.13	1	.29	1.01	1.00	1.01
Constant		0.62	0.51	1.48	1	.22	1.85		

β: Coefficient for the constant, S.E: standard error, Exp (β): odds ratio, CI: Confidence Intervals; IMD: Index of Multiple Deprivation.

The only significant predictor of outcome was whether the patient was recommended to have a F2F appointment. Specifically, patients who were advised, and subsequently had a F2F consultation were 4.7 times more likely to be correctly managed, relative to those who were managed over the phone (Exp(β) for F2F, relative to telephone = 5.657, $p < .001$). There was no significant effect of area ($p = .052$), SES ($p = .32$), patient age ($p = .29$), optometrist ($p = .35$), or source of referral ($p = .58$), on outcome.

Errors are reported in table 7.5. For the telephone consultation all referrals to a F2F optometrist were considered appropriate with the exception of conditions that had self-resolved by the time of the appointment and those where the F2F optometrist managed the patient over the phone (n=7). The present study identified one case, where the patient attended a F2F appointment where they subsequently were referred to the HES for suspect scleritis that was diagnosed ultimately as keratitis (Incorrect diagnosis, referred to HES). This was able to be classified as an incorrect diagnosis by the F2F optometrist only through the impressive detail provided by the patient on the phone call to the researcher. Similarly, two patients reported that the telephone optometrist reported the patient had blepharitis, but as the condition improved it became clear (to the patient) that it was a stye. These are marked as incorrect diagnosis, treatment worked. Further details of major errors are provided in table 7.6.

Table 7.5. The types and numbers of errors made by the telephone optometrists (tele) and face-to-face optometrists (F2F).

Outcome		Tele (n)	Tele (%)	F2F (n)	F2F (%)
Recommendation didn't work	Condition Deteriorated	17	10	2	7
	Condition Stable	62	37	7	25
Unnecessary referral to	HES	4	2	15	54
	GP	2	1	0	0
	F2F	7	4	0	0
Incorrect Diagnosis	Resolved with treatment	2	1	0	0
	Partially resolved with treatment	12	7	0	0
	Px used different treatment which resolved	28	17	2	7
	Unnecessary treatment (self-resolved)	15	9	0	0
	Referred to HES	0	0	1	4
Major errors		23	14	1	4
Total		170		28	

Tele: Teleconsultation; F2F: Face-to-Face; HES: Hospital Eye Service; GP: General Practitioner; Px: Patient

Additionally, one patient was classed as a correct decision but the patient came to harm. The telephone optometrist referred the patient to secondary care (bypassing the F2F optometrist). The patient experienced severe difficulty getting seen and so the patient just kept self-presenting to a hospital that kept turning them away. By the time of his appointment, the patient was diagnosed with a macula-off retinal detachment, which, at the time of telephone consultation was described as only some ‘misty vision’.

Table 7.6. The outcomes of major problems identified by the patient. Red highlights potentially more severe missed pathology, relative to orange.

Age Sex	Problem	Recommendation	Outcome
	Face to face		
32 M	itchy, scratchy uncomfortable eye, painful on morning	Infection, recommended antibiotic eye drops	Px attended A&E who referred to HES and was diagnosed with recurrent corneal epithelial erosion.
	Teleconsultation		
50 M	Painless loss of vision in one eye after bending over and standing up	Book a sight test	Px felt it required more urgency - rang 111 who sent to Walk in centre who referred immediately, and was admitted to the stroke ward for 3 days. Px was having a stroke. Now medicated
82 F	Visual Aura	Would self-resolve	Px subsequently attended GP who referred to hospital. Px treated for stroke, once treated, eye problem resolved.
23 F	Blurred vision in right eye and that was accompanied by headaches and a very stiff neck and watery eye	Book a sight test	2 days later (before sight test) px could 'no longer see' and was vomiting. Px rang 999, who organised ambulance which took px to hospital. Here the px had a lumbar puncture and was diagnosed with LE optic nerve swelling as a result of intracranial hypertension. Saw Ophthalmologist who expected px to be left blind in LE. Px has now been re-examined by ophthalmology who report vision has begun recovering in that eye. Px is now under neurology and ophthalmology.
26 F	Sharp pain in one eye on looking up	Would self-resolve	Getting worse and feels like the eye movement is becoming increasingly restricted. When does try look up now also gets 'stars in vision'
57 F	Flashes of light mainly in RE, but if closes eye can also see	Visual migraine	Happened again the next day so rang GP who sent px to A+E. A+E admitted px as suspected 'brain bleed'. No brain bleed was found, but hospital ruled out migraine. GP

	in LE		subsequently referring px to neurology.
23 F	Temple pressure affecting jaw, neck and shoulder	Book a sight test	Before managing to get a sight test condition deteriorated. Px rang 111 who sent to A+E. A+E gave pain relief and told to see GP. GP wouldn't see as told to ring OO phone line. Eventually got an appointment with OO who referred back to GP. GP Referred to neurology, where px has had an initial assessment and a follow up appointment now booked for this month.
38 F	Spider like floaters which are visible at night	Migraine	Didn't resolve so the px went to A+E - CT was clear so wrote to GP to refer px for MRI. GP arranging MRI and changing medications as GP suspects a brain issue as px is experiencing hallucinations (not migraine).
68 M	LE ache followed by pixelated peripheral vision	Visual Migraine	Still gets pixelated peripheral vision after, for example, running up the stairs.
43 M	Itchy sore photophobic eye	Chloramphenicol	Condition deteriorated, so the px rang back where the telephone optometrist suggested different drops. This didn't work so px went to A+E who gave different drops and told him to ring back the phone line. Px rang back (3rd time) and was booked a F2F appointments. F2F referred emergency to HES who diagnosed orbital cellulitis (~1 week between first tele and F2F)
29 F	Bloodshot eye with a 'lump'	Chloramphenicol	Chloramphenicol didn't help, so the px rang back where the service arranged a F2F. The px never heard back from service with an appointment, so rang back again where they did arrange a F2F appointment. F2F referred to HES, diagnosed with scleritis. (~5 week wait between first phone call and F2F).
54 F	Px thought they had an eye infection, but after using chloramphenicol for a week still has a gritty watery red eye	Dry eye drops	Condition deteriorated so the px rang back where a F2F was arranged, who subsequently referred the px to HES where they were diagnosed with corneal ulcer.
68 F	Sore, gritty eyes	Told this service	Approx. 4 weeks later GP referred to HES. Px prescribed oral + topic antibiotics,

		is only for major eye issues, stop taking antibiotic and attend GP	cyclosporine + topical steroids.
68 M	Red, watery light sensitive eye	Dry eye drops	Conditioned deteriorated, so the GP referred the px to the HES where they were diagnosed with 'bilateral blepharoconjunctivitis' - prescribed 'prednisolone eye ointment + maxitrol drops + carbomer' and has had a follow and due back in just under 2 months' time
57 F	Very painful pressure sensation in RE and temple	Book a sight test	Caught COVID between telephone call and booking a sight test - so hasn't attended, now can't see well through that eye
29 F	Bilateral sore, painful eyes	Can't recall specific recommendation but knows it didn't work	Rang 111 who referred px to HES prescribed steroids and reviewed px a few times. Ultimately diagnosed with severe conjunctivitis.
57 F	Intermittent kaleidoscope type bright light in LE	Possible migraine, book a sight test	At the sight test (5 days later), the px was referred to the HES - 'detached retina' - At the time of ringing tele OO and seeing OO in person the only symptoms were flashes of light. Now the px is unable to see through that eye anymore 'just a black curtain across the whole eye'.
58 M	Eye pain when coughing and new floaters	Wait for diabetic retinal screening appointment (~1 week later)	DRS found 'bleed on back of eye' which is now being scheduled for laser surgery.
66 F	RE misting over and noticing a floater in centre of vision	Self-resolve	Vision still feels like part of it is misted over and getting 'blind spots' in vision.
32 F	Flashes & Floaters in one	Migraine	Flashes and floaters now getting worse in that eye

	eye		
50 M	'Shadow' in vision	Visual migraine	Still seeing shadow in vision - no change from when called
31 F	Floaters	Book a sight test	Px had to self-isolate (COVID) between teleconsultation and booking a sight test - not had it checked, still seeing floaters.
75 F	'In remission from AMD' and reading vision has suddenly deteriorated	Would self-resolve	Px disagreed with teleconsultation so rang own optometrist who saw px F2F. Diagnosed wet AMD in the good eye (other eye is already receiving injections for wet AMD) and now ophthalmology has scheduled px for injections in both eyes.
72 F	Eye became blurry and tired after COVID vaccine	Booked a MECS, but suggested it was a visual migraine	Px didn't go to F2F (as tele had suggested visual migraine), however, px eventually attended eye casualty who diagnosed Inflammation of gut causing inflammation of eye. HES diagnosed uveitis and macular oedema. Px still under HES

M: Male; F: Female; Px: Patient; LE: Left Eye; GP: General Practitioner; A+E; Accident and Emergency; CT: Computerised Tomography; MRI: Magnetic Resonance Imaging; F2F: Face-to-face; HES: Hospital eye service; AMD: Age-related Macular Degeneration.

Similarly, whilst the above table highlights patients with flashing lights and floaters that subsequently deteriorated. Instances of these symptoms where the telephone optometrist diagnosed a PVD / visual migraine and now the symptoms have resolved were included as correct decisions. Importantly, recommending a sight test was considered a major error for the above people. As a sight test is indicated for patients with symptoms of refractive nature (section 1.1.4), this is inappropriate for patients with acute-onset visual problems. In total, 186 patients were recommended to attend a ‘sight test’. For 150 (80.6%) of these patients, an urgent eye care appointment was more appropriate (table 7.7)

Table 7.7. Presenting symptoms that led the telephone optometrist to recommend a 'sight test' instead of a CUES appointment (n=186).

Appropriate sight test recommendation?	Condition	Number
No	Flashes/ floaters/ visual disturbance	59
	Red eye(s)	29
	Painful eye(s)	15
	Sudden loss of vision (including peripheral)	13
	Sore/gritty/inflamed eyelid(s)	12
	Watery / sticky eye(s)	11
	Sore eye(s)	4
	Growth/lump on eyeball	3
	Sudden onset Diplopia	1
	Headache with Jaw pain	1
	Dry eyes	1
	Photophobia	1
Yes	Blurred vision	22
	Aching / tired eyes	5
	GP recommended ST	4
	Headaches	4
	Required more drops following cataract surgery	1

GP: General Practitioner; ST: Sight test

For the majority of patients who were recommendation a sight test, an urgent eye care appointment would have been more appropriate (80.6%). The major errors associated with these recommendations are highlighted in table 8.6.

The present study can also be used to identify false-positive referrals to secondary care as a proportion of total referrals. Of the original 1106 patients, 164 (14.8%) were referred to secondary care. Of these, 115 (70.1%) were true positives (i.e. ophthalmology either treated or followed up, including foreign body removal), 27 (16.5%) were false positives (I.e. discharged without

treatment, or given dry eye drops (i.e. within the scope of practice of an optometrist) and for 22 (13.4%) patients the outcome is unknown (e.g. referred for conditions where the patient hasn't had an appointment yet). Excluding the unknowns, this equates to 81% and 19% true and false positive rates, respectively. When breaking this down into teleconsultation and F2F referrals, differences are apparent. For patients referred directly from telephone consultations, excluding unknown outcomes, 12/21 patients (57%) were true positives, with the remaining 43% being false-positive referrals. In contrast, for patients who received a F2F consultation, 103/121 (85%) referrals to secondary care were true positive and 15% were false-positive.

Due to the nature of the service, only patients with acute eye problems would be 'attending'. Accordingly, the overall uptake was low (0.075% of total population). Uptake of the service was higher amongst patients from higher socio-economic areas (i.e. least deprived) (figure 7.4).

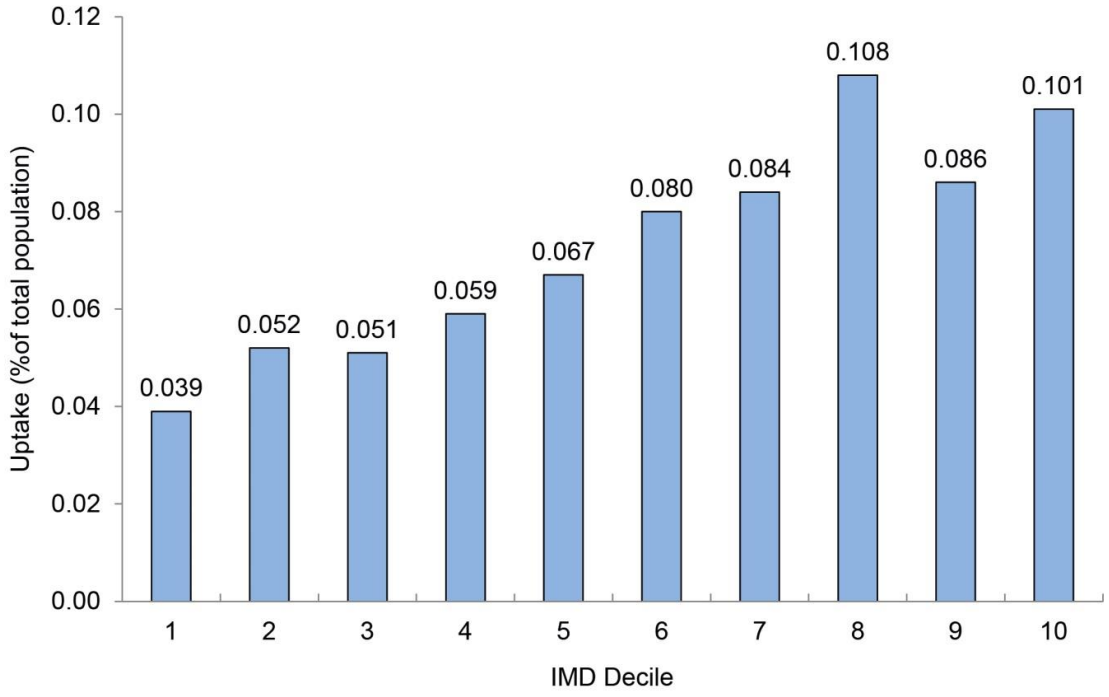

Figure 7.4. Service uptake by IMD decile. Service uptake was lower from patients living in the most (IMD decile 1), relative to least (IMD decile 10), socio-economically deprived areas.

Patient satisfaction was generally very high. Satisfaction levels were obtained for 1055 patients (figure 7.5)

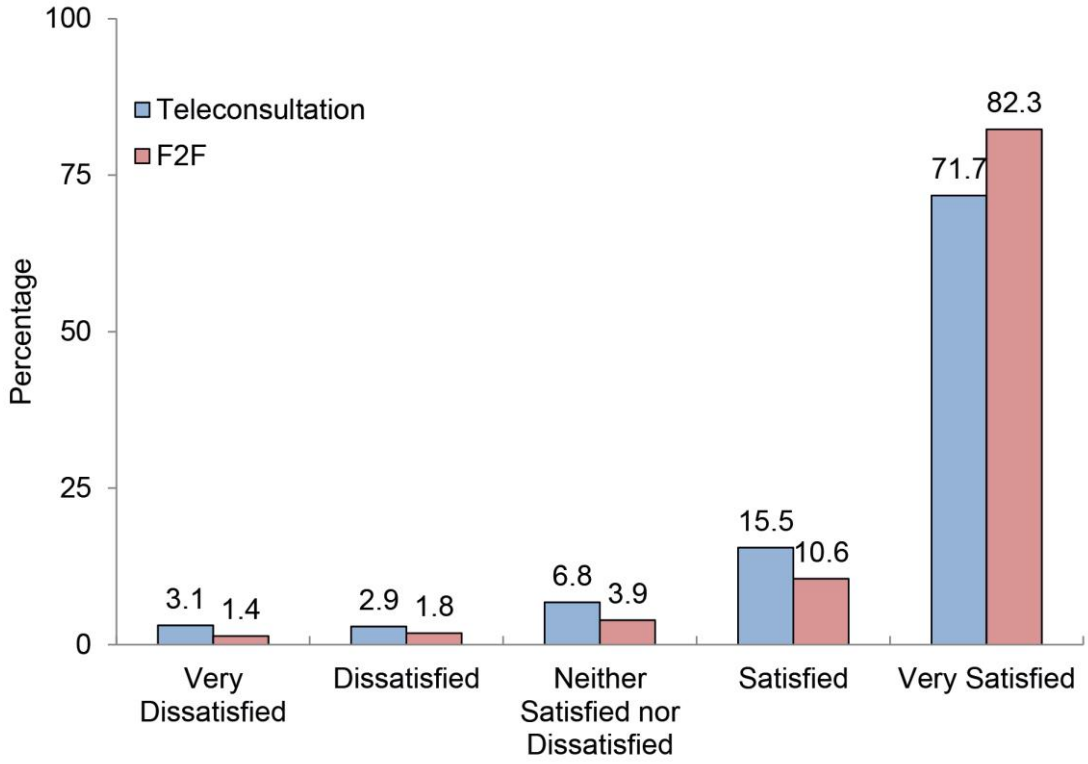

Figure 7.5. Satisfaction level of the service provided (n=1055). The blue bars represent the satisfaction level about the face to face appointment of patients who received a face-to-face (n=436). The red bars, on the other hand, represent the satisfaction level of patients who were managed with by a teleconsultation (n=619).

Overall, 82.3% and 61.7% were very satisfied and 92.9% and 87.2% of patients were very satisfied or satisfied with their F2F and teleconsultation respectively.

7.3.4. Alternate source of care

In total, 85 patients attended alternative forms of care. 82 of these were after the teleconsultation only and three were after a F2F optometrist appointment. Patients attended a wide range of providers which is detailed in table 7.8

Table 7.8 Providers of care who patients attended, without recommendation by the optometrist (n=85).

Original Provider	Alternate providers		Patients (n)
	Initially	Subsequently	
Phone	Optometrist		27
	Optometrist	HES	4
	Optometrist	GP	1
	GP		17
	GP	HES	5
	GP	Hospital	1
	GP	A+E, HES, Neurology	1
	HES		4
	A+E		5
	A+E	GP, Neurology	1
	A+E	Optometrist	1
	A+E	HES	1
	Pharmacy		4
	999 (ambulance)	Hospital, HES. Neurology	1
	111	Walk in centre, HES	1
	111	Walk in centre, Stroke ward	1
	111	GP, A+E	1
	111	A+E	1
	111	HES	1
	Walk in centre		2
	Urgent care centre		1
	GP practice nurse		1
Total			**82**
F2F	Optometrist		2
	A+E	HES	1
Total			**3**

A+E: Accident and Emergency; GP: General Practitioner; HES: Hospital Eye Service

Overall, out of the 630 patients ‘managed’ by the telephone service without recommending further care, 13% of patients subsequently sought the advice of another professional. In contrast, only 0.7% sought alternative care after a F2F appointment with an optometrist. Furthermore, not included in the above analysis are 6 patients who had received a telephone consultation either, during, or after the patient had self-presented to A+E due to delays between registering their details with the service, and receiving a teleconsultation.

7.3.5. Patient reported problems of the service.

The purpose of the study was not to assess systemic issues of England’s eye care provision. However, a few cases are worthy of note to aid future research. The numbers of patients who commented dissatisfaction about an aspect of the service was surprising given patients were not specifically asked what their issues were. In summary, a number of patients feel that teleconsultations created a delay in their access of care (n = 42), experienced communication issues [n = 26: Due to GP (n=9), patient (n=9) between providers (n= 8)] and didn’t resolve anxiety (n = 20). A further four patients mentioned accessing the service wasn’t easy. Another nine patients expressed dissatisfaction with the system of eye care provision generally in England. Two patients mentioned treatment of their condition was too expensive, two patients were unhappy with the choice of provider (not being able to see their usual optometrist) and one patient (who previously lived in Scotland) commented that the Scottish system of eye care is better than the English.

7.4. Discussion

In contrast to our hypotheses, this independent prospective evaluation of a CUES identifies that, as reported by patients, telephone consultations conducted by optometrists in the present study were neither clinically effective nor safe, for some acute eye pathologies. Patients attending F2F appointments were approximately 4.7 times more likely to be managed correctly, relative to those patients who were solely managed via a teleconsultation. Despite this, within the context of a global pandemic, patients rated the service typically as

either satisfactory, or very satisfactory. The present study failed to find any significant difference in performance between optometrists with a range of experience and qualifications. Overall, the service failed to appropriately manage patients with a number of serious conditions, such as strokes, intracranial hypertension, suspected space-occupying cranial lesions, orbital cellulitis, scleritis, anterior uveitis and macular oedema, wet age-related macular degeneration, retinal detachment and corneal ulcers. Interestingly, patients living in higher socio-economic areas are more likely to access the service. 13% and 0.7% of patients accessing telephone and F2F consultations, respectively, subsequently accessed an additional alternate provider of health care. The purpose of the study was not to assess the cost effectiveness; however, given the proportion of patients that were either incorrectly managed, or subsequently accessed alternative providers of care after an optometrist delivered tele-consultation, it may not be cost effective system wide. An important consideration, however, is that CUES was commissioned to reduce potentially life-threatening face-to-face contact due to COVID-19. This is of particularly importance for optometrist consultations where prolonged close proximity contact can be involved. Throughout the study period, however, optometry practices were open and able to see patients for F2F consultations.

COVID-19 resulted in a rapid transfer of care based on the perceived risk of F2F consultations. Although this was done with the intention of reducing unnecessary F2F contact during a global pandemic, the clinical safety of optometrists participating in a system that was novel to them and that they had little or no specific training for (telemedicine) was unknown. The methodology of the present study allowed for a comprehensive capture of what has happened to patients who experienced optometrist-led telemedicine. The finding that 27% of patients who did not receive a F2F appointment did not have their presenting symptoms resolved by telemedicine is worth noting. The aim of the COVID urgent eye care service was to appropriately manage patients with acute, potentially sight threatening, eye problems. Accordingly, any errors could be sight-threatening. Previous studies have revealed that F2F MECS appointments reduce unnecessary referrals into the hospital eye service (Konstantakopoulou et al. 2014; Konstantakopoulou et al. 2018) and are

clinically satisfactory (Sheen et al. 2009). To the author's knowledge, there is only one previous study that has aimed to examine the safety of urgent eye care schemes. Sheen and colleagues (2009) reviewed hospital notes as a method of detecting patients that were inappropriately referred and also conducted telephone interviews 1 and 4 weeks after F2F consultations to determine appropriate management of patients who accessed the nationally commissioned Welsh PEARS. Patients who reported persistent symptoms after 1 week were called again at 4 weeks to see if their condition had resolved. The specifics of the telephone interview outcomes are not reported in detail but the authors report that 3/289 patients were inappropriately managed. These appear to be patients who were referred to the GP but the referral letter did not contain sufficient information for the GP to action. The authors state, therefore, that approximately 1% of optometrist F2F appointments were incorrectly managed (when not referring to HES) and 18% to 25% of optometrists' referrals to the HES were inappropriate. The present study provides a similar value for false-positive secondary care referrals (17%) from F2F consultations, but a larger number for telephone consultations (52%) and a significantly larger number of incorrectly managed patients, who were not referred (19%). This large difference is possibly attributable to the methodological differences between that, and the present study, differences in time and service specification. This does however, highlight, the significant disadvantage in examining only false-positive hospital referrals as a basis of implying scheme safety. The present study also highlights that direct referrals from telephone optometrists to secondary care were true positives in only 57% (12/21) of cases. In contrast, 85% (103/121) of referrals from F2F optometrists to secondary care were true positives. Due to the small sample size of telephone optometrist's direct referrals, further research is required to determine whether the benefit in the 57% of cases (e.g. speed of treatment) is outweighed by the 43% of cases being incorrectly referred (unnecessarily taking up resources).

The addition of a compulsory telephone service in the present study appears to be partly attributable to the failures of the scheme. Specifically, 'getting it right first time' is proposed to reduce waiting times, provide cost savings and improve the patient journey (Briggs 2012; MacEwen et al. 2017; NHS Providers 2018).

The service evaluated in the present study doesn't appear to meet this aim. Specifically, 41% (n = 445) of patients required a F2F consultation: therefore, an unnecessary additional step in the patient journey. Of the remaining 59% (n = 629) of patients who were managed over the phone line 13% (n = 82) went on to access alternate care and 27% (n = 170) had their problems unsolved. To highlight the severity of unnecessary delays in care, unfortunately, the present study identified two confirmed cases of patients where a retinal detachment progressed from macula-on to macula off prior to receiving a hospital ophthalmology appointment. These patients reported times of 2-5 days between first contacting an optometrist and receiving an ophthalmology appointment which emphasises the importance of getting it right first time and minimising delays in access of care. The prior urgent eye care system of an optical practice seeing the patient same day and subsequently referring the patients as an emergency to the hospital eye service is likely to have been quicker, and could, therefore, have prevented sight loss in these individuals. Similarly, the finding that, of patients who solely had a teleconsultation, 27% (n = 170) did not have their presenting symptoms resolved, 13% (n = 82)subsequently accessed up to four further providers of health care and 11% (n = 69) had to re-present unscheduled, to the telephone service suggests that the telephone service does not 'get it right first time'. This is in contrast to F2F consultations where 6.2% of patients presenting symptoms were not resolved and 0.7% of patients resulted in the patient self-presenting to alternate providers of health care. One of the limitations of a central phone line, rather than done by individual practices, is that the triaging optometrist has no access to the patients past records and history. The approach of telephone discussions with patients utilised by Sheen and colleagues (2009) and the present study are likely to underestimate the total number of patients incorrectly diagnosed by optometrists. As forementioned, patients who are given treatment for a self-resolving condition or misdiagnosed the condition for another with a similar treatment plan would be unable to be accurately determined by the patient-reported outcome.

The 23 patients who were classified as 'major' errors highlight that diagnosing acute eye problems over the phone is extremely difficult and can lead to major problems for patients. These can be broadly categorised as four main types:

systemic (n = 8), red/sore eyes (n = 7), flashes/floaters (n = 6) and acute vision loss (n = 2). For patients with flashing lights and floaters, it has been reported that 9.4-14.5% have a retinal tear, hole or detachment (Diamond 1992; Hollands et al. 2009; Khandhadia et al. 2009; Bond-Taylor et al. 2017; Seider et al. 2021) and approximately 1.1 to 3.4% of patients with a PVD will subsequently develop a retinal tear or detachment within 6 weeks (Hollands et al. 2009; Seider et al. 2021). Seven patients in the present study were not directed to appropriate urgent F2F care and subsequently had (n = 1), or could have had (n = 4), a retinal tear/ detachment missed or a vitreal haemorrhage detected later than it could have been (n = 1). The advice for this group of patients is clear: they require urgent dilated fundus examination (The College of Optometrists 2020b). The College of Optometrists guidance further states that for this cohort of patients that can be managed in practice there is: no change in vision, no tear or detachment present, no anterior vitreous pigment and the patient is informed of what to do in the event of worsening symptoms (in writing). Some of these parameters cannot be measured over the phone and, therefore, it would be advisable to follow College of Optometrist's advice regarding symptoms that require investigation (e.g. flashing lights / floaters) in the design of any scheme to prevent issues as identified in the present study.

For systemic issues, it is unclear whether these would have been correctly identified by a F2F appointment. The most likely cause of a sudden 'painless loss of vision' in a patient aged over 30 is a central retinal artery occlusion, which if undetected could be life threatening (Georgalas et al. 2014; Weymouth and Pedersen 2019). The number of potentially missed systemic conditions (n = 8) that could have been life threatening could indicate deficiencies in the training of UK optometrists. Importantly, any missed conditions that ultimately resulted in loss of life would not have been detected by the present study. The remaining groups of major errors were red/sore eyes (n = 7) and loss of vision (n = 2). These errors highlight the difficulty of performing consultations on eyes relying on a) patients descriptions b) the optometrists adequately understanding these descriptions. This also highlights the difficulty in differentiating potentially sight threatening eye pathology from non-sight threatening. Guidance does exist however, for GPs when examining patients with red eyes (Teo 2014;

Kilduff and Lois 2016; National Institute for Health and Care Excellence 2016b). Specifically, patients with moderate to severe pain, photophobia, marked redness, foreign body, reduced vision or unilateral symptoms require urgent ophthalmological opinion. If this guidance was followed at least 4 out of 7 patients with missed potentially major pathology related to red eyes and 2 out of 2 patients with acute vision loss could have been detected. For inappropriate sight tests, one possible explanation could be attributable to the funding of sight tests and CUES. Whilst sight testing is funded from a national budget (NHS England), CUES are funded on a local level. The finding therefore, of the large number of patients inappropriately being recommended sight tests could indicate underfunding on a local level of the CUES service in the areas examined (i.e. the budget is not capable of meeting the demand on the service). On the other hand, it could be that the triaging optometrists are uncertain which symptoms are not appropriate for a sight test. The Association of Optometrists has issued clear advice on this issue (Association of Optometrists 2015) and the data from the present study supports the conclusion that sight tests are inappropriate for patients with acute eye problems, and by attending sight tests, instead of CUES, adverse events and near misses occurred.

The very large effect of F2F, relative to telephone, consultations (Exp β: 5.7) when assessing whether the patient was correctly managed and the overall low number of patients whose condition deteriorated despite having seen an optometrist in person (0.4%) point to the conclusion that optometrist F2F appointments are clinically safe. Further research explicitly examining the safety of MECS is required. This is also in line with a recent report of the CUES in Manchester (Kanabar et al. 2021). Authors reported that patients who were seen in person by an optometrist were significantly more likely to have made a diagnosis that corresponded to that of the hospital ophthalmology department, relative to patients who were managed by a telephone optometrist.

Interestingly, the scheme in the present study employed a variety of optometrists with varying levels of qualification (4-47 years qualified), additional qualifications (none – diploma in independent prescribing) and prior experience

in different work settings (University to primary care to secondary care). Despite this, there was no significant effect of optometrist on patient safety. Accordingly, future research is required to examine if qualifications and/or experience are significant predictors of improved patient care. Another interesting finding of the present study is that higher SES is associated with an increase in likelihood of accessing the service. Patients living in the least deprived decile were approximately 2.6 times more likely to access the service, relative to those living in the most deprived decile. Whilst the scheme potentially reduces costs of accessing the care (e.g. no travel), other factors appear to not be significantly reduced. Whilst there are no previous studies examining uptake of urgent eye care appointments in relation to socio-economic status, inequalities of access to primary care sight tests has been reported. For example, uptake of NHS funded eye tests is 15% - 71% higher in people living in the least, relative to most, deprived quintile (Shickle and Farragher 2014; Shickle et al. 2017). Further work is required to reduce barriers that patients living in the most deprived areas face whilst accessing primary eye care services.

Previous research has reported that MECS are either cost-effective (Sheen et al. 2009), provide (Mason et al. 2017), or have the potential to provide (Swystun and Davey 2019) cost savings, relative to when MECS isn't commissioned in an area. For example, Sheen and colleagues reviewed HES records to detect patients that subsequently presented to the HES after a PEARS appointment with a community optometrist. In the present study, however, of the 85 patients who reported that they sought further advice after the optometrist appointment, only 19 (22%) subsequently attendined to the hospital eye service. Similarly, Mason and colleagues (2017) reported that two areas of London with a MECS had significantly lower increase in overall eye health system costs, relative to an adjacent area without a MECS. One aim of the service in the present study was to further reduce costs of the delivering of eye health care by paying a lower fee for telephone, relative to F2F consultation. The present study wasn't specifically aimed at examining the cost effectiveness of such a service.

However, the proportion of patients subsequently accessing alternative forms of care (13%) and the greater proportion of patients with ocular problems not

resolved by the phone line who could have had, or would have required another appointment (27%) and the unknown number of unnecessary treated patients suggests that reducing F2F consultations may reduce costs of one part of the health care system at the expense of an increase in costs elsewhere. It cannot, therefore, be assumed that this alteration results in a decrease in overall system costs. Further research is required to quantify this.

One possible explanation for the schemes poor safety could be the funding structure. For example, as the companies weren't being paid 'per patient', if patient numbers were higher than expected the company would have to specifically reduce the number of F2F consultations in order to meet budget. This could account for patients with symptoms requiring F2F consultations (e.g. flashes/floaters) either not receiving one or being incorrectly sent for a sight test. Whilst under-funding of primary care services have been reported to be a contributor to poor uptake of NHS sight tests, (Leamon et al. 2014; Shickle and Griffin 2014; Shickle et al. 2015a) the effect of funding structures on acute eye consultations is unknown. One of the main differences for the commissioners and service providers arising from the recommendation of a sight test, instead of an urgent eye care appointment is the funding. Specifically, whilst the local CCGs pay for urgent eye care appointments, if the telephone service recommends a 'sight test' this is to be funded by the patient (or NHS England if they are eligible). The result from the present study that a significant proportion of patients who were directed to a sight test would have been more suitable for an urgent eye care examination, therefore, points to the conclusion that the financial package and/or structure may be an influence in telephone optometrists decision making. A qualitative stakeholder study (e.g. Konstantakopoulou et al. 2014) would be useful in understanding what optometrist's influences were in the decisions that they were making.

In summary, the optometrist-led tele-consultations in the present study do not appear to provide appropriate patient care for patients with acute onset eye problems.

7.4.1. Limitations

The main limitation of the study is that the outcomes are patient reported. For example, there was no clinician checking and confirming the diagnosis of the optometrists. It was based purely on the patient's subjective report of whether the treatment resolved their symptoms or not. Accordingly, some of the episodes where the recommended treatment didn't work, could have resulted in major misdiagnosis or deterioration that the present study could not determine. This limitation however, can be balanced against the purpose of an acute eye service – which is to resolve problems that the patient perceives that they have.

Although the present study did not specifically include a qualitative element, positive ratings of the telephone service were often quantified with comments such as: 'not much you can over the phone' or 'difficult over the phone to get it correct'. Accordingly, the satisfaction level should only be used as an indicator of patients experience through a global pandemic where patients were generally informed of the need of minimising F2F contact. This is not to say that patients would rate the service highly, when F2F contact is re-normalised. Similarly, it is possible that a potential cause for patients not having their presenting issue resolved is difficulty with communicating what the signs of their presenting issue are. Patients typically report presenting symptoms, but do not often have experience elucidating a description of what is going on with their eye as this is generally visible to the clinician.

Another limitation is that patients who were managed over the telephone could be systematically different from those managed in person. However, it would be expected that patients managed over the phone would have symptoms that were particularly indicative of a condition for which treatment was known to resolve the problem; any issue that was unclear or potentially ambiguous would have been sent to F2F consultation. Accordingly, it would be expected that F2F consultations would see patients of increased difficulty and, therefore, result in more adverse events. This appears not to be the case.

A further limitation is that the present study was not conducted to explore the root cause of the incorrect decisions made by optometrists. For example, it could be that poor integration between primary and secondary care and financially motivated reasons could account for some of the services deficiencies. Further work is required to explore this.

7.5. Conclusion

1) Telephone consultations delivered by optometrists should not be assumed to be clinically effective until evidence is provided to support this. Moreover, services should be commissioned either a) on an existing evidence base or b) in a way to obtain the evidence base prospectively in the initial period in the absence of existing evidence.

2) The major errors resulting in potential harm to patients could have been avoided, and patient safety improved, by: a) Increasing optometrists' awareness of systemic pathology. b) Ensuring there is a formal procedure for referring patients to F2F appointments in line with available evidence based guidance (e.g. College of Optometrist / Royal College of Ophthalmologists / National Institute of Health and Care Excellence).

8. Overall discussion, conclusions and future research

The overall aim of the present thesis was to investigate the current system of delivering eye care in the UK, with particular reference to fragmented services that are currently delivered in England and how this impacts the patient. The work details each step of the journey starting with investigating inequalities of outcome of the basic provision of eye care in England: the NHS funded sight test. We then examined the impact that suspending this routine sight testing, and diabetic retinal screening had on the numbers of patients with delayed / undetected diagnoses of glaucoma and diabetic retinopathy as a result of a temporary suspension of this service delivery. Moving forward, due to the shortcomings of the NHS sight test, we examined whether there was a need for a Minor Eye Condition Service in the locality of Leeds Bradford and Airedale. Due to paucity of published evidence we then attempted to compile all available evidence on the safety of these urgent eyecare services (MECS/ PEARS/ CUES). Finally, we then performed an extensive evaluation of the safety of a CUES.

Previous research had pointed to the conclusion that the NHS sight test is inadequate to deliver eye health care to the population (Shickle et al. 2015a). Unlike in Scotland and Wales where the overall system of delivering eyecare has been updated on a national scale, England still has a ‘post-code lottery’. In some areas, the NHS sight test is the only available eyecare outside of the general practice and secondary care. Accordingly, we investigated whether two most common types of optometric practice (multiples and independents) and socio-economic status was associated with the outcome of these tests. In summary, we reported that associations do exist, with patients attending multiples being significantly more likely to end up obtaining a new prescription, relative to not having a prescription compared to patients attending independent practice. Furthermore, the data examining socio-economic status on refractive and referral outcome pointed to the conclusion that patients living in lower socio-economic areas could be delaying attending routine sight tests until they’re sufficiently symptomatic – thus reducing the preventative health care aspect of the service.

This eyecare was temporarily suspended as a result of the COVID-19 pandemic. Accordingly, it would be expected that this would have an impact on the ocular health of patients. Whilst the NHS allowed the continuing of the sight test for patients with ‘emergency or urgent’ needs, the routine provision was suspended. Similarly, the diabetic retinal screening programme which provides eye health checks for patients with diabetes was also suspended temporarily. The study in the present thesis estimated the numbers of patients that would have potentially missed a diagnosis of glaucoma (the most frequent asymptomatic condition detected through sight testing) or would have developed new diabetic pathology as a result of these suspensions. Fortunately, due to typical slow-progressing nature of glaucoma and the short suspension of diabetic screening the numbers of patients likely to suffer permanent visual reduction was small. However, it’s important to consider that not all disease progresses at the same rate and a small number of patients will have permanently lost vision as a result.

At the time of writing chapter 5 there was no commissioned MECS in Bradford / Leeds or Airedale, UK. Accordingly, an assessment was done to examine whether this would provide benefit to the patients and hospital trust. Previous research had suggested that MECS can reduce unnecessary referrals to hospital ophthalmology services (Sheen et al. 2009; Konstantakopoulou et al. 2016). Whilst the data from Wales covered the country, data from England was limited to small areas. Accordingly, before a scheme could be commissioned, a needs assessment was required to estimate the benefit to the area. The study reported in the present thesis found that a MECS would reduce the burden on general practice and hospital services whilst patients would rate the service highly and provide theoretical cost savings to the system. The data, however, pointed to the conclusion that there might be some presenting symptoms (e.g. sudden visual loss) which more often than not result in an onwards referral.

The available evidence on MECS is lacking. Specifically, at the time of writing, studies examining false-negatives of optometry delivered services were limited to Glaucoma (Ratnarajan et al. 2015) and the Welsh PEARS (Sheen et al.

2009). Accordingly, we aimed to identify and publish all available collected data regarding urgent eye care services (CUES/ MECS/ PEARS) across England. Surprisingly, this data is neither being collected, nor shared. The limited data gathered in chapter 6, however, supported the conclusion from chapter 5 that patients presenting with acute onset loss of vision were often (60%) referred onto GP or ophthalmology care. Further research, however, is needed to quantify this and the risk-benefit that bypassing the optometrist would have. One company, was willing to enable the study of patients who may have being erroneously managed as a result of a MECS service.

An evaluation of the clinical safety and effectiveness of an urgent eye care service (CUES, adapted MECS) was commissioned. Overall, a significant proportion of patients who were attempted to be managed over the phone were not appropriately managed. The majority of major errors could have been detected by referring patients with flashing lights and floaters, or uni-ocular red, painful or photophobic eyes for a F2F consultation. A number of patients either came to harm, or were at risk of harm as a result of the two-tiered system of eye-care delivery in the UK. For example, some patients who were recommended a sight test, relative to CUES unfortunately permanently lost sight as result. Whilst this result has implication for telephone triage systems it raises questions of the scale of this problem in areas where urgent eye care services (PEARS/ MECS/ CUES) aren't commissioned. Moreover, there also appeared to be a lack of awareness of the systemic / neurological causes of visual symptoms. This is perhaps more important given the possible life-threatening implications of undetected systemic and neurological disease and could highlight deficiencies in training of UK optometrists and / or the lack of experience in dealing with these patients.

Further research could be to perform studies evaluating patient reported symptoms that could be highly indicative of life/ sight threatening pathology. As reported in the present work, symptoms such as pain, photophobia, sudden loss of vision and flashes of light and/or floaters being referred to a F2F appointment would have potentially detected the majority of serious pathologies excluding systemic issues. However, this omits the symptoms of patients that were

correctly managed. For example, following focus groups and interviews, questionnaires could be developed that optometrists could use to identify patients symptoms. These symptoms could then be matched against final diagnosis which could highlight symptoms with a specified sensitivity and specificity at identifying patients with each eye disease. Similarly, more research is required determining optometrists capability of identifying system problems and, on a broader level, whether optometric-led urgent eye care services are clinically effective, or safe. Whilst it is unlikely that only symptoms would correctly identify the pathology, it is possible that some symptoms would be less likely to be indicative of serious pathology and, therefore, be appropriate to attempt management not in person, whilst other symptoms may necessitate an in-person consultation. Accordingly, this would improve efficiencies, reduce delays in access of care and improve the ocular health care of patients whilst freeing up capacity across the primary care system. Moreover, further research could be done to elucidate the limitations of the system of primary eye care in the UK. For example, a randomised control trial could be commissioned to investigate the detection and management of eye disease by different pathways. This could involve patients presenting with acute eye problems being randomised to a) optometrist, b) IP optometrist, c) GP, d) A+E. The outcomes of a) time taken from initial contact to receiving the final care, b) correct treatment/ management c) cost to the overall health service d) cost to patients could then be calculated. This would provide conclusive evidence for or against the widespread funding of optometrists been the provider of emergency eye care.

As mentioned throughout the thesis, one possible benefit of optometrists participating in community optometric services is that it frees up capacity in secondary care, allowing ophthalmologists to see patients that require advanced care. This benefit has yet to be quantified. It could be that the costs and any potential reduction in care (optometrist examining and treating patients instead of an ophthalmologist) are outweighed by enabling high complexity patients to receive the care of an ophthalmologist more quickly. This would facilitate the more prompt detection and management of potentially sight threatening eye conditions (i.e. reduce hospital waiting lists). It would be expected that this would provide savings in social care in addition to health

care. One way of examining this would be conduct a study where an expert panel of optometrists assess a hospitals waiting list for patient who could be managed by an optometrist. These patients are then discharged to a funded optometric service where the patient is subsequently rechecked by a panel of consultant ophthalmologists. The result of incorrect optometrist management decisions can be determined using published progression rates of eye diseases. This can then be compared to expected progression of these patients across the time that would have elapsed before their hospital consultation. Together, the results of future studies could be used to provide further evidence for restructuring the GOS sight test in England.

Another area of research could be to examine the effect of false positive referrals from optometrists to the hospital eye service on the likelihood of future attendance at sight tests. False positive referrals for breast cancer screening have been shown to reduce likelihood of attending future screenings (Brett et al. 2005). As patients report not attending sight tests due to fear of getting tests wrong or looking foolish, it could be that a false negative referral to secondary care could be perceived as 'getting a test wrong' and lead to the likelihood of subsequently attending sight tests to be reduced. One method of examining this could be to contact patients two years after their hospital discharge and examine whether a true versus false positive referral has an effect on subsequently attending their routine sight test (attend/ not attend). This could also be compared to a third group of patients matched for age, refractive status and other demographics who had had an eye test at the same time who were not referred to the hospital ophthalmology department. These results could be used to further support or refute the idea that optometrists should receive appropriate training and funding to provide management and follow up of patients with suspected eye problems in primary care.

In conclusion, the present thesis contributes to the body of evidence of the limitations of the present system of eye-health care delivery in England such as health inequalities and patients coming to harm. This also highlights the potential need for a system with national coverage, where postcode lotteries do not determine patient safety.

9. References

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10. Appendix

10.1. Publication from chapter 3

Journal of Optometry (2021) 14, 69–77

Journal of Optometry

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ORIGINAL ARTICLE

Exploring the effect of optometrist practice type on NHS funded sight test outcome

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KEYWORDS
Optometry;
Sight test;
First sight test;
Socio economic status;
Practice type;
NHS

Abstract
Purpose: The United Kingdom (UK) National Health Service (NHS) currently provides sight tests at no cost to patients for all those aged <16 or ≥60. Some 'at-risk' patients and those in receipt of means-tested benefits are eligible for a NHS sight test between the ages of 16 and 60. In the UK, community optometrists typically either work in independent or national chain practices (multiples). The present study aims to explore whether practice type has any association with sight test outcome. As sight tests are essential in detecting early childhood visual problems, we also aim to explore children's first sight tests.
Method: Data from 664,480 NHS sight test claims submitted in Essex from April 2015 to September 2016 were analysed using regression analysis. Practice type (multiple, independent) and children's first sight test were examined with respect to socio-economic status (SES, based on index of multiple deprivation rankings), age and sight test outcome.
Results: The median age for a first NHS sight test was 6 years old and was clinically independent of SES. Children's first sight tests typically resulted in neither a spectacle prescription being issued nor an onwards referral. Patients that attend multiples are significantly more likely to receive a new prescription, relative to no prescription, compared to a patient attending an independent ($p < .001$).
Conclusions: Inequalities in sight test outcome appear to exist with differing type of practice (independent or multiple). Choice of practice type appears to be influenced by SES. Children have their first sight test at a later age than recommended.

10.2. Publication from chapter 5

RESEARCH ARTICLE Open Access

A needs assessment for a minor eye condition service within Leeds, Bradford and Airedale, UK

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Abstract

Background: There are a number of limitations to the present primary eye care system in the UK. Patients with minor eye conditions typically either have to present to their local hospital or GP, or face a charge when visiting eye care professionals (optometrists). Some areas of the UK have commissioned enhanced community services to alleviate this problem; however, many areas have not. The present study is a needs assessment of three areas (Leeds, Airedale and Bradford) without a Minor Eye Conditions Service (MECS), with the aim of determining whether such a service is clinically or economically viable.

Method: A pro forma was developed for optometrists and practice staff to complete when a patient presented whose reason for attending was due to symptoms indicative of a problem that could not be optically corrected. This form captured the reason for visit, whether the patient was seen, the consultation funding, the outcome and where the patient would have presented to if the optometrists could not have seen them. Optometrists were invited to participate via Local Optical Committees. Results were submitted via a Google form or a Microsoft Excel document and were analysed in Microsoft Excel.

Results: Seventy-five percent of patients were managed in optometric practice. Nine and 16% of patients required subsequent referral to their General Practitioner or hospital ophthalmology department, respectively. Should they not have been seen, 34% of patients would have presented to accident and emergency departments and 59% to their general practitioner. 53% of patients paid privately for the optometrist appointment, 28% of patients received a free examination either through use of General Ophthalmic Service sight tests (9%) or optometrist good will (19%) and 19% of patients did not receive a consultation and were redirected to other providers (e.g. pharmacy, accident and emergency or General Practitioner). 88% of patients were satisfied with the level of service. Cost-analyses revealed a theoretical cost saving of £3198 to the NHS across our sample for the study period, indicating cost effectiveness.

Conclusions: This assessment demonstrates that a minor eye condition service in the local areas would be economically and clinically viable and well received by patients.

Keywords: Needs assessment, MECS, Minor eye condition service, Optometry, Primary care, PEARS

10.3. Publication from chapter 7

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OPO THE COLLEGE OF OPTOMETRISTS

ORIGINAL ARTICLE

A prospective evaluation of the clinical safety and effectiveness of a COVID-19 Urgent Eyecare Service across five areas in England

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Abstract

Purpose: Although urgent primary eye care schemes exist in some areas of England, their current safety is unknown. Accordingly, the aim of the present study was to quantify the clinical safety and effectiveness of a COVID-19 Urgent Eyecare Service (CUES) across Luton, Bedford, Hull, East Riding of Yorkshire and Harrogate.

Methods: Consenting patients with acute onset eye problems who had accessed the service were contacted to ascertain what the optometrist's recommendation was, whether this worked, if they had to present elsewhere and how satisfied they were with the CUES.

Results: A total of 27% (170/629) and 6.3% (28/445) of patients managed virtually and in person, respectively, did not have their acute eye problem resolved. Regression analysis revealed that patients who attended a face-to-face consultation were 4.66 times more likely to be correctly managed [Exp (β) = 5.66], relative to those solely managed virtually. Optometrists' phone consultations failed to detect conditions such as stroke, intracranial hypertension, suspected space occupying lesions, orbital cellulitis, scleritis, corneal ulcer, wet macular degeneration, uveitis with macular oedema and retinal detachment. Of referrals to hospital ophthalmology departments, in total, 19% were false-positives. Patients, however, were typically very satisfied with the service. Uptake was associated with socioeconomic status.

Conclusion: The present study found that a virtual assessment service providing optometrist tele-consultations was not effective at resolving patients' acute-onset eye problems. The range and number of pathologies missed by tele-consultations suggests that the service model in the present study was detrimental to patient safety. To improve this, optometrists should follow evidence based guidance when attempting to manage patients virtually, or in person. For example, patients presenting with acute-onset symptoms of flashing lights and/or floaters require an urgent dilated fundus examination. Robust data collection on service safety is required on an ongoing basis.

KEYWORDS
COVID-19 Urgent Eye Care Service, CUES, MECS, ophthalmology, optometry, socio-economic status

10.4. Other Publication 1

Referral in a routine Italian optometric examination: towards an evidence-based model.

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Abstract

Whilst Italian optometrists refract patients and prescribe optical appliances, it is ophthalmologists who are responsible for the detection, diagnosis, and treatment of ocular pathology. In settings with similar scope of practice, close collaboration between optometrists and ophthalmologists is required to minimise avoidable visual impairment. Referral to ophthalmology represents the basis of this synergy, yet no formal guidance is available to Italian optometrists indicating when referrals are warranted. This study aimed to identify circumstances deserving a referral in a routine Italian optometric examination in adults, constituting preliminary evidence-based indications of a referral model.

A literature review was conducted using Pubmed and the Cochrane Library. To derive clinical guidance, the main focus was high quality secondary literature such as systematic reviews and clinical guidelines.

Several signs and symptoms detected during a routine Italian optometric exam might constitute reasons for referral. Further, while a wide range of anomalies of the visual system are likely to be detected by the exam, up to 19% of patients could suffer an asymptomatic condition potentially undetected by the current assessment. This results in the need to refer seemingly healthy patients if they have not attended routine ophthalmological examinations within optimal time frames.

The current training and scope of practice of Italian optometrists requires close collaboration with ophthalmologists to safeguard the ocular health of patients. Referral is a fundamental instrument that in Italy, and countries with similar settings, optometrists must use to enable early diagnosis and treatment of ocular conditions by ophthalmologists. We have presented a preliminary evidence-based framework for optometric referral which identifies categories constituting reasons for referral. This has the potential of standardising optometric practice, enhancing optometry-ophthalmology synergism and, more importantly, improving ocular and general wellbeing of patients.

Keywords: Referral, routine eye examination, avoidable vision loss, refraction, asymptomatic patients, public health

Italian optometrists have no legal responsibility to detect ocular pathology. In Italy, access to the optometric profession is granted either by a 3-year university-based BSc degree or by professional diplomas implemented by private institutions. Although the duration of diploma courses varies across different institutions, these are usually 1 year long and accessible only by individuals already qualified as opticians (i.e. level 2 from the WCO competences model (Kiely & Chappell, 2015)). Overall, educational programmes mirror the scope of practice, with reduced focus on competencies required for the diagnosis and practical management of eye disease, in favour of skills relevant to optical technology and investigation, and correction of visual function. This is in contrast to other parts of Europe, such as the United Kingdom, where optometrists are also trained in the detection and management of eye disease, both roles that pertain solely to ophthalmologists in Italy. Nevertheless, the relationship between the Italian optometrist and patient is one of assistance and care. Accordingly, the care an optometrist provides must be given in the best interest of the patient (Schwartz, 2002). This translates to an aim of promoting general and ocular health in order to reduce visual loss to individuals seen in practice.

Vision impairment is one of the main causes of disability (Kassebaum et al., 2016), and is consistently reported to affect quality of life and psychological wellbeing (Kempen & Zijlstra, 2014; Lamoureux et al., 2009; Patino et al., 2010; Senra et al., 2015). Because of the associated sequelae, vision loss is a well-defined public health issue linked to remarkable burden. Approximately 0.5% and 4.5% of adults living in central Europe are estimated to be blind and suffer moderate-severe visual impairment (MSVI), respectively. Age-related macular degeneration (AMD), glaucoma and diabetic retinopathy are among the main causes of irreversible vision loss in the Western world (Bourne et al., 2018; Bourne et al., 2014; Flaxman et al., 2017), and recent European population-based studies show their prevalence to range between 2 and 4%, increasing significantly with age (Colijn et al., 2017; Kapetanakis et al., 2016; Li et al., 2020; Yau et al., 2012). Notably, almost half of MSVI in Europe results from uncorrected refractive error (Bourne et al., 2018). Beside the effects on visual function, uncorrected refractive error can also affect independence and quality of life (Wolffsohn et al., 2011). As such, minimising barriers to visual correction (e.g. a low clinician to population ratio and long waiting times for eye examinations) is a priority of many countries, in which optometry can play a pivotal role (R. S. Baker et al., 2005; Durr et al., 2014).

For many eye diseases early diagnosis and timely treatment would prevent visual damage, making the majority of global blindness avoidable (Flaxman et al., 2017; Robinson et al., 2012). Yet, applying the idea of safeguarding the visual integrity of patients to the Italian setting requires some consideration of the education system and professional regulation. Indeed, the lack of a thorough assessment of ocular heath within the optometric eye examination hampers the ability to identify people at risk of visual impairment. Therefore, in Italy and other coun-

10.5. Other publication 2

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Quantifying the effect of viewpoint changes on sensitivity to face identity

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ABSTRACT

Although faces can be recognized from different viewpoints, variations in viewpoint impair face identification ability. The present study quantified the effect of changes in viewpoint on sensitivity to face identity. We measured discrimination thresholds for synthetic faces presented from several viewpoints (same viewpoint condition) and the same faces shown with a change in viewpoint (5°, 10° or 20°) between viewing and test. We investigated three types of viewpoint change: (i) front-to-side (front-view matched to 20° side-view), (ii) side-to-front (20° side-view matched to front) and (iii) symmetrical (10° left to 10° right). In the same viewpoint condition, discrimination thresholds were lowest for faces presented from 0° and increased linearly as the viewing angle was increased (threshold elevations: 0° = 1.00×, 5° = 1.11×, 10° = 1.22×, 20° = 1.69×). Changes in viewpoint between viewing and test led to further reductions in discrimination sensitivity, which depended upon the magnitude of viewpoint change (5° = 1.38×, 10° = 1.75×, 20° = 2.07×). Sensitivity also depended upon the type of viewpoint change: while a 20° front-to-side viewpoint change increased discrimination thresholds by a factor of 2.09×, a symmetrical change in viewpoint, of the same magnitude, did not significantly reduce sensitivity (1.26×). Sensitivity to face identity is significantly reduced by changes in viewpoint. Factors which determine the extent of this reduction include the magnitude of viewpoint change and symmetry. Our results support the premise of viewpoint-dependent encoding of unfamiliar face identities, and suggest that symmetry may be used to recognize identities across different viewpoints.