Domiciliary eye care and service recipients in the North West of England

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Summary

Very little research to date has been conducted within the field of domiciliary eye care in the United Kingdom. However, with the ageing population, this sector is likely to expand in the coming years. The programme of research presented in this thesis investigated the visual needs and demands of domiciliary eye care recipients by conducting a questionnaire based survey involving the housebound population; a retrospective review of sight test record cards examined their clinical characteristics compared to conventional practice-based patients, and determined the changes in self-reported visual function following cataract surgery using the VF-14 instrument. All research was conducted in the North West of England.

The initial questionnaire survey obtained 412 responses and highlighted that domiciliary eye care recipients engage in similar leisure activities as the general population of comparable age. Watching television followed by reading were the most frequently-performed activities. Use of PC/ internet browsing was very limited amongst care home residents, but was a common leisure activity performed by almost 40 % of domiciliary patients residing in their own homes. The majority of respondents considered that provision of perfect vision would have a positive impact on their quality-of-life; however, poor vision was not cited as a cause for their housebound status. Many respondents (11.8 %) reported symptoms of tear film disorders, which could be amenable to treatment by mobile eye care practitioners.

The retrospective review of sight test data (including 650 record cards) revealed that there was a greater prevalence of age-related macular degeneration and cataract in domiciliary eye care recipients, particularly amongst care home residents, resulting in a higher rate of visual impairment compared to conventional practice-based patients aged 70 and over. Cataract was the most common reason for referral to the Hospital Eye Service (37.9 % of referrals), indicating that many domiciliary patients are living with correctable visual impairments.

Changes in self-reported visual function following cataract surgery were assessed using questionnaires (VF-14) administered pre- and post-operatively to domiciliary eye recipients (n = 52) and in-practice patients (n = 26). Despite having a limited range of daily activities due to their housebound status, domiciliary eye care patients demonstrated significant improvements in self-reported visual function after cataract surgery (median VF-14 score change for care-home patients was 23.4 [range 12.5-55.0, P <0.001]). The results indicate that where it is in the best interests of the patient, domiciliary optometrists should not be reluctant to refer housebound individuals for cataract surgery.

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I am very grateful to my supervisor, Dr. Amy Sheppard, for her continuous help and support throughout the process, without her assistance, completion of the study would not have been possible. I would like to extend my greatest appreciation to every patient who participated in the various aspects of the study. Finally, I would like to thank my parents for their encouragement.

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List of Abbreviations

ADL	Activities of daily living
AION	Anterior ischaemic optic neuropathy
AMD	Age-related macular degeneration
AREDS	The Age-Related Eye Disease Study
CAG	Closed angle glaucoma
CE	Communal establishment
CI	Cognitive impairment
CNV	Choroidal neovascularisation
COPD	Chronic obstructive pulmonary disorder
CRAO	Central retinal artery occlusion
CVD	Cardio vascular disease
CVDA	Corrected distance visual acuity
DEC	Domiciliary Eyecare Committee
DM	Diabetes mellitus
DR	Diabetic retinopathy
DS	Down's Syndrome
DTA	Decision Tree Analysis
GA	Geographic atrophy
GOS	General Ophthalmic Services

HH	Household
HTN	Hypertension
IADL	Instrumental activities of daily living
IOP	Intraocular pressure
LOC	Local Optical Committees
LOCS III	The Lens Opacities Classification System III
MS	Multiple Sclerosis
NHS	National Health Services
LAT	Local Area Team
LVA	Low vision aid
MGD	Meibomian gland dysfunction
OA	Osteoarthritis
ONS	Office for National Statistics
PCT	Primary Care Trusts
PRO	Patient-reported outcome
QOL	Quality of life
RA	Rheumatoid Arthritis
RFV	Reason for visit
RPE	Retinal pigment epithelium
TED	Thyroid Eye Disease

UK	United Kingdom
USA	United States of America
VA	Visual acuity
VCI	Vascular cognitive impairment
VI	Visual impairment
VFA	Visual field analyser
VRQOL	Vision-related quality of life
WHO	World Health Organisation
WMAR	Weighted logMAR acuity

1.0 Domiciliary eye care demographics

1.1 General Introduction

A regular sight test is a vital health check to ensure optimal vision for daily living and to prevent avoidable sight loss (Domiciliary Eyecare Committee, 2015). Visual impairment (VI) can lead to difficulties in performing activities of daily living (ADL), such as reading, meal preparation and driving (Goldzweig *et al.*, 2004, Vu *et al.*, 2005, McKean-Cowdin *et al.*, 2007). Furthermore, VI among the older population is strongly associated with increased risk of falls and fall related injuries, along with depression and social isolation (Crews and Campbell, 2004, Wood *et al.*, 2011). Although elderly people are at the greatest risk of VI (Wormald *et al.*, 1992), a regular sight test may be overlooked as a part of a health routine due to possible inability to access eye care services or manage their eye care independently (Domiciliary Eyecare Committee, 2015). The World Health Organisation (WHO) defines VI as binocular visual acuity (VA) of less than 6/18 (World Health Organisation, 2010), whereas the American criterion defines VI as VA of less than 6/12 in the better seeing eye (Mönestam and Wachtmeister, 1997, Lamoureux *et al.*, 2008a). For the purpose of sight impaired or severe sight impairment registration in the United Kingdom (UK), the effect of visual field defect (VFD) is also taken into consideration; therefore, VA of 6/18 or better with gross VFD (hemianopia) is classified as partially sighted (Jackson and Wolffsohn, 2007). Studies investigating the universal prevalence of VI, measure the presenting VA with the aid of any habitually worn refractive correction, as opposed to best corrected vision. Uncorrected refractive error induced VI implies VA of less than 6/18, which can be improved to, equal to or better than 6/18 with the provision of accurate refraction or pinhole (Resnikoff *et al.*, 2008).

The population of the United Kingdom (UK) is continually ageing (Office for National Statistics, 2013); according to the Office for National Statistics (ONS) 2013 data, the average life expectancy at birth for males and females has increased to 79 and 82.7 years, respectively, compared to 71.1 and 77 years in 1982 (Office for National Statistics, 2014a). Consequently,

the prevalence of age related VI (Evans *et al.*, 2004a, Slade, 2014) and activity-limiting disabilities has also increased, resulting in more people becoming housebound (Office for National Statistics, 2013)*,* and therefore the demand for domiciliary eye care is set to rise further (Domiciliary Eyecare Committee, 2007). Despite the obvious importance of domiciliary eye care services, there is a paucity of published data relating to this sector of optometric practice. Such data would be valuable in providing evidence base for professional practice and clinical decision making (Anderton, 2007). The sections that follow in this introductory chapter provide an overview of the key issues linked to domiciliary eye care and VI, establishing a rationale for the subsequent experimental chapters.

1.2 Domiciliary optometry

The National Health Service (NHS) funds General Ophthalmic Services (GOS) for eligible patients in the UK (Primary Care Commissioning, 2014). Eligibility criteria include age (under 16 and over 60 years); diagnosed diabetes or glaucoma; positive close family history of glaucoma in those aged over 40, and receipt of income-related benefits. The majority of community optical practices have a contract with the NHS via Local Area Team (LATs), allowing them to provide NHS ophthalmic services to eligible patients (Shah *et al.*, 2007). A fundamental NHS principle is that housebound and disabled patients have the same right to eye care provision as able-bodied people (Domiciliary Eyecare Committee, 2007). Furthermore, due to the Disability Discrimination Act 1995 (amended in 2004), provision of domiciliary optometry is required to ensure the whole of the population has access to eye care services (Shah *et al.*, 2007).

Domiciliary sight tests involve an optometrist or ophthalmic medical practitioner (OMP) conducting the examination in the patient's normal place of residence, or at a day centre (Domiciliary Eyecare Committee, 2015). A person is defined as housebound if leaving their home requires substantial effort or assistance due to physical or mental limitations through illness or injury (Qui *et al.*, 2010). Housebound people may continue to live in their own home

or, in instances where continuous care is required, they may move to communal establishments (CEs), for example care-homes or nursing-homes (Domiciliary Eyecare Committee, 2007). All housebound patients who are eligible for an NHS-funded sight test are entitled to a GOS domiciliary examination. If a patient does not qualify for NHS funding, the domiciliary visit can be arranged on a private basis. Domiciliary eye care services are provided by numerous established national optical chains as well as independent community opticians, though there is no specific list of providers available for the general public.

Mobile eye care providers are required to notify the relevant Health Board or NHS LAT of their intent to provide domiciliary services prior to examining any patient. Details including the date and approximate time of visit; full name and address at which domiciliary services are to be provided; date of birth and National Insurance number (if known), along with date of last General Ophthalmic Services (GOS) test, are required for all patients. In England and Wales, the notice of intent must be submitted at least 48 hours ahead of examining one or two patients at the same address, while a minimum of three weeks' notice (one month in Scotland) is required when three or more patients are to be examined at a single address for example at a care home (The Association of Optometrists, 2013). In addition to the current (April 2015 – March 2016) standard NHS sight test fee of £21.10, a further supplementary domiciliary fee is applicable; £37.19 for the first and second patients examined at the same address and £9.31 for any subsequent patients tested at the same premises (Department of Health, 2014).

According to 2014 GOS activity statistics (Health and Social Care Information Centre, 2014), there were 12.8 million NHS-funded sight tests conducted in England between April 2013 and March 2014; this is an increase of 25.9 % from 2004/05. In comparison, 428,109 domiciliary sight tests were conducted between 2013 and 2014, representing a rise of 46.3 % from 2004/05; sight tests reimbursed at higher rate (up to 2 patients examined at the same address) increased by 74.6 %, whilst sight test reimbursed at lower rate (3 or more patients at the same venue) increased by 15.8 %. However, no data are available on the cause of housebound

status amongst domiciliary sight test patients, thus the reasons for the increase in service utilisation are only speculative; ageing of the population appears to be the most plausible of reasons (Health and Social Care Information Centre, 2014), although an increase in domiciliary service providers may also be relevant.

Given that there are at least 1.4 million housebound people in the UK (Domiciliary Eyecare Committee, 2007), and GOS activity statistics indicate that there were circa 518,000 domiciliary eye examinations in 2013-14 (Health and Social Care Information Centre, 2014, National Services Scotland, 2015, Business Services Organisation, 2013), it appears that there is an under-provision and/ or under-access of domiciliary eye care services. Possible reasons may include poor public knowledge regarding the availability of such services, and/ or fewer of number of practitioners in this field. Lack of availability/ uptake of mobile sight test services could be contributing towards the number of cases of correctable VI in the UK, caused by conditions such as cataracts and uncorrected refractive error (Wormald *et al.*, 1992).

The Joint UK Domiciliary Eye Care Committee (DEC) is a combined group formed by the Association of Optometrists (AOP), the College of Optometrists, the Association of British Dispensing Opticians (ABDO) and the Federation of Ophthalmic and Dispensing Opticians (FODO). The DEC is pivotal in promoting the highest standard of patient care and lobbying the NHS for equal access to eye care for the housebound population. Furthermore, it provides guidance for service providers, practitioners and Local Optical Committees (LOCs). The DEC published a 2007 paper entitled *"A Fundamental Right to Sight"* (Domiciliary Eyecare Committee, 2007) aimed at service providers and commissioning groups, highlighting many aspects and concerns surrounding the domiciliary eye care sector. The DEC may mediate matters delegated to them and help resolve issues that may arise between various parties; for example, in 2010, several Primary Care Trusts (PCTs) suggested it would be mandatory for service providers to have access to portable electronic visual field analysers (VFAs) in order to maintain their additional service contracts. A subsequent practitioner survey indicated only 18.3 % of respondents had access to such portable VFAs, and further, only 9 % of them used

the devices on a regular basis. A likely explanation for the scarceness of VFA use, would be due to the considerable amount of sustained concentration that is required by the patient to accurately complete an automated visual field assessment; the majority of the housebound population are unable to fulfil such demand due to physical posture related difficulties or mental fatigue (Craig and Warburton, 2011). Ensuing guidance from the DEC recommended use of VFAs (either manual or electronic), which produce recordable results, for example the Damato Campimeter, in addition to confrontation assessments (Domiciliary Eyecare Committee, 2011). The DEC recommends the minimum and suitable mobile equipment necessary for practitioners to provide satisfactory eye examinations (Table 1.1).

Tasks	Domiciliary setting	Conventional practice setting
External examination of the eye	Small light source and magnification	Slit-lamp biomicroscope, pen torch and keratometer.
Internal examination of the eye	Direct ophthalmoscope or Indirect ophthalmoscope or Portable digital imaging system	Direct ophthalmoscope or Indirect ophthalmoscope and Digital imaging system
Refraction	Distance test chart and near vision tests, and tape measure. Retinoscope or portable auto-refractor. Trial lenses, trial frame and accessories	Suitable distance test chart and near vision test chart, e.g. Mallet unit. Letter matching cards (for children). Retinoscope or auto-refractor. Trial lenses, trial frame and accessories or refractor head.
Ocular motor balance/motility	Distance and near oculomotor balance tests plus suitable targets and occluder	Distance and near oculomotor balance tests, prism bars, accommodation rule, tests for stereopsis
Intra ocular pressure	Tonometer; e.g. Tono-pen or icare tonometer.	Non-contact tonometers for screening purposes and contact tonometers (e.g. Goldmann) for referral purposes
Visual field assessment	Means of checking peripheral and central visual fields; e.g. Damato Campimeter or Red dot, and Amsler chart.	Peripheral and threshold controlled visual field equipment.
Identification and measurement of current spectacles	Focimeter or Equipment for hand neutralisation	Focimeter

Table 1.1 The list of equipment recommended by the DEC (Domiciliary Eyecare Committee, 2006) for use in mobile ophthalmic services, compared to the instrumentation advised by the College of Optometrists (The College of Optometrists, 2015) for conventional in-practice examination.

1.3 Demographic considerations

The population of the UK is ageing; according to ONS mid-2013 data (Office for National Statistics (b), 2014), 11.1 million people are aged over 65 (17.4 % of the UK population), representing an annual increase of 2.6 % from mid-2012 and 17.3 % since 2003. Life expectancy at age 65 in 2012 was 18.3 years for males and 20.7 years for females, compared to 13.0 years and 17.0 years in 1982 for males and females, respectively (Office for National Statistics, 2014c); Figure 1.1 illustrates the historic and projected life expectancy at birth in the UK (Office for National Statistics, 2014a).
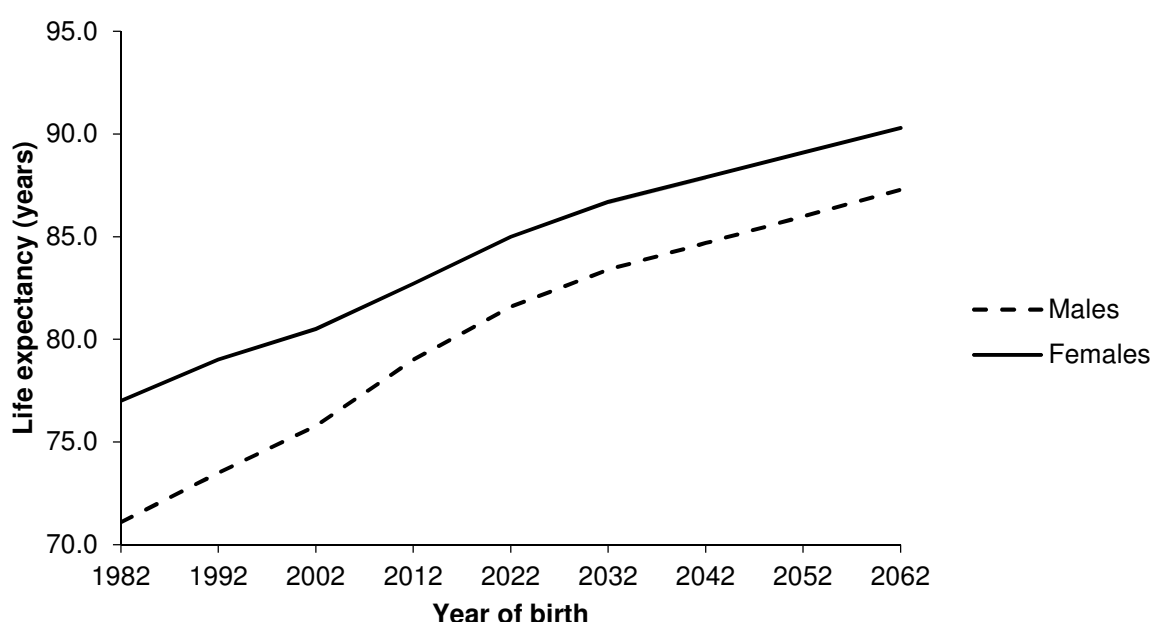
Figure 1.1 The historic and projected increase in life expectancy at birth in the UK, from 1982 to 2062. Data extracted from ONS Statistical Bulletin 2014 (Office for National Statistics, 2014a).

The proportion of people in the oldest age bands is increasing at the fastest rate (Office for National Statistics, 2008). In 2006, there were 4.7 million people in the UK aged 75 and over, which was projected to increase to 5.5 million by 2016 and to 8.2 million by 2031- a rise of 76 % over 25 years. The projected age distribution of the UK population also reflects the ageing population, by 2031 it is estimated that 28.2 % of the UK population will be over 65 compared

to 21.3 % in 2006, whilst the proportions in all other age groups are predicted to reduce (Figure 1.2).
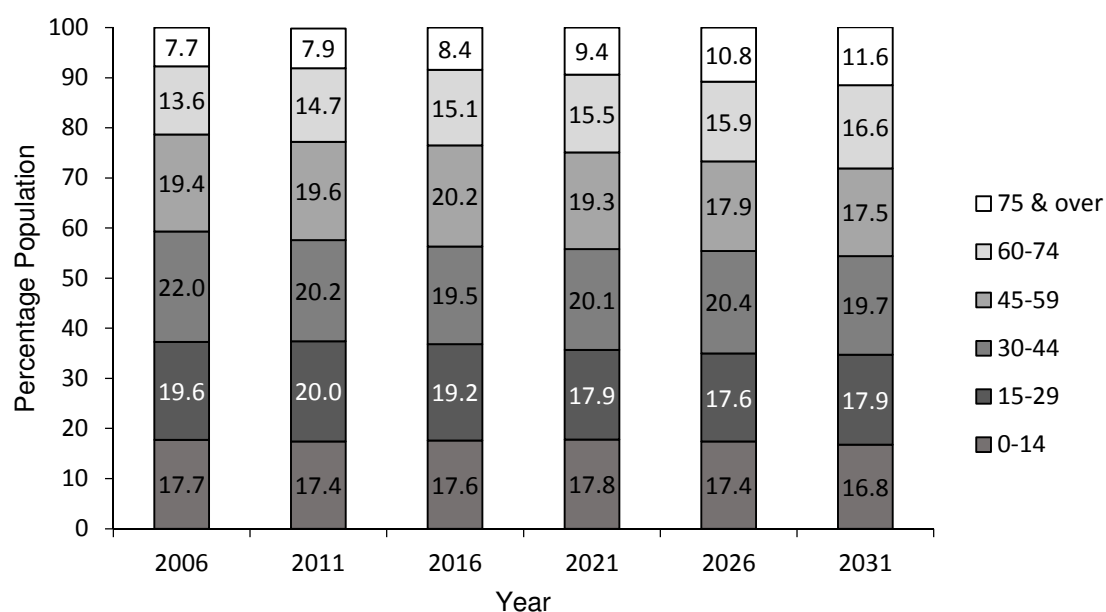
Figure 1.2 The actual and projected age distribution of the UK population (data extracted from Office for National Statistics, 2008).

Of the estimated 1.4 million housebound people in the UK (Domiciliary Eyecare Committee, 2007), 352,000 are currently residing in CEs, and 27 % are male compared to 73 % female (Office for National Statistics, 2013). The gender disparity is attributable to the longer life expectancy of females at age 65 (20.7 years) compared to males (18.3 years) (Office for National Statistics, 2014c). In 2011, 82 % of the CE population were aged 65 years and over with 58 % of them being aged 85 years and over (Office for National Statistics, 2013). Compared to 2001, the proportion of people aged between 65 and 84 living in CEs has decreased from 46 % to 42 %, whilst the proportion of residents aged 85 years and over, increased from 54 % to 58 %. The increase in the age of CE population suggests people are living in their own homes for longer and only moving to CEs with further advancement of age (Office for National Statistics, 2013).

Increased life expectancy does not necessarily mean the additional latter years are spent in a good state of health (Office for National Statistics, 2013). ONS 2008-10 data shows that at 65

years of age, Healthy Life Expectancy (life spent in either "very good" or "good" general health as opposed to "fair", "bad" or "very bad") is 10.2 years for men and 11.4 years for women – representing 57 % of the remaining life expectancy. Furthermore, Disability-Free Life Expectancy (life spent free from a limiting persistent illness and disability) is 10.4 years (58.3 % of the remaining life expectancy) and 11.2 years (54.6 % of the remaining life expectancy) for males and females, respectively. According to 2011 census data, 50 % of the household (HH) population (people living in their own homes) aged 65 and over in England and Wales reported having very good or good health; 35 % reported fair health, and 15 % reported bad or very bad general health. In contrast, 47 % of the CE population reported fair health and 37% reported bad or very bad health. In addition, activity-limiting illness in people aged 65 and over has also increased from 50 % to 52 % from 2001 to 2011 (Office for National Statistics, 2013). Furthermore, the Department of Health estimates three-quarters of the CE population are suffering from severe physical or mental disabilities; 76 % of men and 81% of women in CEs are suffering from locomotor disability (inability to execute activities related to movement; Ebrahim *et al.*, 2000) compared to 30 % of men and 33 % of women in the HH population. Additionally, 33 % of the CE population are diagnosed with severe cognitive impairment (CI) compared to 2 % of the HH population. The proportion of people suffering from severe disabilities is higher in people aged 80 and over (Department of Health, 2002). Available data indicate that the increase in life expectancy has consequently increased the incidence of illness and disabilities, particularly in the final few years and VI accounts for one type of disability. The increased emphasis on assisting people to remain in their own home, rather than moving to CEs, means the provision and promotion of domiciliary eye care services is ever more important as more vulnerable older adults will be living alone in their home (Jones, 2007).

1.4 Activity limiting illness and disability

Housebound individuals frequently suffer from multiple simultaneous health disorders (Dogan and Deger, 2004, Qui *et al.*, 2010). Ageing is associated with chronic diseases; presence of

two or more diseases co-existing is defined as multi-morbidity, and its occurrence is increasing with the ageing population (Marengoni *et al.*, 2008). Age related multi-morbidity leads to a state of frailty, which is a deterioration of physical and psychological well-being (Walston *et al.*, 2006, Marengoni *et al.*, 2008), resulting in reduced physical strength, endurance, mobility and cognition (Fried *et al.*, 2001, Ferrucci *et al.*, 2004). Impairment to the endocrine system, cardiovascular disease (CVD), musculoskeletal diseases including rheumatoid arthritis (RA) and osteoarthritis (OA) are identified as leading disorders contributing towards frailty, resulting in individuals becoming housebound (Kauppi *et al.*, 2005, Cesari *et al.*, 2006, Walston *et al.*, 2006, Barzilay *et al.*, 2007, Brenton-Rule *et al.*, 2012). The definition of frailty has differed between individual epidemiological studies; using physical impediments exclusively as the defining factors, 9.9 % of community-dwelling older persons were found to be frail in a review of 15 USA based papers; however, when psycho-social factors were also included, the prevalence increased to 13.6 % (Collard *et al.*, 2012). Other clinical studies have shown up to 40.8 % of housebound individuals to be suffering from 2 to 3 medical and/or psychiatric comorbid conditions and 30.8 % to have 4 or more comorbid conditions (Beck *et al.*, 2009). The following section will explore in detail, the most common disorders linked to housebound status.

1.4.1 Stroke

The WHO defines stroke as a vascular event leading to a rapid focal or global cerebral dysfunction, and the resultant symptoms last more than 24 hours, unless it is a fatal incident (Warlow, 1998, Feigin *et al.*, 2003). There are two major types of stroke, ischaemic and haemorrhagic; approximately 85 % of all strokes are ischaemic (Intercollegiate Stroke Working Party, 2012, Luengo-Fernandez *et al.*, 2013). Ischaemic strokes are usually caused by cardio-embolism or artherosclerosis of large arteries, whereas haemorrhagic strokes are either intra-cerebral (bleeding within the brain) or subarachnoid (bleeding on the surface of the brain; Amarenco *et al.*, 2009). Haemorrhagic strokes are associated with more severe impairments and have higher risk of mortality (Andersen *et al.*, 2009); 10-15 % of patients die before

reaching hospital and 25 % are deceased within 24 hours of the event occurring (Intercollegiate Stroke Working Party, 2012). Stroke is responsible for 9 % of total global mortality and is the second most common cause of death after ischaemic heart disease (Donnan *et al.*, 2008). According to the UK Stroke Association, there were 1,182,110 stroke survivors and 151,968 new stroke episodes registered in 2013-2014 (Stroke Association, 2015). Although the prevalence of stroke is increasing (Feigin *et al.*, 2014), the incidence rate has steadily reduced over the past few decades; a comparison of statistics from 1990 to 2010 showed a decrease of 19 % in the UK (Lee *et al.*, 2011, Stroke Association, 2015). The decline can be attributed to the improved management of the risk factors such as obesity; smoking; excessive regular consumption of alcohol; hypertension (HTN); diabetes mellitus (DM) and high cholesterol (Donnan *et al.*, 2008, Feigin *et al.*, 2003). However, the most significant determinant is advancing age (Carroll *et al.*, 2001); the risk of having a stroke doubles every decade after the age of 55 years (Brown *et al.*, 1996), and it is estimated that 20 % of the female and 16.5 % of the male population aged 75 years and over in the UK have suffered from an episode of stroke (Seshadri *et al.*, 2006). Stroke is responsible for multiple disabilities (Cameron *et al.*, 2003), which include communication problems (aphasia; Engelter *et al.*, 2006); motor deficits (upper and lower limb impairments; Lawrence *et al.*, 2001); CI (de-Jong *et al.*, 2002) and psychological symptoms (anxiety, confusion and depression; Bonita *et al.*, 1997, Macintosh, 2003, Hackett *et al.*, 2005). The severity of the stroke-related impairment depends on factors such as the age of the patient, duration of the stroke before treatment was administered, and the presence of any pre-existing comorbidities (Paker *et al.*, 2010). Approximately 50 % of stroke patients suffer from some form of disability (Adamson *et al.*, 2004); common physical incapacities involve difficulties with motor functions; balance; walking speed and endurance (Kollen *et al.*, 2005, Port *et al.*, 2008), and as a result an estimated 37 % of stroke patients require help with performing ADL (Chemerinski *et al.*, 2001, Stroke Association, 2015). Visual disorders develop in 66 % of the post-stroke cases (Macintosh, 2003), which include visual field defects (hemianopias and quadrantanopias), ocular motility and visuospatial defects (Tarbert *et al.*, 2014). Identification and management of visual

symptoms will help enhance the possibility of a successful rehabilitation and optimise long-term recovery of a stroke patient (Diamond, 2001).

1.4.2 Cardiovascular disease

The prevalence of CVD is rapidly increasing worldwide and is a leading cause of disability and mortality (Nangia *et al.*, 2014, Protulipac *et al.*, 2015). Advancing age is a major risk factor for development of atherosclerotic CVD, including coronary artery disease, peripheral arterial disease and ischaemic stroke (Rich, 2014). It is estimated that 70 % of people aged 75 years and over are diagnosed with HTN and 22-33 % of people aged 65 years and over are suffering from DM; HTN and DM are identified as strong risk factors for CVD and stroke (Rich, 2014). Physical inactivity (a lack of regular walking or cycling, recreational activity or sporting activity; Ebrahim *et al.*, 2000) in the older population, which may be due to functional problems and CI also increases the risk of developing CVD, and reciprocally, CVD leads to further reduced physical activity, ultimately resulting in restricted mobility and housebound status (Patel *et al.*, 2010). It is estimated that over 80 % of people aged 75 and over suffer from clinically manifest CVD, and it is the most frequently occurring medical disorder in the elderly population resulting in individuals becoming housebound (Qui *et al.*, 2010, Rich, 2014). According to the British Heart Foundation, there are an estimated 7 million people living in the UK with some degree of CVD and 2.3 million have diagnosed coronary heart disease (CHD; British Heart Foundation, 2008).

1.4.3 Arthritis

Arthritis is one of the most frequently occurring health disorders in the ageing population resulting in physical disabilities and mobility difficulties (Hirvensalo *et al.*, 2000, Kauppi *et al.*, 2005). There are two major types of arthritis associated with ageing; RA and OA. RA is a chronic progressive inflammatory disease characterised by articular damage, resulting in deformities of limb joints, ultimately causing immobility (Goksel K.A *et al.*, 2010). Deformation of the foot joint is a common symptom associated with RA; previous studies have established

that 75 % of patients with RA develop foot joint abnormalities within 4 years of the disease onset, increasing to 90 % with progression of the condition (Silvester *et al.,* 2010). Thirty-one to thirty-three per cent of RA patients have a fall at least once a year, and 16-52 % suffer a repeated fall within the year (Fessel and Nevitt, 1997, Armstrong *et al.*, 2005).

OA is a chronic degenerative disease involving cartilage loss, abnormal remodelling and attrition of subarticular bone, ligamentous laxity and weakening of periarticular muscles; typically affecting the knee, hip and hand joints (Hutton, 1989, Arden and Nevitt, 2006). It is the most common form of joint disorder in the Western population, with a prevalence rate of 80 % in people aged 75 and over (Arden and Nevitt, 2006) and 42-62 % of the housebound population (Qui *et al.*, 2010). The risk factors for OA include age, female gender, congenital joint malformation, positive family history and previous joint related injuries in earlier life (Arden and Nevitt, 2006).

1.4.4 Chronic obstructive pulmonary disease (COPD)

COPD is a progressive inflammatory response in the airways, characterised by a limitation of airflow to the lungs (Vestbo, 2014). It is responsible for a substantial level of global mortality and morbidity (Shahab *et al.*, 2006); there are an estimated one million people in the UK diagnosed with the disease (Health and Safety Executive National Statistics, 2014). The risk of developing COPD increases with age and smoking; 50 % of the smoking population aged 65 and over are diagnosed with COPD compared to 15 % of non-smoking counterparts. Commonly reported symptoms include breathlessness and cough (NICE, 2009a), which can limit an individual's ability to perform physical activities resulting in immobility.

1.4.5 Cognitive Impairments

CI is defined as diminished capacity to comprehend the surrounding; it is classified by physicians based upon the presenting signs and symptoms, following which, clinical examination reveals the cause and mechanism for the impairment (Folstein *et al.*, 1985).

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1.4.5.1 Down's Syndrome

Down's Syndrome, (also known as Down Syndrome; DS) is the most frequently occurring congenital cognitive disorder in the UK; the natural prevalence is 1 in every 600 live births (Marder and Dennis, 2001).However, due to prenatal identification and termination of some affected pregnancies, the incidence rate is 10.3 in every 10,000 live births (Bell *et al.*, 2003). Average life expectancy at birth of individuals with DS has increased from 35 years in 1982, to 60 years in 2002 (Bittles and Glasson, 2004). DS is a multi-system disorder with wide ranging ailments, and the extent of the disease varies between individuals (Marder and Dennis, 2001). The most frequently occurring health disorders include congenital heart disease (40-60 % of new-borns); orthopaedic problems; hearing impairment (50 %); type 1 DM; depression; seizures and autism (Marder and Dennis, 2001, Henderson *et al.*, 2007). An estimated 43 % of children with the disorder need a refractive correction, and further, 45 % may also have accompanying strabismus (Stephen *et al.*, 2007). Common ophthalmic disorders in adults with DS include, nystagmus (12 %); refractive error of 3 dioptres or more (25 %); kerataconus (5-8 %) and cataracts (42 %; Krinsky-McHale *et al.*, 2012). Therefore, routine eye examination of DS patients is important to diagnose and treat any ocular disorders that can lead to VI (Georgalas *et al.*, 2014).

1.4.5.2 Post-Stroke cognitive impairment

Vascular cognitive impairment (VCI) refers to all forms of CI caused by cerebrovascular disease (O'Brien *et al.*, 2003). The severity of stroke, advancing age and previous mental decline independently contribute towards the risk of developing VCI (Barba *et al.*, 2000). Common underlying pathologies includes strategic infarcts, where lesions affect the areas of the brain which control or participate in cognition and behaviour (D'Abreu and Ott, 2005), and small-vessel disease which causes occlusion of one of the penetrating arteries that provides blood to the brain's deep structures, resulting in lacunar infarcts (de-Jong *et al.*, 2002). It is estimated that 66 % of all stroke patients suffer from some form of neurological damage (Feigin *et al.*, 2010), though after a period of 5 years and 14 years, the level of cognitive deficit

reduces to 22 % and 21 %, respectively (Douiri *et al.*, 2013). The immediate cognitive deficiencies include memory loss, reduced visuospatial ability, lack of attention and processing speed; whilst potential long-term problems include the development of vascular dementia and Alzheimer's disease (AD; Pendlebury and Rothwell, 2009). CI can reduce functional capacity, therefore resulting in poorer rehabilitation outcomes and diminished ability to perform ADL independently (Mellon *et al.*, 2015).

1.4.5.3 Dementia and Alzheimer's Disease

Dementia is a global term used to describe a group of pathologies and disorders that develop due to death or malfunction of the brain cells/ neurons leading to a progressive cognitive decline in one or more domains, such as short-term memory; abstract thinking; judgment; language and personality changes (Thies and Bleiler, 2013, Chertkow *et al.*, 2013). It is a major reason for disabilities amongst older people and eventually leads to loss of independence (Sosa-Ortiz *et al.*, 2012). It is estimated that there are 24.3 million people affected by dementia worldwide, and it is predicted to increase to 42.3 million by 2020 (Ballard *et al.*, 2011). Alzheimer's Disease International (ADI) estimate that there are 4.6 million new cases annually and the number of people affected by the disease will increase to 100 million by 2050 (Alzheimer's Disease International, 2008). The European dementia meta-analysis (EURDEM) used data from 11 cohorts from 8 European nations to calculate the incidence rate and prevalence of dementia. Incidence of dementia cases increases from 0.2 in people aged 60 - 64 years to 4.0 and 8.2 per 100 male and female persons aged 90 years and over, respectively. Similarly, the prevalence of dementia increases from 0.4 % in males and females aged 60 – 64 years to 22.1 % and 30.8 % in male and female aged 90 years and over, respectively (Lobo *et al.*, 2000).

There are many risk factors that may contribute towards the development of dementia, such as, advancing age; female gender; physical inactivity and obesity; smoking; excessive alcohol consumption; DM; HTN and genetic pre-disposition (Chen *et al.*, 2009, Mayeux and Stern,

2012). Miscellaneous environmental factors, such as head trauma can also be responsible for onset of dementia in later life (Weiner *et al.*, 2013). Dementia can be categorised according to the aetiological basis of the disease, which include neurodegenerative diseases, systemic disorders or miscellaneous background. (Thies and Bleiler, 2013). The most prevalent form of dementia is associated with AD, which accounts for 62 % of all dementia cases, followed by vascular dementia (17 %) (Nowrangi *et al.*, 2011, Mayeux and Stern, 2012). Mixed forms of dementia, typically AD in association with vascular dementia, account for approximately 10 % of all dementia cases, though any two or more sub-types of the disorder can co-exist to give rise to a mixed form of dementia (Armstrong and Kergoat, 2015). Up to 90 % of individuals suffering from dementia experience neuropsychiatric symptoms, such as aggressive behaviour, distress, depression, repetitive vocalisation, sleep disorders, delusions, paranoia, hallucinations memory loss (Georges *et al.*, 2008, Steinberg *et al.*, 2008). Table 1.2 summarises different types of dementias, their clinical characteristics and common symptoms.

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Table 1.2 Summary of the different types of dementia and their clinical characteristics, symptoms and estimated proportion of dementia attributed to each condition (Thies and Bleiler, 2013, Armstrong and Kergoat, 2015).

AD progresses in stages, from mild to moderate, and then moderate to severe, and the extent of symptoms varies according to the stage of the disease. In the advanced stage, AD can cause loss of basic motor functions such as walking, swallowing, and ultimately prove fatal (Thies and Bleiler, 2013). Visual deficits associated with AD includes deterioration in visual acuity (VA); reduced stereopsis and contrast sensitivity; colour vision impairment and ocular motility disorders (Liu *et al.*, 2015). Epidemiological studies in Western developed countries indicate that the prevalence of AD increases with age; on average 1- 3 % of people aged 60- 64 years are affected by the disease, increasing to 3- 12% in people aged 70- 80 years, and 25- 35 % in people aged 85 years and over (Kukull and Bowen, 2002, Walsh and Selkoe, 2004). The Alzheimer's Society estimated that there were 815,000 people in the UK with diagnosed dementia in 2015, and it will increase to 1 million by 2025, and further, to 2 million by 2051; however, only 44 % of the population with dementia are officially diagnosed (Alzheimer's Society, 2015). Estimates suggest that 1.7 % of people aged 65 - 69 years suffer from some form of dementia in the UK, which increases to 17 % and 40 % in people aged 80 - 94 years and 95 years and older, respectively. Dementia also affects younger people, as there are an estimated 40,000 dementia patients in the UK under the age of 65 years (Alzheimer's Society, 2015). Two-thirds of dementia-affected individuals live in community HHs compared to one-third in CEs, though 80 % of the CE population are believed to suffer from a form of dementia or from severe memory loss (Alzheimer's Society, 2015). Although, there are medications available to control the symptoms of AD, there is no treatment available to prevent or slowdown the progression of the disease (Sibenera *et al.*, 2014). Several clinical trials are being conducted, attempting to discover a method of decelerating the advancement of the disease; however they are all in their early stages of investigation (Ballard *et al.*, 2011). Other observational studies have reported that patients using simvastatin to lower cholesterol, have a reduced risk of dementia onset, though such theories need rigorous scientific investigation before widespread application (Chen *et al.*, 2009).

Longer life expectancy has increased the prevalence of multiple morbidities, including dementia and VI. The Royal National Institute of Blind People (RNIB) estimates that there are currently 2 million people in the UK living with VI, and it will rise to 4 million by 2050 (Access Economics, 2009); at the same time it is predicted the number of people living with dementia will also double to 2 million (Alzheimer's Society, 2015). Dementia can be directly responsible for VI (Liu *et al.*, 2015); however, studies have also suggested dementia patients are more at risk of not having a regular eye examination, resulting in increased prevalence of correctable VI among this population (McKeefry and Bartlett, 2010). As a result, resources are being invested to establish methods to minimise the consequence of coexisting dementia and VI. One such project is the ongoing ProVIDe study (Prevalence of Visual Impairment in Dementia), a recent multidisciplinary project led by the College of Optometrists. The aim of project is to investigate and establish eye care needs of people with dementia and help develop a Dementia Eye Care Pathway (DECP), which will promote the need for timely intervention and treatment of VI in people with dementia (Hancock *et al.*, 2015). The College of Optometrists has also published professional guidance in relation to adaptations in approach that may be necessary, prescribing patterns and management strategies, for optometrists providing eye care services to patients with CI.

1.5 The Ageing Eye

Ageing is accompanied with compromised function of the eye (Voleti and Hubschman, 2013) due to anatomical changes in ocular structures, including loss and attenuation of cells, leading to damaged tissue (Grossniklaus *et al.*, 2013). This section will review the key ocular pathologies associated with ageing and their impact on vision.

1.5.1   Cataract

Cataract is the loss of lens clarity and formation of media opacities resulting from denaturation of lens proteins and oxidative damage (Michael and Bron, 2011). It is a leading cause of VI worldwide (Abraham. *et al.*, 2006); according to the World Health Organisation (WHO), 33 %

of global VI and 51 % of blindness is caused by cataracts (World Health Organisation, 2010). According to the RNIB, there are 206,224 partially-sighted and 27,907 blind people in the UK as a result of untreated cataracts; the figures are predicted to increase to 248,504 and 32,750 by year 2020, respectively (RNIB, 2009). Cataract is most prevalent in the older population, and it typically requires surgical intervention to restore vision (Foster, 2001). There is a higher risk of developing cataract with advancing age; female gender; having a genetic predisposition; smoking; DM and exposure to UVB radiation (Vrensen, 2009). Steroidal medications have also been associated with stimulating early formation of cataracts (Taylor, 1999). Cataracts can be classified according to their anatomical location (histological), or on aetiological basis, which include congenital; age-related; traumatic; drug-induced, and secondary to other ocular or systemic diseases. However, age-related cataract is often multifactorial (Prokofyeva *et al.*, 2013), and therefore histological classification is deemed as more appropriate. There are three main types of cataracts; nuclear, cortical and posterior sub-capsular (Taylor, 1999, Hammond, 2001), although a combination of more than one type coexisting is frequently encountered (Asbell *et al.*, 2005a). The density and yellowing of the crystalline lens increases with age and it becomes more apparent from the age of 40 years (Duncan *et al.*, 1997). The changes in the structural properties of the lens are caused by the accumulation of pigments and oxidation of glutathione in the nucleus resulting in nuclear sclerosis (Salvi *et al.*, 2006, Michael and Bron, 2011). The ageing process results in degradation of the optical properties and increased light scattering, which is debilitating to various degrees (Vrensen, 2009). The presence of a cataract does not necessarily warrant an immediate surgical intervention, as it has a broad spectrum of severity. In the early stages, adjustment to the spectacle/ contact lens power may be sufficient to compensate for any alteration to refractive power caused by thickening of the lens (Voleti and Hubschman, 2013) and optimisation of the light source where necessary, for instance, when reading, may keep cataract related symptoms at a minimum (Vrensen, 2009). Currently, there are no definitive cataract referral criteria; the Royal College of Ophthalmologists guidelines states that there must be "sufficient cataract to account for visual symptoms affecting patient's lifestyle and the

patient must be informed of risks and benefits of surgery and willing to undergo surgery in an attempt to improve vision" (The Royal College of Ophthalmologists, 2010). The WHO has set a target rate of 3000 cataract surgery per million people per year as the minimum necessary to eliminate cataract induced blindness (Erie, 2014). In England, cataract extraction is the most frequently performed NHS-funded surgical procedure, with approximately 389,000 operations performed in 2010 and this figure is expected to increase to 473,944 cases per year by 2020 (Royal College of Ophthalmologists, 2010, RNIB, 2009). The rate of cataract extraction has increased since the phacoemulsification technique was introduced, originally in 1967 (Linebarger *et al.*, 1999); it is regarded as one of the safest and most cost-effective surgical procedures in medicine (Abell and Vote, 2014). Accurate optical biometric measurements allow precise selection of intra-ocular lens (IOL) implants (Bakbak *et al.*, 2013), minimising post-surgical refractive error and thereby allowing most patients to have reasonable unaided distance vision (Chang-Godinich *et al.*, 1999). According to an audit by the Royal College of Ophthalmologists, in the absence of any other ocular comorbidity, 85 % of people undergoing cataract surgery achieved post-surgical unaided vision of 6/12 or better, increasing to 92 % with refractive correction. In instances where other ocular diseases were present, 65 % of the patients achieved an unaided vision of 6/12 or better, increasing to 77 % with the help of corrective spectacles (Royal College of Ophthalmologists, 2010). Additional benefits of having clear optical media include the ability to perform other ocular diagnostic examinations accurately and produce meaningful results; for example optical coherence tomography (OCT) used in management of glaucoma (Bambo *et al.*, 2014). Furthermore, cataract surgery is effective in lowering IOP by up to 4 mmHg for at least one year, which represents on average, a 16.5 % reduction compared to preoperative IOP; however, the effect diminishes over a 3 year period (Ansberger *et al.*, 2012).

Age-related cataract contributes towards a significant proportion of VI worldwide (Michon *et al.*, 2002); however, timely detection and referral for surgical intervention can restore vision (Asbell *et al.*, 2005b). Therefore, domiciliary eye examinations are instrumental in identifying

vulnerable housebound people who are suffering from cataract-related VI and in need of surgical interventions.

1.5.2 Glaucoma

Glaucoma is a multifactorial disease, characterised by loss of retinal ganglion cells and optic atrophy, resulting in progressive loss of visual field and VA (Foster *et al.*, 2002) (Chader and Taylor, 2013). Glaucoma is classified according to its aetiology- primary, secondary or developmental (Kroese *et al.*, 2002). The classification system is further divided into specific sub-types according to pathophysiological origin, which include primary open angle glaucoma (POAG); normal tension glaucoma (NTG); primary angle closure glaucoma (PACG); secondary open angle glaucoma (SOAG) and secondary angle closure glaucoma (SACG).

Secondary glaucoma is a consequence of another ocular disorder, causing a sudden exponential rise in intraocular pressure (IOP); a clinical reason is evident for the physician to distinguish from other types of glaucoma (Casson *et al.*, 2012). Risk factors for developing glaucoma are, advancing age; positive family history; ethnicity (particularly Afro-Caribbean background); DM; high myopia; ocular trauma; inflammatory disease (uveitis) and use of topical corticosteroids (Voleti and Hubschman, 2013). Although historically, elevated IOP was the defining characteristic of glaucoma, subsequent studies have identified it as a risk factor only (Foster *et al.*, 2002) and elevated IOP without optic neuropathy or visual field defect is described as ocular hypertension (Kass *et al.*, 2002).

Epidemiological studies investigating the prevalence rate of glaucoma have mainly focussed on POAG, as it is the most common form of the disease. WHO estimates that glaucoma is responsible for 2 % of global VI and 8 % of blindness (World Health Organisation, 2010). According to UK-based studies, there were 265,973 diagnosed cases of glaucoma in 2010, and this is projected to increase to 327,440 by 2020. Moreover, 57,646 of sufferers are estimated to be partially sighted and a further 17,511 are likely to be blind. Assuming the

disease incidence and detection rate remain constant, by 2020 the figures will rise to 71,806 partially sighted and 22,261 diagnosed as blind (RNIB, 2009). The prevalence of glaucoma increases with age; from 2 % in people aged 40 and over, to 10 % in people aged 75 and over; 10 % of UK registration as severely sight impaired is attributed to glaucoma (NICE (b), 2009). In the initial stages of POAG, patients are asymptomatic, and only develop symptoms when significant visual field loss has occurred; therefore early diagnoses and intervention of the disease increases the chance of preserving vision (Maier *et al.*, 2002). Currently, maintaining a relatively reduced level of IOP is the only effective treatment available to control the disease (Heijl *et al.*, 2002, Leske *et al.*, 2003). Regular monitoring of glaucoma patients is necessary to ensure the prescribed treatment is maintaining the desired level of IOP and there are no further glaucoma-related adverse changes to the vision (Alezzandrini *et al.*, 2014).

1.5.3   Age Related Macular Degeneration

In developed countries, age-related macular degeneration (AMD) is the leading cause of irreversible vision loss in people aged 55 and over (Tomany *et al.*, 2004). AMD is a chronic degenerative disease of the macula, characterised by the progressive destruction of the retinal pigment epithelium (RPE), resulting in central visual scotoma (Ambati *et al.*, 2003). The major risk factor for AMD is advancing age; the prevalence increases from 2 % in people aged 40-50 years, to 35 % in people aged 80 years and over (Chader and Taylor, 2013). Other risk factors include female gender; positive family history; smoking and exposure to ultraviolet light (Ambati *et al.*, 2003) (Tomany *et al.*, 2004) (Cachulo *et al.*, 2015). There are two types of AMD based on their pathogenesis; atrophic and neovascular/ exudative AMD. Early stages of atrophic AMD, also known as age-related maculopathy (ARM), are characterised by the presence of soft drusen and pigmentary abnormalities within 2 disc diameters of the fovea. In later advanced stages, there is extensive damage to the RPE layer and choriocapillaris, leading to a state of geographical atrophy (GA), where no central vision remains. Currently, there is no treatment available for this form of AMD other than managing risk factors, for example smoking; however, it takes many years to reach the advanced stage (Cachulo *et al.*,

2015). In exudative AMD, choroidal neovascularisation (CNV) occurs, and new blood vessels leak blood and serum beneath the macula; if left untreated, it permanently damages the RPE and results in formation of scar tissue causing irreversible loss of central vision (Berg *et al.*, 2015). Before the introduction of anti-VEGF therapy (bevacizumab or ranibizumab), treatments such as photodynamic therapy in conjunction with verteporfin were used to stabilise vision, which often left patients with poor central vision and/ or noticeable central scotomata (Macular Photocoagulation Study Group, 1991, Verteporfin In Photodynamic Therapy Study Group, 2001). Treatment with anti-VEGF agents have shown to stabilise vision, and some studies have reported improvement in VA following the treatment (Bressler *et al.*, 2010). According to the RNIB estimates for 2015, 1,661,499 people will have early stage ARM in the UK, and it will increase to an estimated 1,821,434 people by 2020. In addition, the number of people suffering from exudative AMD and GA in 2015 will increase from 455,675 and 212,627 to 515,509 and 240,358, respectively, by 2020. In 2009, AMD was cited as the reason for 153,468 partially sighted registered people and 105,056 registered blind people in the UK, and it is predicted to increase to 171,530 partially sighted and 120,452 blind people by 2020 (RNIB, 2009).

People with central vision loss experience increased difficulties in recognising faces, performing ADL and engaging in leisure activities, for example reading and watching television (Albert *et al.*, 2007). Impaired central vision in older adults is also associated with greater risk of falls and fall-related injuries (Wood *et al.*, 2011); furthermore, the fear of falling reduces social and physical activity (Wang *et al.*, 2012). Such visual limitations are linked to reduced quality of life (QOL) and depression (Mathew *et al.*, 2011). Low vision rehabilitation and provision of low vision aids (LVAs) are effective in improving the functional ability of visually impaired patients (Goldstein *et al.*, 2014), therefore visually-impaired housebound patients may experience similar visual benefits with the provision of optimal refractive correction and LVAs.

1.5.4 Diabetic Retinopathy

Diabetic retinopathy (DR) is a microvascular disease, and it is a leading cause of VI in people of the working age (Mazhar *et al.*, 2011). The prevalence of DR increases with the duration of DM, with almost 100 % of type-1 and 60 % of type-2 DM sufferers likely to develop some level of DR after 20 years (Lamoureux *et al.*, 2010). An investigation of the prevalence of DR in the old and the young did not reveal any marked differences, with a prevalence of 1.7 % in people aged below 60 years; 2.4 % in age group 60-69 years; 2.7 % in people aged 70-79 years and 2.4 % in people aged over 80 years (Mitchell *et al.*, 1998). In 2010, there were approximately 748,000 people in the UK with background DR and 85,484 people with non-proliferative and proliferative DR. It is estimated that in the next 10 years, the number of people suffering from background DR will increase to 938,000 and the number of people with non-proliferative and proliferative DR will increase to 107,218. However, most DR-related VI is associated with the development of macula oedema (Chader and Taylor, 2013); approximately 187,842 people were detected to have some level of diabetic maculopathy in 2010, which is likely to increase to 235,602 in the following 10 years. In 2009, approximately 40,982 people were recorded as partially-sighted and a further 24,976 people as severely sight impaired due to DR; over the next decade, it is expected to rise further to 46,473 people partially-sighted and 29,957 people as severely sight-impaired (RNIB, 2009). Regular retinal examinations are important in diabetic patients, as early detection and timely intervention reduces the incidence and progression of DR-related VI by up to 50 % (Agardh *et al.*, 1993) (Scanlon, 2008). Although it is preferable to use a digital fundus imaging technique for the purpose of DR screening, regular dilated funduscopy with direct and indirect ophthalmoscopy provides valuable, accurate and cost-effective means of screening where imaging technology is not accessible (Cheung *et al.*, 2010).

1.5.5 Tear film disorders

The International Dry Eye Workshop defines dry eye as "a multifactorial disease of the tears and the ocular surface, resulting in discomfort and visual disturbance from increased

osmolarity of the tear film and tear instability; in addition, inflammation and damage to the ocular surface may occur" (DEWS Definition and Classification, 2007). Quality of the tear film composition is important to maintain the ocular surface integrity and health (Ding and Sullivan, 2012). The tear film is composed of three layers; the inner underlying mucin layer, the middle aqueous layer and the overlying lipid layer. Disruption to any one of these layers can lead to tear film disorder and accompanying symptoms (Nichols *et al.*, 2011).

The lipid layer is produced by the meibomian glands, and it is responsible for preventing tear film evaporation (Den *et al.*, 2006). Meibomian gland dysfunction (MGD) leads to poor lipid layer, causing evaporative dry eye, which is the most prevalent form of dry eye in the ageing population (Schaumberg *et al.*, 2009). Some studies estimate that up to 67.2 % of people aged 60 years and over have some level of MGD, compared to 0 % in children aged 10 years or under (Bron *et al.*, 2004). Given that the tear film disorders increases significantly with age (Sharma and Hindman, 2014), a considerable proportion of the domiciliary eye care recipients are likely to be affected. The mainstay of dry eye management is through the use of ocular lubricants to restore the balance of tear composition and quantity, together with appropriate lid hygiene to treat any associated MGD and other lid conditions, for example blepharitis (Pflugfelder *et al.*, 2000, Olson *et al.*, 2003). Regular routine eye examinations will be sufficient in detecting and managing dry eye syndrome and its associated symptoms.

1.6 Quality of life and impact of VI

The WHO defines QOL as "the individual's perception of their position in life in the context of their culture; values; goals; expectations; standards and concerns" (Parrish, 1996). Furthermore, the WHO defines health as "a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity" (Ellwein *et al.*, 1995). QOL is a multidimensional construct, incorporating many aspects of life-conditions and personal satisfactions (Felce and Perry, 1995). It includes physical parameters (disease symptoms and treatment efficacy), functional parameters (mobility, ability to perform ADL, and

independence), social parameters (social interaction and relationships), and psychological parameters (cognition, emotional status/well-being, satisfaction and happiness; Aaronson, 1988).

The assessment of health-related QOL (HRQOL) is a common procedure employed in clinical research to gauge the impact of a particular disease and/ or level of success of an intervention (Wolffsohn *et al.*, 2000, Revicki, 2007). Understanding the patient's perspective of their health outcomes is an important factor in implementing healthcare programmes; using clinical parameters in isolation may no longer be considered adequate for evaluation of the limitations of a disease or benefits of a treatment (Tadi *et al.*, 2013, Bowlinga *et al.*, 2015). Acquiring the patient's subjective view can also form a part of the prognostic indicators and assist future decision making for subsequent patients with similar conditions (Fallowfield, 2007).

Over the past 20 years, the use of patient-reported outcomes (PROs) has increased significantly (Bottomley *et al.*, 2009). A number of PRO instruments, in the form of questionnaires, have been developed (Khadka *et al.*, 2015). A PRO instrument can be generic, designed to cover multiple domains, or disease-specific, focusing on one particular dimension, for example, the effect of stroke on the functional abilities of the sufferer (De-Boer *et al.*, 2004a).

In the ophthalmic field, a wide array of questionnaires have been developed, which cover a diverse range ocular disorders and their impact on VRQOL (Khadka *et al.*, 2015). The availability of a large number of instruments provides researchers with a choice and a challenge to select the most suitable instrument for the intended research (Khadka *et al.*, 2013). An appropriate questionnaire should have the relevant descriptive qualities and high psychometric values to ensure the instrument is well suited to the research protocol and it is sensitive as an outcome measure (Pesudovs *et al.*, 2002). The descriptive aspects involve the target population (VI in general or disease/ concept specific); the dimensions of QOL involved;

the number of items assessed; the response categories and the mode of administration (De-Boer *et al.*, 2004a).

The validity and the reliability of a PRO instrument determines the psychometric qualities. The validity refers to the ability of the instrument to investigate the objective of the study (Guyatt *et al.*, 1993); it can tested by examining the content validity; face validity; construct validity; criterion validity and group validity (Lundstrom and Wendel, 2006). The reliability refers to the ability to produce constant results and it is determined by factors such as repeatability, reproducibility and internal consistency (Lundstrom and Wendel, 2006, Pesudovs *et al.*, 2007).

Additional aspects to consider when selecting a questionnaire include item responsiveness and respondent-burden. Responsiveness refers to the aptitude of the instrument to detect change over time, in the concept being measured (Terwee *et al.*, 2003). Respondent-burden is defined as the amount of time and energy required to complete the survey. This is particularly important when the target population include people who suffer from disabilities, and the request to complete the survey may place physical and/ or emotional strain upon them. Therefore it has been proposed that surveys should be limited to 15 minutes for completion (Andresen, 2000).

The two imperative features that are requisite for a quantifying instrument is that it is one-dimensional - therefore it only measures one entity and the scale is interval-level - thus the difference between each level on the scale is equal (Mallinson, 2007). A recent systematic review, examining the robustness of ophthalmic PRO instruments, revealed only 48 of the 121 available questionnaires adopted an interval scoring system. These 48 questionnaires were further scrutinised, to establish the most vigorous questionnaire in each field; the results are summarised in Table 1.3 (questionnaires relating to children's low vision, strabismus and amblyopia are excluded from the table).

Table 1.3 Details of ophthalmic PRO instruments, including recommendations and criticisms of each questionnaire (Khadka *et al.*, 2013).
*Modified version with revised scale. Original version lacked MP and/ or not one-dimensional
**Modified version with revised subscale. Original version lacked MP and/ or not one-dimensional
+Modified version with new scale. Original version lacked MP and/ or not one-dimensional
MP. Measurement precision

Consideration should be given to the PRO instrument selection process. Psychometric robustness ensures the results obtained are a true reflection of the concept being investigated. Other key factors to consider are concept appropriateness, respondent burden and relevance to the target population (Khadka *et al.*, 2013).

1.7 Summary

With the ageing population in the UK, it is likely that the number of people confined to their homes will increase further in coming years. The housebound population need regular domiciliary eye examinations to safeguard against avoidable sight loss (most notably cataract and uncorrected refractive error), although there seems to be an under provision/ under access of services. The literature review revealed a paucity of published research linked to this specific patient group, and no previous studies have examined the specific visual

demands, VRQOL or ophthalmic clinical characteristics of the UK domiciliary eye care recipients. It is important to investigate and report on this growing and significant part of the community. The following experimental chapters will address these key issues, and provide detailed information to enhance evidence-based domiciliary optometric practice.

The specific aims of the thesis are:

1. To report on the visual experiences and patient characteristics of UK domiciliary eye care recipients for the first time.

2. To compare the clinical characteristics of GOS domiciliary eye care recipients (CE and HH residents) with conventional in-practice patients of a similar age.

3. To assess the changes in self-reported visual function following cataract surgery in housebound versus non-housebound individuals.

Chapter 2. Visual experiences of domiciliary eye care recipients in the North West of England; a questionnaire study

2.1 Introduction

Life expectancy in the UK is continuing to rise (Office for National Statistics, 2014c), resulting in the ageing of the population (Office for National Statistics, 2008). The mid-2014 population estimates indicated that 8 % of the UK population are aged 75 years and over and the median age has increased to 40 years compared to 33.9 years in 1974 (Office for National Statistics, 2015a). Advancing age has health-related implications, resulting in many people becoming housebound in their later years (Qui *et al.*, 2010). A person may be described as housebound if they require a substantial effort or assistance to leave their home (Qui *et al.*, 2010), are receiving domiciliary medical care (Cohen-Mansfield *et al.*, 2012), or going outdoors once or less than once per week (Fujita *et al.*, 2006).

People aged 75 years and over are more likely to be affected by VI than any other age group (Wormald *et al.*, 1992). The study of Evans *et al.* (2004a) investigated causes of VI (binocular VA of <6/18) in people aged 75 years and over, registered in 49 general medical practices across Britain (an add-on study to the MRC Trial of the Assessment and Management of Older People in the Community). There were 14,403 participants, of whom 12.5 % were visually impaired; the main causes of visual loss were AMD (36.2 %), followed by uncorrected refractive error (31.6 %) and cataract (24.5 %). However, the study excluded nursing-home residents, who are estimated to be 3 to 5 times more likely to suffer from VI compared to community dwelling residents of similar age (Klein *et al.*, 1991) (Mitchell *et al.*, 1997). Furthermore, VFD-related VI was not investigated, which is known to contribute towards the prevalence of VI (Taylor *et al.*, 1997), therefore the true prevalence of VI may be significantly higher.

The ability to perform ADL (for example, cooking, reading, and driving) and to live independently is an instrumental aspect of QOL (Lamoureux *et al.*, 2004). People with VI experience greater difficulties in undertaking ADL and are at an increased risk of falls and fall-related injuries, which can lead to social isolation and poorer overall health (Scott *et al.*, 1999, Brown *et al.*, 2003, Fylan *et al.*, 2005, Chou *et al.*, 2013). Functional and physical disability is a key contributor towards the development of depression in the older adults (Dunne *et al.*, 2011). Inability to perform basic tasks often provokes negative thoughts and emotions; people living in care-homes and nursing-homes are found to be particularly susceptible to such psychological symptoms (Bozo *et al.*, 2009). Untreated depression has been linked to increased risk of CVD, Parkinson's disease and chronic pain (Cahoon, 2012, Simone and Haas, 2013, Slavich and Irwin, 2014). Participation in leisure activities can maintain positive mood and enhance physical health (Simone and Haas, 2013). Moreover, reduced engagement in ADL and leisure activities increases the risk of developing dementia in old age, and therefore stimulation of cognitive processes is perceived as an important preventative approach (Foubert-Samier *et al.*, 2014).

Individuals with low vision often experience mobility restrictions and reduced capacity to execute day-to-day tasks (Fylan *et al.*, 2005). In the study of Scott *et al.* (1999), three PRO instruments (SF-36, VF-14 and NEI-VFQ) were used to investigate the functional status, QOL and impact of low-vision rehabilitation in visually impaired patients. Low-vision patients were found to have lower physical capability and greater role limitations compared to published age-matched visually-normal subjects in the USA. Low-vision rehabilitation was found to be successful in improving subjective functional status in 98.7 % of the study participants and 53.9 % described the service as "very useful". However, the study cohort was from an outpatient clinic, therefore it is unclear if visually impaired housebound patients would experience similar benefits.

Frailty is a common clinical state in older adults (Gill *et al.*, 2006), frequently caused by the weakening of muscles, loss of balance due to unsteady footing and diminished lung functionality (Klein *et al.*, 2003). Frail people are likely to experience difficulty in mobility and are at a higher risk of injurious falls resulting in hospitalisation and institutionalisation (Xue, 2011). With the ageing population, it is likely that the number of people suffering from age-related frailty is likely to increase further, resulting in a greater number of older adults becoming housebound. Given the importance of participating in daily activities to maintain the welfare of older people (Chan *et al.*, 2014), there is a lack of data on the interests and hobbies of housebound people. Learning how often and the duration of time spent on each hobby per day will provide an insight into their motivations, goals and priorities.

As this is a novel attempt to directly involve the housebound population in a questionnaire-based survey, one of the aims of the study is to discover whether it is feasible to conduct a research survey amongst this population. Therefore, the study is confined to the metropolitan county of Merseyside in the North-West of England, without attempting to conduct a national study or to examine regional variations at this stage. According to GOS activity statistics for Merseyside between the period 1st April 2014 to 31st March 2015, 272,648 NHS funded sight tests were carried out, of which 11,570 (4.2 %) were domiciliary examinations (Health and Social Care Information Centre, 2015), compared to 9,036 (4.6 %) domiciliary sight tests out of 198,264 NHS funded eye examinations in the same period in 2012-2013 (Health and Social Care Information Centre, 2013a). Concurrently, the number of people 60 years and older having a NHS funded sight test increased from 73,281 (representing 37 % of all NHS funded eye examinations) in 2012-2013 to 109,756 (40.3 %) in 2014-2015. Therefore, despite the proportion of the older population having an eye examination growing by 3 %, the number of domiciliary eye examinations have decreased by 0.4 %, signifying a possible under-access/ uptake of the service.

The purpose of the survey is to gather information on general characteristics of domiciliary eye care recipients, the type of leisure activities they participate in and the type of visual aids they habitually use. Additionally, it aims to explore some aspects of VRQOL, including visual problems experienced during specific tasks and the prevalence of dry-eye associated symptoms. The findings of the study could be beneficial to domiciliary eye care providers.

2.2 Methods

The study was conducted in accordance with the tenets of the Declaration of Helsinki, with ethical approval obtained from the Aston University Life and Health Sciences Research Ethics Committee.

Participants were recruited by inviting all new and existing HH and CE residents registered with the optometric practice of the author to complete a questionnaire, provided they were able to make an informed decision to participate and complete the survey (with the help of a family member or carer if necessary). A simple paper- based questionnaire was distributed to consecutive domiciliary patients examined in metropolitan county of Merseyside. Given a 2006 UK population approximation of 60.7 million (Office for National Statistics, 2011) and an estimation from the same year that 1.4 million UK residents were housebound or unable to leave their home unaccompanied (Buisson, 2006), it was determined that across the nation, approximately 2.3 % of residents were housebound. Thus, with a regional population of 1.35 million (Office for National Statistics, 2012b), it was estimated that the housebound population of Merseyside was circa 31,000. Given this population estimate, and using the national Health and Social Care Information Centre online calculator (Health and Social Care Information Centre, 2013b), a minimum sample size (number of responses) of 380 to provide a 95 % confidence level and maximum 5 % margin of error for individual questions, was determined.

A bespoke and primarily a multiple choice questionnaire was designed and reproduced on pink paper; use of pink paper may increase the response rate of written surveys (Etter *et al.*,

2002). The purpose of the simple questionnaire (Table 2.1) was to gather information on the visual experiences of domiciliary patients (related to activities performed); types of optical prescriptions and visual aids used; perceived problems with vision; ocular comfort and its impact on aspects of VRQOL. Given the possible physical and cognitive limitations of the study population, it was vital to create a concise questionnaire to minimise respondent burden; as a result, assumptions were made with regards to the type of leisure activities which they may engage in. The questionnaire was distributed with an explanatory cover letter to consecutive domiciliary eye care patients (or their carers) examined in Merseyside by a registered optometrist (KR) from March 2013- February 2014. Responses were gathered via post with pre-paid envelopes provided, or at subsequent spectacle delivery/ adjustment visits. An initial aim of the study was to determine whether a survey of this patient group would be feasible by conducting the survey on a small scale; 100 questionnaires were distributed of which 45 were returned via post or at a secondary visit (e.g. for spectacle delivery/ adjustment). As this response rate is in line with previous healthcare-based questionnaires (Puffer *et al.*, 2004), the survey was then conducted on a larger scale, between May 2013 and March 2014. At this stage it was decided to add two further questions, adapted from VQF-25 (RAND, 2000) regarding the implications of poor vision on general wellbeing/distress and whether poor eye sight was responsible for individuals to become housebound. In the second phase of the survey, a further 712 questionnaires were distributed and the responses generated from both phases were collated for analysis.

Item	Response options
Is this your first home eye test?	Yes/ No
How did you find out about the home eye test service?	Word of mouth/ Internet/ From being previous in-practice patient/ Community nurse/ Other (please state)
Do you undertake any of the activities listed? If yes, indicate how any hours per day (approximately).	Watching television/ Reading books/ Reading newspapers/ Sewing/ knitting/ Cooking/ Computer/Internet
Do you have any vision problems currently? If "Yes", with which activity?	Yes/ No
Do you use any of the following visual aids? Please tick all that apply	Distance glasses/ Reading glasses/ Bifocal glasses/ Varifocal glasses/ Magnifiers
How often do you worry about your eyesight or vision?*	Never/ Rarely/ Occasionally / Sometimes/ All of the time
How often do you notice or think about your eyesight or vision? *	Never/ Rarely/ Occasionally / Sometimes/ All of the time
How often do you experience pain or discomfort in and around your eyes (for example, burning, itching, or aching)? *	Never/ Rarely/ Occasionally / Sometimes/ All of the time
How much does dryness in your eyes bother you? *	Don't have dryness/ Not at all/ Very little / Moderately / Quite a bit/ A lot
If you had perfect vision without glasses, contact lenses, or any other type of vision correction, how different would your life be? *	No difference/ Small difference for the better/ Large difference for the better/ I have this already
I am often irritable because of my eyesight**	Definitely true/ Mostly true/ Mostly false/ Definitely false/ Not sure
I don't go out of my home alone because of my eyesight**	Definitely true/ Mostly true/ Mostly false/ Definitely false/ Not sure

Table 2.1 Summarised version of the questionnaire utilised in the study. Question 4 was open ended to allow respondents to specify the visual problem they were experiencing.
Questions marked: *are adapted from the National Eye Institute Refractive Error Quality of Life Instrument (RAND, 2001).
**are adapted from the National Eye Institute Visual Functioning Questionnaire – 25 (RAND, 2000).

2.3 Data analyses

Attributable (frequency of a particular variable) or distributional (mean value of a variable and its conformity to normal distributional curve) data are usually presented in result tables and various types of charts and graphs (Armstrong and Eperjesi, 2000). Qualitative data is often categorised into groups to derive meaningful figures (Turner *et al*., 2005). The data analysis usually involves drawing a comparison of difference in quantity or percentages between the study groups; t-tests (one or two tailed) and chi-square tests are often employed as a mode of statistical analysis, while the probability (*P)* value is usually set at 0.05/ 5 % (Armstrong and Eperjesi, 2001, Armstrong and Eperjesi, 2002). Myint *et al.* (2011) conducted an attributable survey investigating the diagnostic tests used to detect glaucoma by community optometrists. Frequency and percentage of different types of instrumentations employed was stated.

Optometric surveys often produce ranked data, where the subject response is placed on a point scale consisting of two extremities with interval levels between the two absolute points (Armstrong and Eperjesi, 2000). Robust statistical analysis is required to reliably identify relationships between the dependant and the independent variables (Faul *et al.*, 2007). On such data type, use of non-parametric statistical analysis, for example Wilcoxon Signed-ranks test, is valuable as it makes no assumptions with regards to the frequency distribution of data being analysed (Prajapati *et al.*, 2010). Loffler *et al.* (2011) investigated treatment prescribing patterns amongst therapeutically qualified optometrists; the survey involved rating of various aspect of training on a point scale ranging from 0-10. The percentage and mean values of various variables were calculated and illustrated graphically, although no further statistical analysis was conducted to identify the independent variable with the greatest influence on any one specific dependent variable.

The ideal statistical test for some aspects of the present study needs to be non-parametric and capable of processing multivariate analysis, where it can consider multiple independent

variables for any one given dependent variable simultaneously. Decision tree analysis (DTA) is capable of detecting non-linear effects on response variables, identify interactions between multiple variants and form a hierarchical structure (Ritschard, 2010). DTA has previously been used in optometric studies; for example (Yu *et al.*, 2011) used it to determine the economics of dry eye treatment, and (Twa *et al.*, 2005) performed DTA to differentiate between regular and keratoconic corneal shapes.

Survey data was considered for residential type (CE or HH) and entered on a Microsoft Excel spreadsheet. Result tables and histograms were used to illustrate attributable and distributable data. Unpaired T-test and Chi-squared "goodness of fit" tests with Yates correction were carried out to determine the statistical significance between HH and CE groups (P= 0.05 and Chi^2 critical value at 3.841). Further statistical analysis was performed using IBM SPSS version 21, employing Chi-squared Interaction Detection (CHAID) DTA. The decision tree is based on hierarchical splitting of groups formed by CHAID identifying the independent variable that has the strongest interaction with the dependant variable in a descending order (IBM, 2012). For the purpose of DTA, all 7 VRQOL questions ("worry about their eyesight"; "think or notice their eyesight"; "ocular discomfort/ pain"; "dry eye"; "how different life would be with the provision of perfect vision"; "irritable due to eyesight" and "poor vision is the reason for being housebound") were individually analysed as the dependent variable, with the remaining 6 factors acted as the independent variables. Additional independent variables added to each analysis included age; gender; resident type (CE and HH) and presence of current visual problems.

2.4 Results

Four hundred and twelve questionnaire responses were received (50.7 % response rate) and used in the analysis; 182 (44.2 %) respondents were using domiciliary eye care for the first time, of which 38.6 % were aged 82 years and older. One hundred and seventy (41.3 %) respondents were male (median age 74.5 years), compared to 242 (58.7 %) females (median

age 82.5). Two hundred and eighty-six (69.4 %) participants were CE based (median age of 82 years) who received the domiciliary eye test as a part of their care-plan. In comparison, the 126 (30.6 %) HH participants (median age of 75 years) used different methods to arrange the sight test at their home. Of the HH group, 50 respondents (39.7 %) were former in-practice patients whom subsequently became housebound; 39 (30.9 %) were referred to the optician by the community nurse; 19 (15.1 %) learnt about the service through word-of-mouth and 18 (14.3 %) respondents discovered domiciliary eye care through the internet.

The number of respondents watching television, reading books and newspapers was similar in the CE and the HH population, while a greater number of HH based participants were involved in cooking and using the PC/ surfing the internet (Table 2.1).

Activity	CE (%)	HH (%)
TV	92.0	99.2
Books	43.7	43.7
Newspaper	53.8	46.0
Sew/ knit	14.7	8.7
Cooking	8.7	73.0
PC/ web	8.7	36.5

Table 2.2 Percentage of CE and HH respondents engaging in different types of leisure activities. Cooking (X^2 =84.866) and PC/ web use (X^2= 29.431) were significantly different between the two groups. CE: communal establishment; HH: household

The mean duration of time spent watching television and reading was similar in CE and HH residents. HH residents dedicated a significant amount of time (54 minutes) on cooking (P= <0.001) and using the PC/ browsing the internet (36 minutes; P= <0.001) on daily basis.

Activity	CE Mean (± SD) minutes per day	HH Mean (± SD) minutes per day
TV (P= 0.49)	150 ± 84	150 ± 72
Books (P= 0.91)	30 ± 42	30 ± 40
Newspaper (P= 0.06)	30 ± 30	24 ± 28
Sew/ knit (P= 0.27)	12 ± 33	12 ± 30
Cooking (P= <0.01)	6 ± 24	54 ± 42
PC/ web (P= <0.01)	12 ± 42	36 ± 34

Table 2.3 Mean duration of time spent on each activity per day by CE and HH residents. Cooking and PC/ web use were significantly different (P= <0.01; unpaired t-test). CE: communal establishment; HH: household.

Overall, 41.8 % of the survey respondents reported a current visual problem at a particular working distance; 40.6 % of CE respondents were unhappy with their vision compared to 44.5 % of HH respondents. Poor overall vision was cited the most, followed by visual problems associated with near vision tasks. A greater number of HH respondents specifically complained with regards to visual tasks associated with intermediate distance (X^2= 7.614).
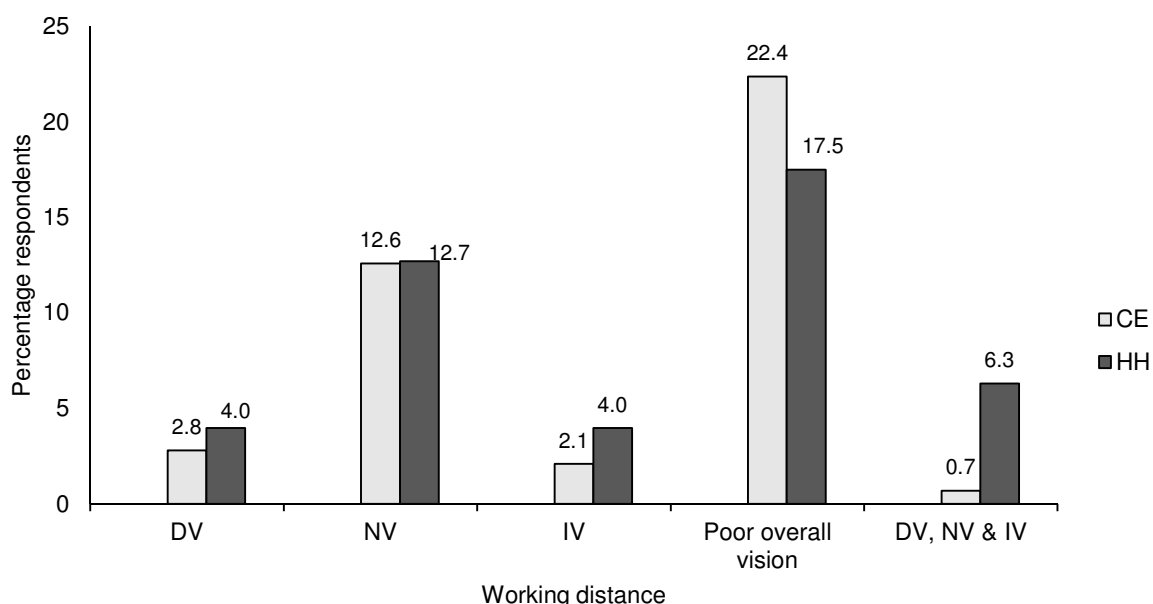
Figure 2.1 The percentage of survey respondents experiencing visual problems at specific working distances. DV: distance vision; NV: near vision; IV: intermediate vision. A greater proportion of HH residents complained of IV (X^2= 7.614). CE: communal establishment; HH: household.

Separate spectacle corrections for distance and near vision was found to be the most frequently used optical aid, followed by use of bifocals and varifocals/ progressives, respectively (Figure 2.2). A significantly greater proportion (X^2= 9.872) of HH residents (18 %) reported using varifocals compared to CE residents (6 %). Two per cent of the survey respondents were using magnifiers as a visual aid.
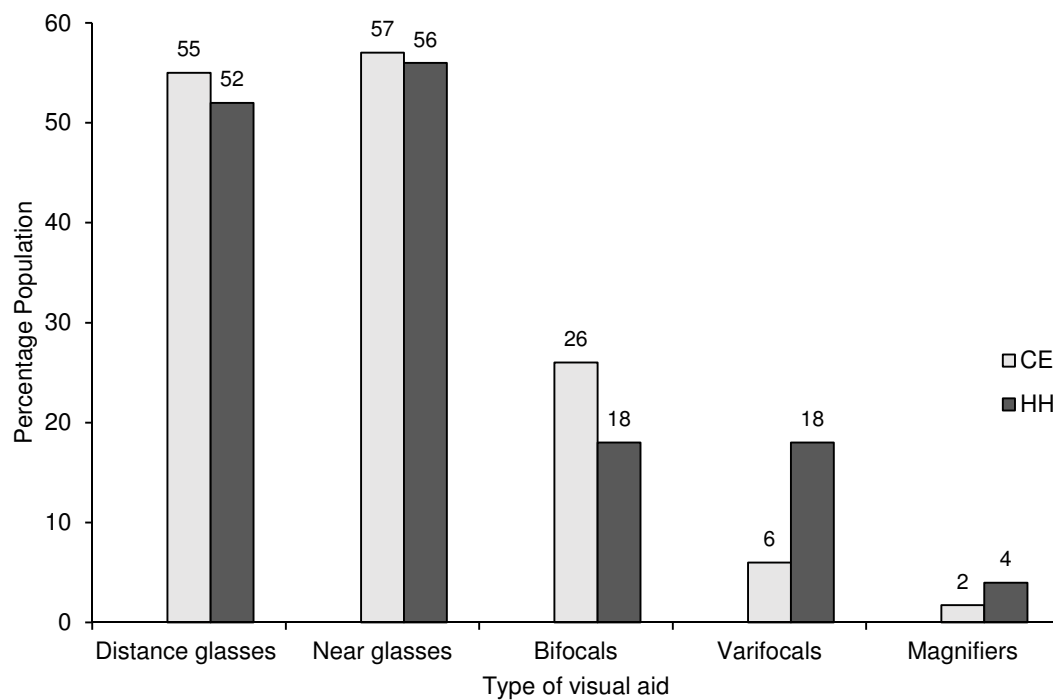
Figure 2.2 The percentage of survey respondents using each type of visual aids. A greater proportion of HH residents were using varifocals (X^2= 98729). CE: communal establishment; HH: household.

The following figures show the raw data collected regarding the aspects of VRQOL investigated. The majority of CE and HH respondents reported that they do not "worry" about their eyesight or vision; only 2.4 % of the study cohort reported to "worry" about their eyesight constantly. There was no significant difference between the groups (X^2= <3.841 across all categories).
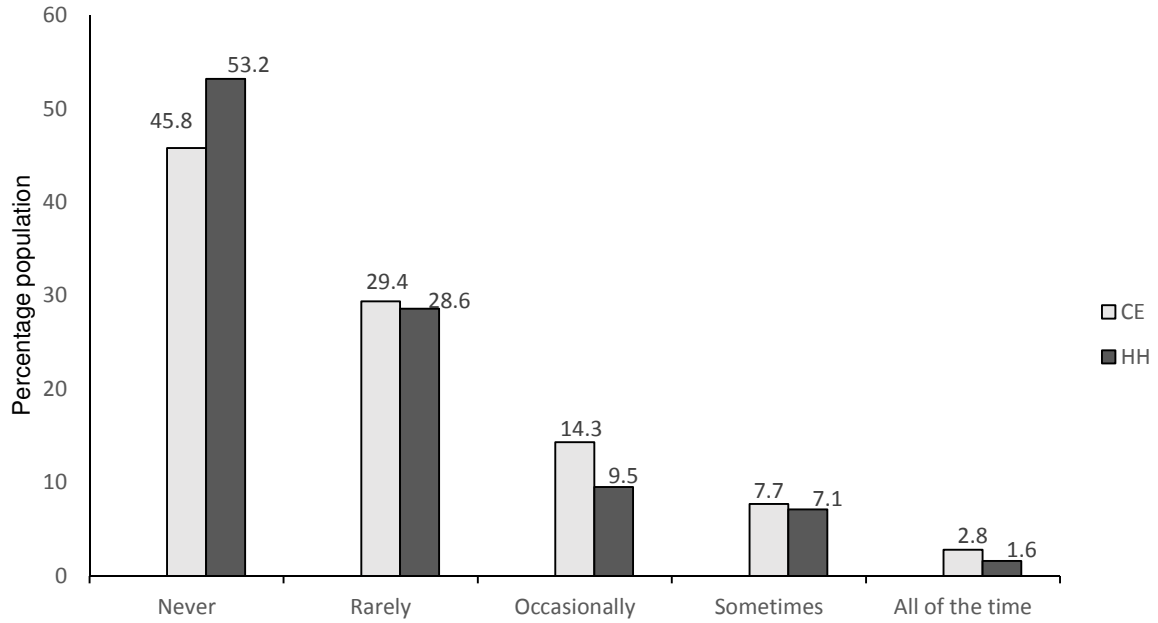
Figure 2.3 The percentage of survey respondents who "worry" with regards to their eyesight or vision. (X^2= <3.841 across all categories). CE: communal establishment; HH: household.

Similar proportion of HH and CE respondents were found to "think/ notice" their eyesight or vision (X^2= <3.841 across all categories).
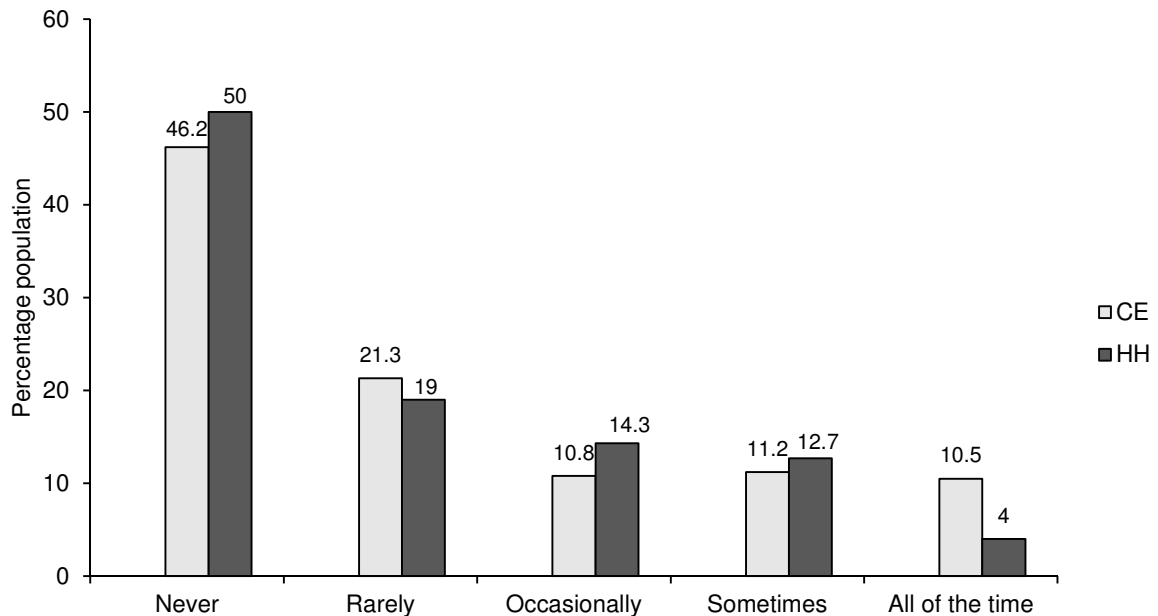
Figure 2.4 The percentage of survey respondents who "think/ notice" their eyesight or vision. No significant difference between the groups. (X^2= <3.841 across all categories). CE: communal establishment; HH: household.

Experience of ocular pain and discomfort on a continual basis was reported by 2.7 % of the survey respondents; a further 9 % indicated they experience such symptoms occasionally or sometimes; no significant difference between the groups (X^2= <3.841 across all categories).
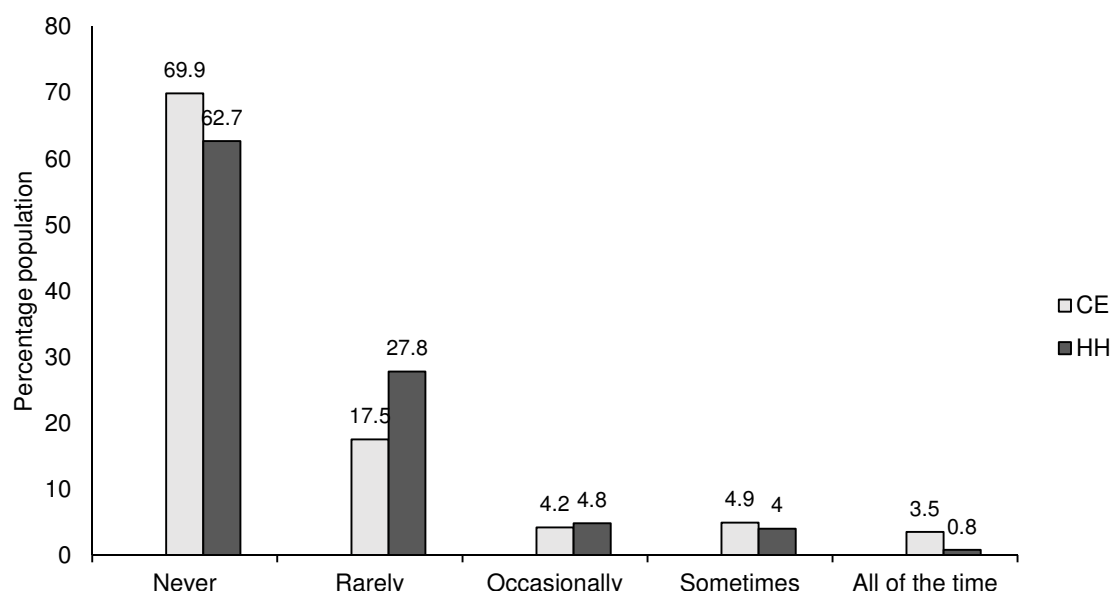
Figure 2.5 The percentage of survey respondents who experience pain/ discomfort in and around their eyes and the associated level of severity. (X^2= <3.841 across all categories). CE: communal establishment; HH: household.

Moderate to severe dry-eye symptoms were reported by 11.8 % of respondents. Similar proportions (X^2= <3.841) of CE and HH patients were affected by the ocular surface disorder.
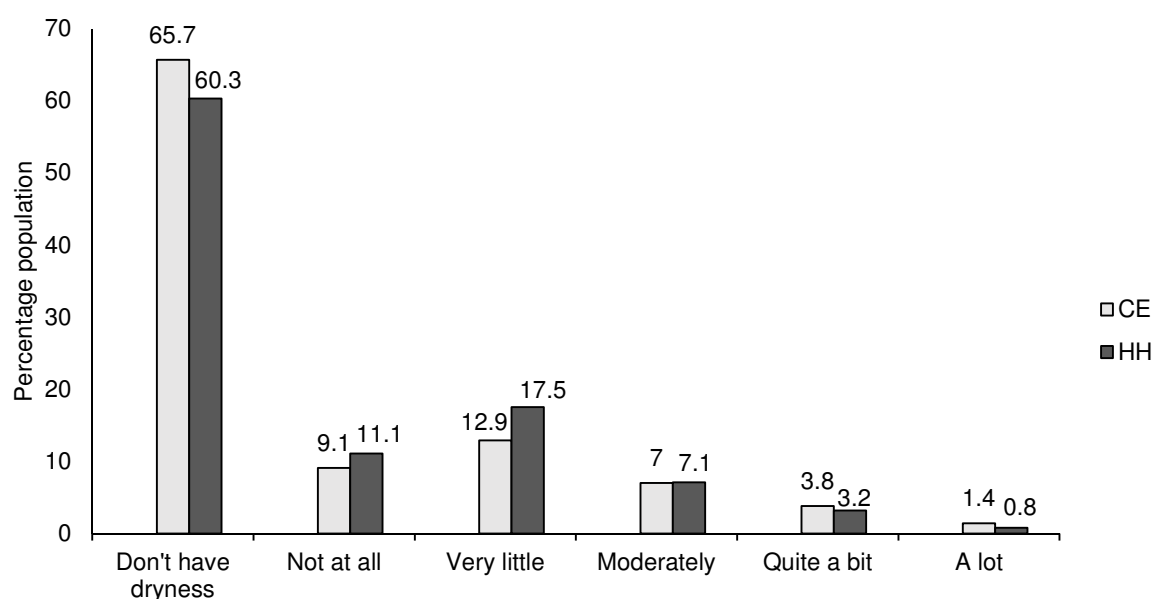
Figure 2.6 The percentage of survey respondents who experience dry eye symptoms and the associated level of severity. (X^2= <3.841 across all categories). CE: communal establishment; HH: household

Up to 74.3 % of survey respondents assumed that the provision of perfect vision would have a positive impact on their lives. There was no significant difference between the groups (X^2= <3.841 across all categories).
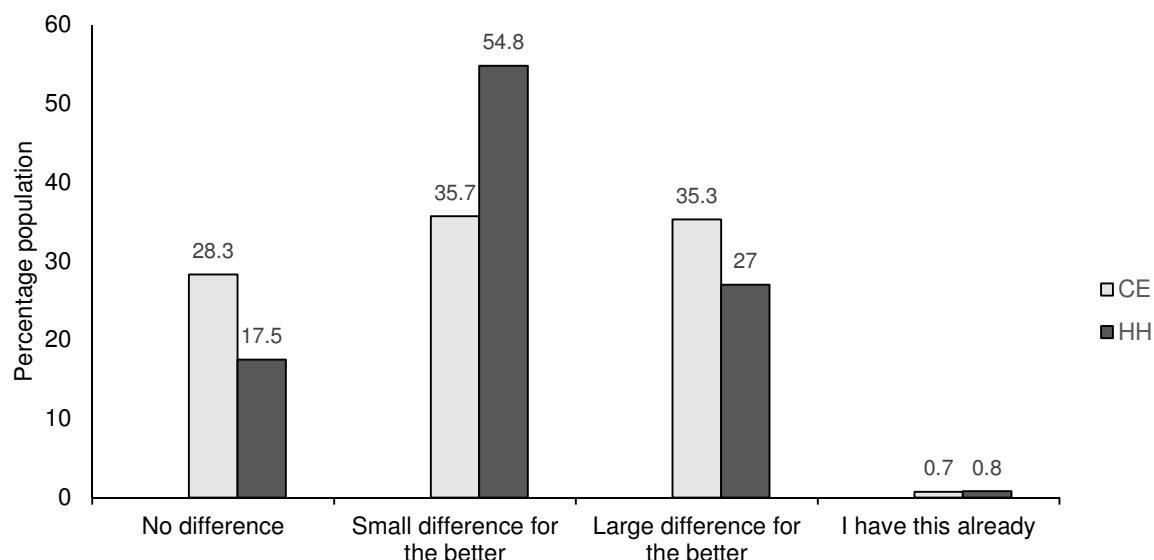
Figure 2.7 The level of difference it would make to respondents' lives with the provision of perfect vision. (X^2= <3.841). CE: communal establishment; HH: household

A minority (4.2 %) of CE residents reported poor vision led to experiencing "irritable" emotions. There was no significant difference between the groups (X^2= <3.841 across all categories).
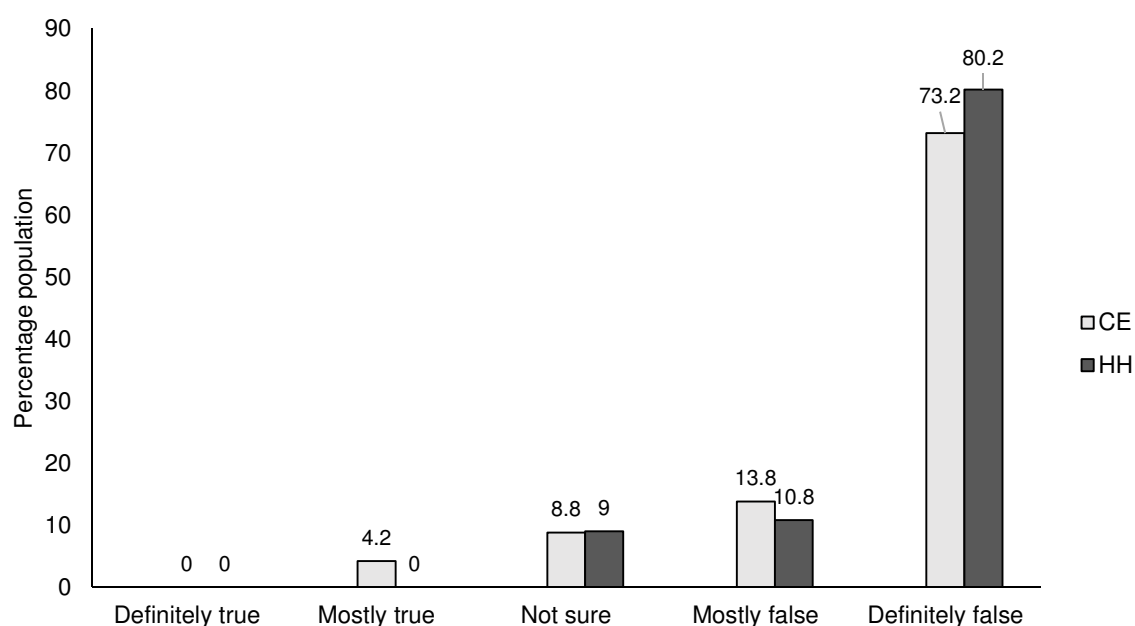
Figure 2.8 Responses of CE and HH residents to the statement "I am often irritable because of my eyesight" are similar (X^2= <3.841). CE: communal establishment; HH: household

It was rare for respondents to report that their vision was responsible for their housebound status; only 1.1 % of the entire cohort reported that poor vision was the reason why they did not go out alone. There was no significant difference between the groups (X^2= <3.841 across all categories).
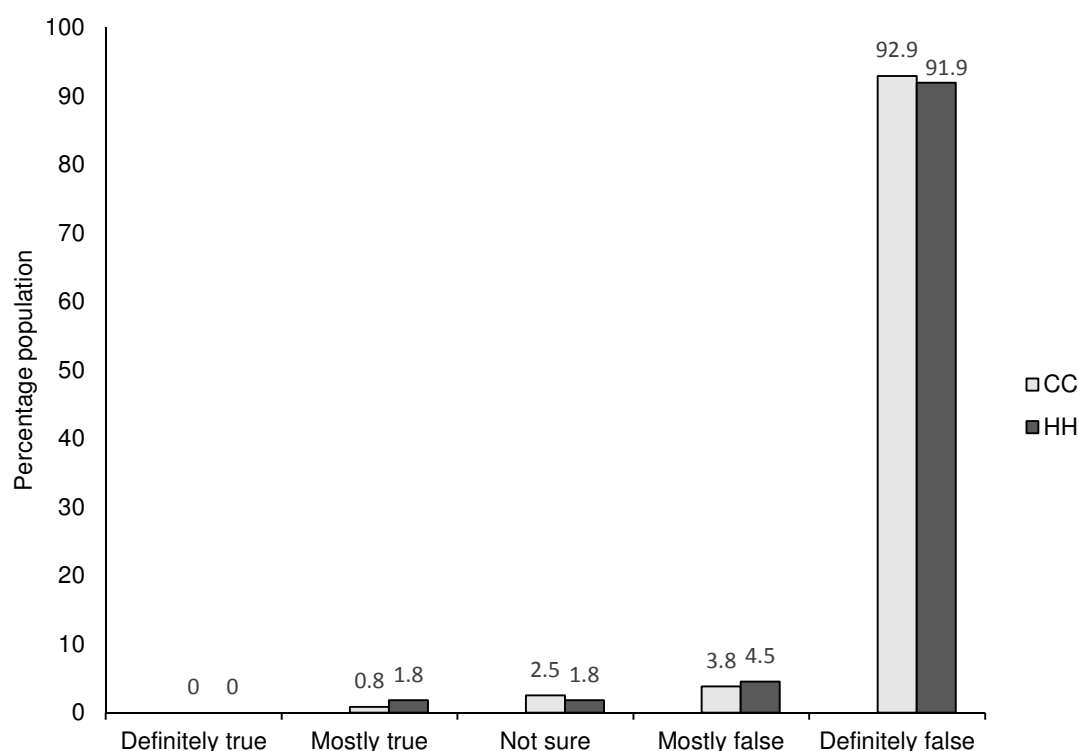
Figure 2.9 Responses of CE and HH residents to the statement "I don't go out of my home alone because of my eyesight". (X^2= <3.841 across all categories). CE: communal establishment; HH: household

The following charts show the results from DTA conducted for the individual questions relating to aspects of VRQOL. Given the large amount of statistical power, the default CHAID settings were used for the analysis, which were 100 parent nodes, 50 child nodes and 3 tree levels. There are no specific recommended settings, however, the default settings will only produce tree branches of the most important independent variables and avoid trivial DTA branches.

According to DTA, the 51.9 % of the respondents who claimed to "worry" (dependent variable) about their eyesight were also likely to be experiencing visual problems (independent variable), and further associated with respondents who "notice" (independent variable) their eyesight.
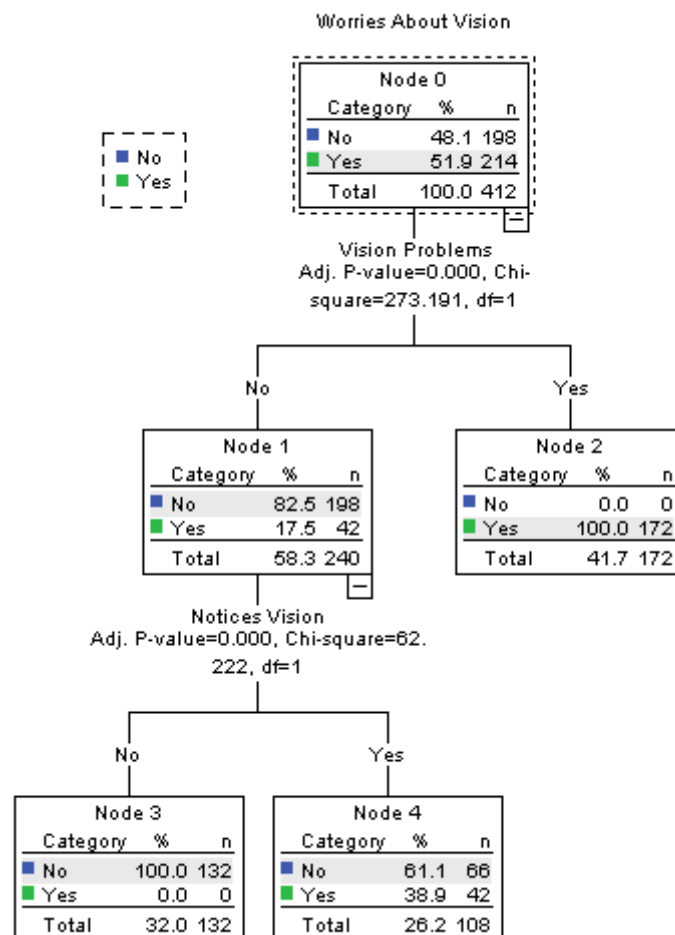
Figure 2.10 DTA shows 51.9 % of respondents reported to "worry" about their eyesight, whom are also likely to be associated with experiencing visual problems and notice their eyesight or vision more frequently.

DTA shows respondents who reported to "notice" their eyesight (dependent variable) are also likely to "worry" about their vision (independent variable). Further breakdown of the decision tree shows this particular group of respondents also believed provision of perfect vision will produce a positive impact on their VRQOL.
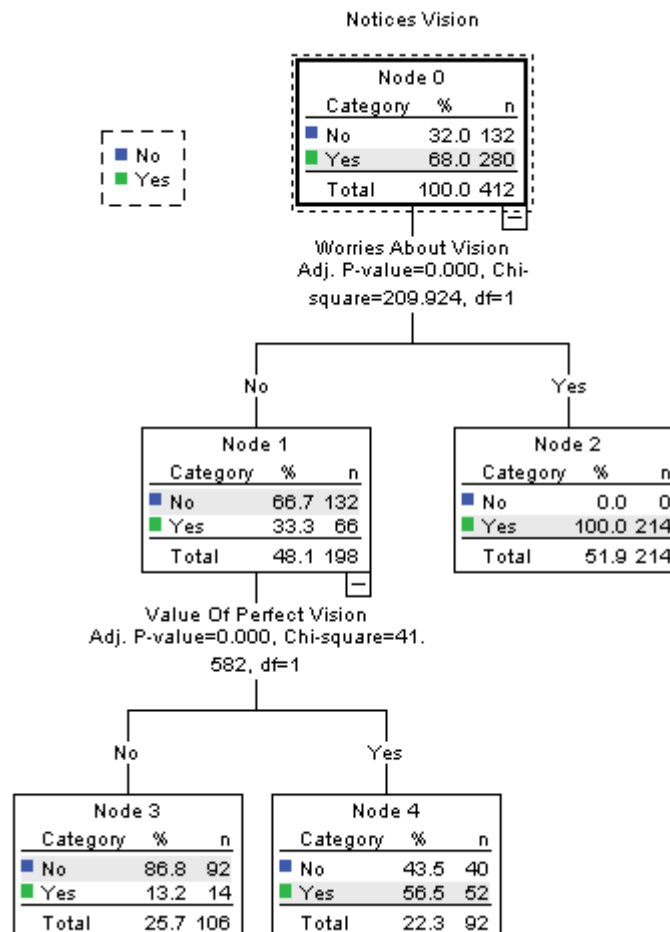
Figure 2.11 Decision tree illustrating the factors that are associated with patients who "notice" their eyesight.

Approximately a third (32.3 %) of respondents reported to be experiencing some level of ocular pain or discomfort (dependent variable), and according to DTA, presence of dry eye (independent variable) is primarily responsible for the symptoms. A portion of such patients were also likely to claim poor vision is responsible for their housebound status.
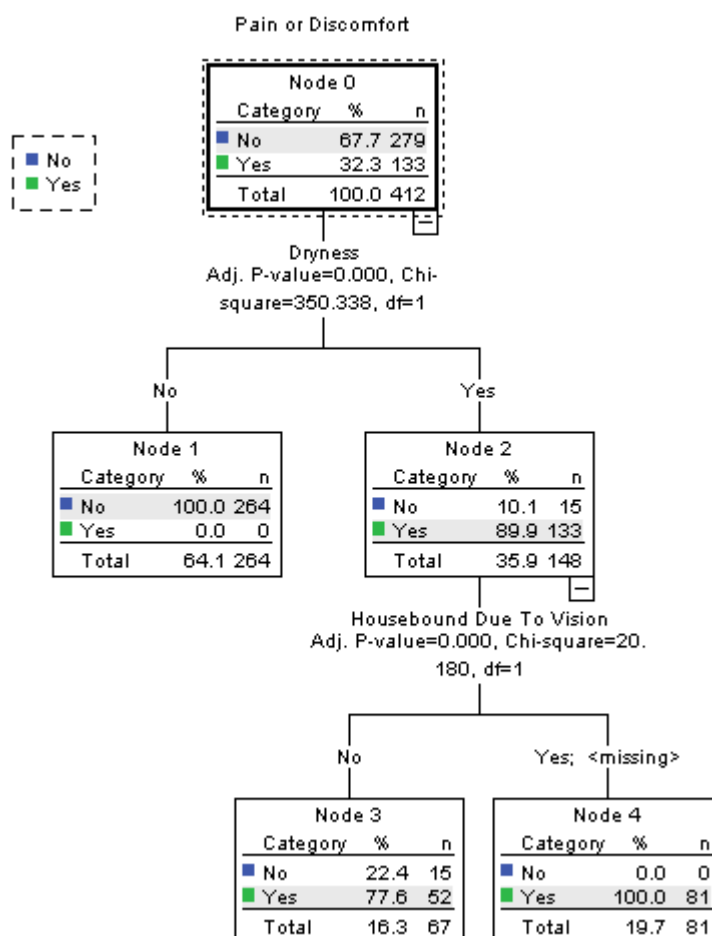
Figure 2.12 Decision tree showing which factors were concomitant with respondents who experienced ocular pain or discomfort.

DTA shows that the extent of ocular surface dryness (independent variable) is mutually related to the degree of pain and discomfort experienced by the patients (dependent variable). Further breakdown shows dryness is also associated with people who worry about their vision.
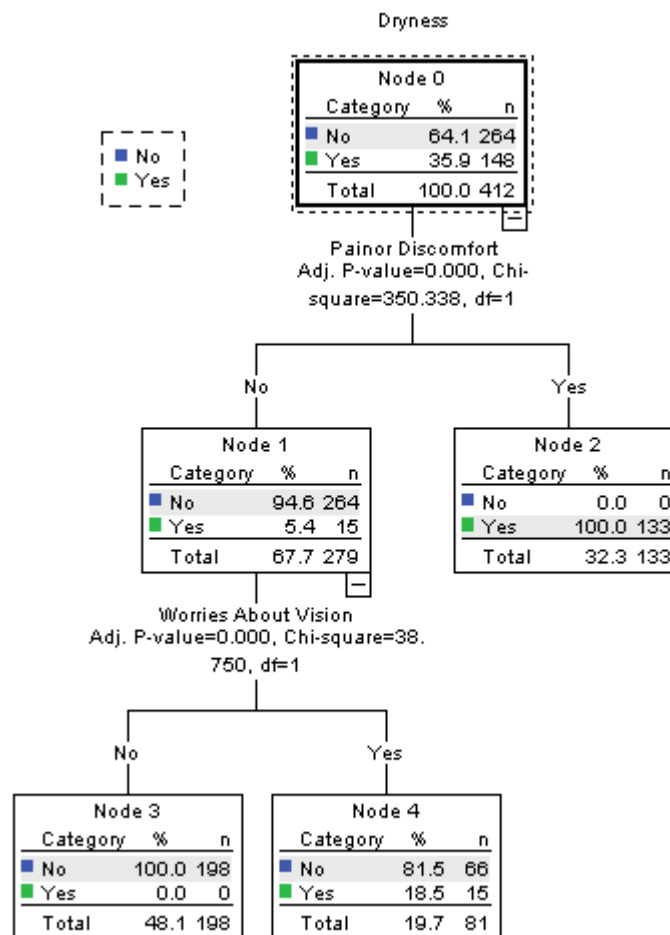
Figure 2.13 Decision tree showing factors that were linked with respondents who experienced dry eye regularly.

People who reported that they "notice" their vision (independent variable) on regular basis also believed that the provision of perfect vision (dependent variable) would have a positive impact on their lives. Further breakdown reveals that the HH residents and respondents who worry about their eyesight (independent variable) were also inclined to believe perfect vision will improve VRQOL.
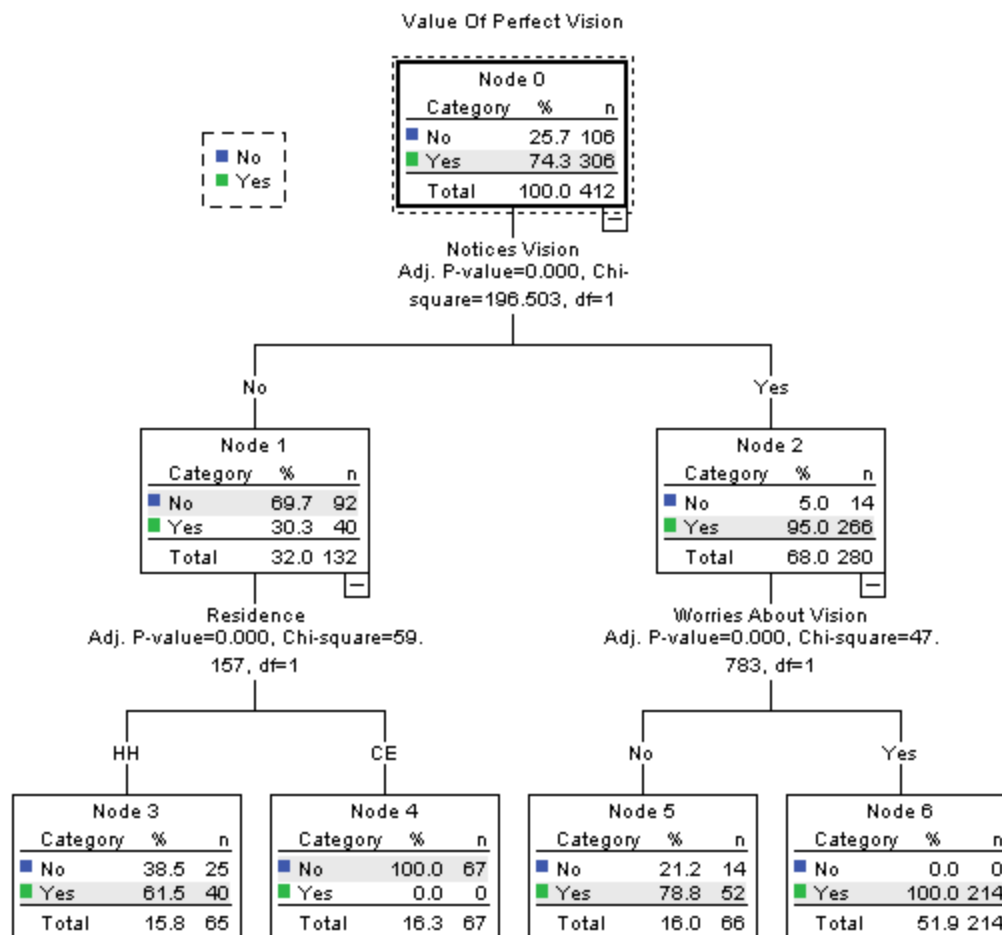
Figure 2.14 Decision tree showing factors associated with how the provision of perfect vision will impact respondents' lives.

Experience of "irritable" emotions (dependent variable) were primarily sensed by those respondents who experienced visual problems (independent variable). No other variables were found to have any significant influence.
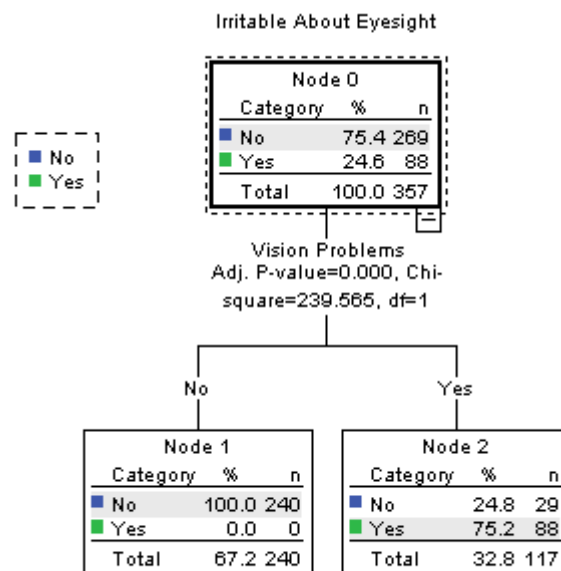
Figure 2.15 DTA of factors linked with irritable feeling with regards to vision.

A minority of respondents attributed their housebound status (dependent variable) to having poor vision; DTA shows respondents who experience ocular pain and discomfort are linked with believing their eyesight is responsible for the housebound status.
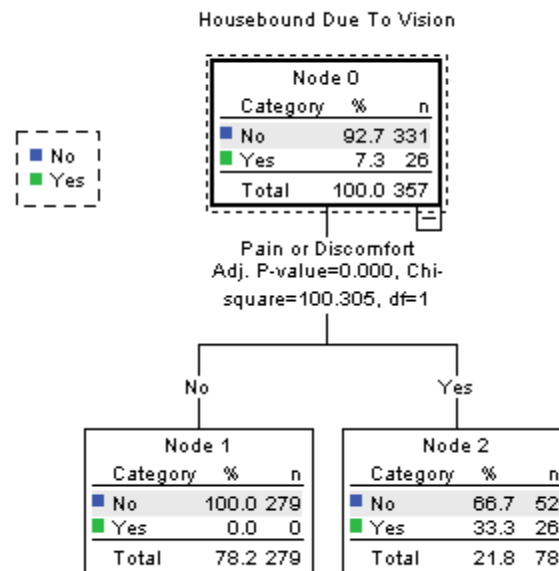
Figure 2.16 DTA inspecting the influence of poor vision and possible associated factors causing respondents to become housebound.

First time domiciliary users were more likely to have a presenting visual problem compared to existing patients and a greater proportion of new users were HH based.
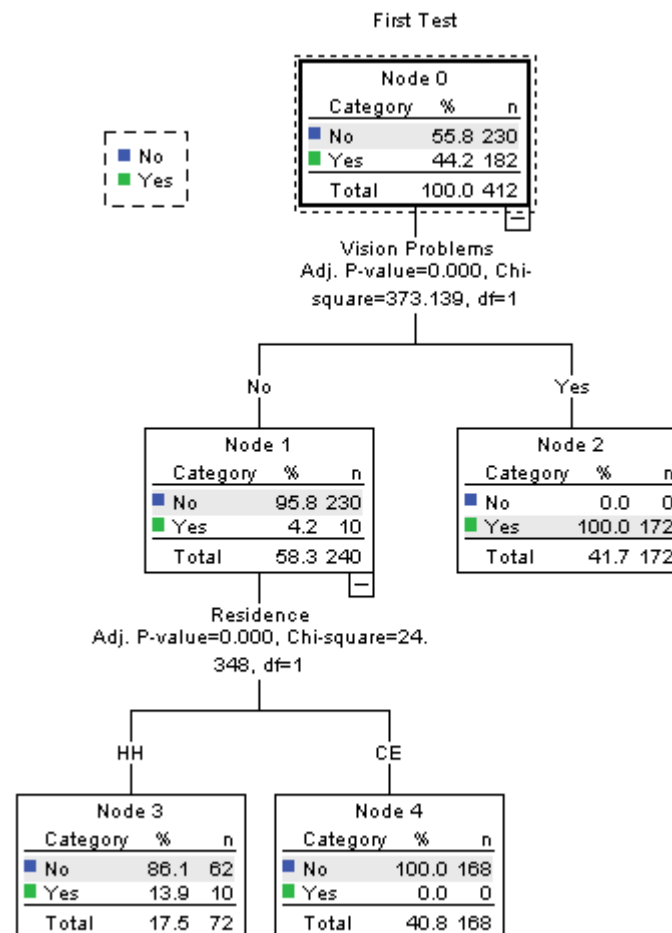
Figure 2.17 Decision tree showing the factors influencing first time domiciliary eye test users.

Presence of visual problems was strongly associated with respondents having their first domiciliary sight test, and were more likely to be HH based.
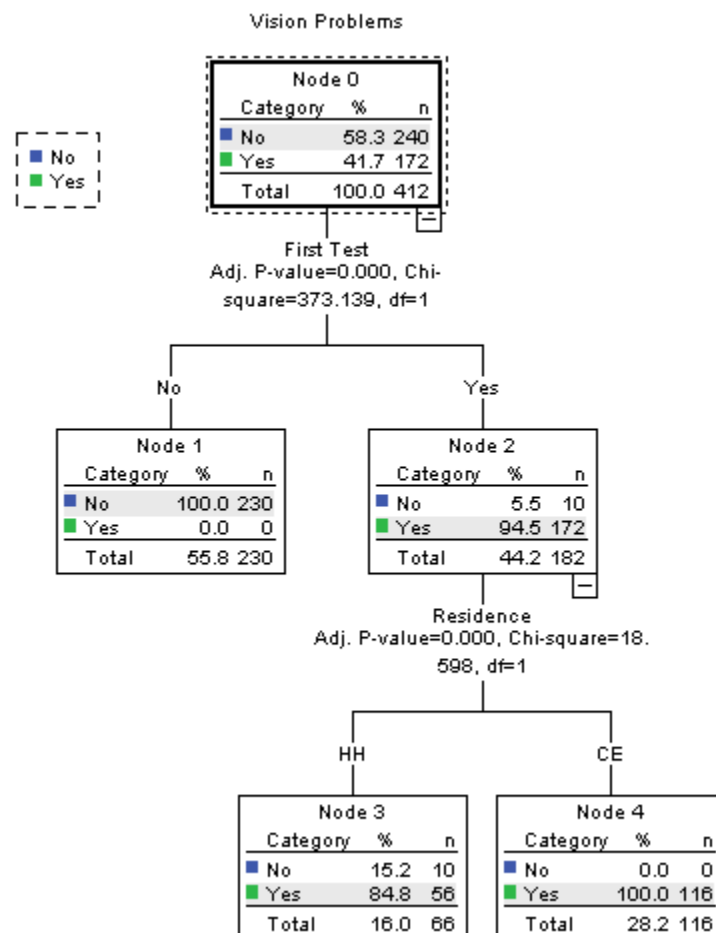
Figure 2.18 Decision tree showing the factors associated with people experiencing visual problems (dependent variable).

2.5 Discussion

This was a novel survey-based study involving domiciliary eye care recipients in England. The purpose of the survey was to gain an understanding of various aspects of housebound patients, including the leisure activities they engage in, the type of visual aids used and some aspects of VRQOL.

Given that the study cohort was based on older housebound people, the response rate (50.7 %) achieved was excellent compared to previously reported response rates accomplished by surveys involving citizens aged 70 and over (Puffer *et al.*, 2004). The high response percentage demonstrates that it is possible to conduct a survey involving housebound people with possible multiple-morbidities, despite the perception of such population being unable or struggle to complete a survey. Wolffsohn *et al.* (2000) discovered that people with VI are equally likely to complete a questionnaire survey compared to those who experience fewer visual difficulties.

Female respondents and the CE population were older than male and HH participants, respectively. The findings are in agreement with the longer life expectancy for females compared to males (Office for National Statistics, 2014c) and the demographics of the CE population (Office for National Statistics, 2013). A significant number of the survey respondents were first time domiciliary eye care service users (44.2 %). The independent optometric practice from which the participants were recruited has a loyal patient base, hence the majority of the HH respondents were identified as former practice patients (39.7 %). Furthermore, the practice has a professional relationship with local care organisations who refer domiciliary patients in need of an eye examination to this particular optical practice. Thus 30.9 % of HH respondents were a result of a direct referral made by the community nurse. Such circumstances may not be representative of the general housebound population. Despite the high number of new users found by the survey (44.2 %), the GOS activity statistics (Health and Social Care Information Centre, 2015) and the estimated number of housebound

people in the UK (Domiciliary Eyecare Committee, 2007), suggests that GOS domiciliary eye care services remain underused or under-accessed as over one million housebound people remain without a regular eye examination across the country. The age profile of first time domiciliary service users in the current study cohort shows that only 38.6 % were aged 82 and over. Therefore it is likely that a substantial number of people over 80 years old are unable to access domiciliary eye care for themselves; obstacles may include lack of service awareness, other morbidities taking precedence or physical inability to arrange an appointment. People residing in care-homes and nursing-homes usually receive a regular eye examination as a part of the care plan implemented by the establishments.

Older people who remain involved in leisure activities are found to maintain a better QOL (Simone and Haas, 2013), therefore a key aim of the survey was to understand the type of hobbies domiciliary eye care recipients participate in. Watching television and reading (Table 2.2) was reported as the most frequently performed activity by CE and HH respondents. A substantial amount of time (150 minutes) per day was dedicated to watching television, may be because half of all older people aged 65 and over in the UK consider television as their main form of company (Age UK, 2014). Seventy three percent of the HH respondents stated spending approximately 54 minutes per day on preparing meals/ cookery activities compared to a limited 8.7 % of CE respondents who dedicate a mere 6 minutes. Provision of prepared meals is usually a part of the service provided by care-homes and nursing-homes to its residents, therefore limiting the need for an individual to engage in such activity. A notable proportion of the HH respondents (36.5 %) acknowledged regularly using a PC/ internet compared to a minority of CE patients (8.7 %). The CE respondents may experience difficulties in operating a computer due to their advanced age, which is often accompanied by physical and cognitive decline, resulting in impairment of psychomotor coordination and memory deficiency (Hawthorn, 2000). May be a lack of internet service and availability of computers in CEs is also a contributory factor for the low uptake of technology. It is likely that the use of internet amongst the elderly population will increase in the future, particularly

because it has become a key mode of communication in connecting family members across the world. It helps maintain independence by making ADL such as banking or shopping more accessible and it is found to be instrumental in reducing depression in the elderly population (Blažun *et al.*, 2012, Jaschinski *et al.*, 2015). Furthermore, the recent rise in portable tablet computers have made it more accessible and perhaps more user friendly, meaning older people are able to utilise them more often. A Chi-square test was performed and it found leisure activities undertaken by the present study respondents were very similar compared to the over 65 general UK population (X^2= <3.841), with the exception of low interest in internet use (X^2= 7.285) by the CE residents (Figure 2.19; Office for National Statistics, 2012a).
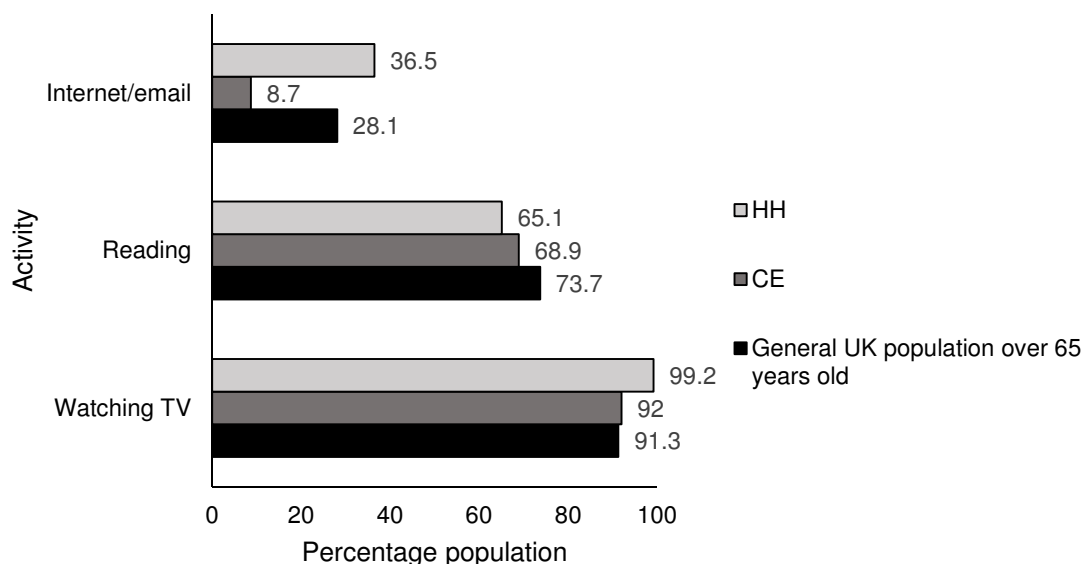
Figure 2.19 Leisure activities performed by the housebound populations compared to the general UK population aged 65 and over (data extracted from Office for National Statistics, 2012a). Survey respondents reading statistics include books and/ newspapers. CE: communal establishment; HH: household.

The survey investigated the prevalence and type of visual difficulties experienced by domiciliary eye care patients. One-fifth (20.9 %) of the respondents reported having a very poor level of vision resulting in experiencing extreme visual difficulties. Given the high mean age (74.5 and 82.5 years for males and females, respectively) of the survey population, it is possible that the VI is caused by ocular pathologies (Evans *et al.*, 2004a). Near vision

impairment, either exclusively (12.6 %) or in association with distance and/ or intermediate vision (2.4 %) was the most task specific complaint, thus providing a possible explanation as to why a lower number of housebound people participate in reading activities compared to the general UK population (Figure 2.19). A lack of PC/ internet use or performing cooking activities by the CE participants meant that visual problems at intermediate distances was infrequent (2.8 %) compared to the HH habitants (10.3 %). A limited proportion of respondents (3.2 %) reported visual difficulties related to distance vision, therefore it can be assumed that the majority of the housebound people are content with their level of distance VA and it is adequately meeting their visual demands.

The type of visual aids used by the housebound population was investigated. Over half of the survey respondents are currently using single-vision glasses; bifocal (26 %) spectacles are more popular than progressive/ varifocal (6 %) lens design in the CE population, whilst equal number of the HH participants are using bifocal (18 %) and varifocal lens design (18 %). Domiciliary patients are primarily presbyopic and therefore separate single-vision glasses or a pair of multifocal (bifocal or progressive) spectacles is required to meet their visual demands. Multifocal glasses are convenient as they are able to cover multiple focal lengths (Haran *et al.*, 2010). However, there is a prismatic jump at the near addition segment edge in bifocal lenses, which causes displacement of object image, while progressive lens have peripheral distortion zones, resulting in narrow clear visual field (Haran *et al.*, 2010). Furthermore, distant depth perception is impaired in the inferior visual field in all multifocal lenses (Lord *et al.*, 2002, Tinetti, 2003), leading to increased difficulty in negotiating steps, navigating around obstacles and poorer foot placement judgement particularly on uneven ground (Johnson *et al.*, 2008, Menant *et al.*, 2009). As a result, older people who wear multifocal glasses are found to be at a higher risk of suffering from trips and fall related injuries (Davies *et al.*, 2001, Johnson *et al.*, 2007). Additionally, the use of prisms to manage binocular vision abnormality, for example decompensated heterophoria, is considered to be a viable option in older people (Gray, 2008). Incorporation of prisms is more economical in the single-vision lenses compared to the

multifocal lenses. Hence, the lack of multifocal use underscores the advantages of single-vision lens design for the older housebound population and it also reflects the sentiments of the prescribers are coherent with the theoretical background. Patients who claimed to experience "poor overall vision" may benefit from an ophthalmological assessment to determine and perhaps seek treatment for the cause of VI. Alternatively, low vision assessment and rehabilitation may potentially improve patients' ability to function with chronic disabling VI, as it teaches the patient to use impaired vision more effectively (Goldstein *et al.*, 2014).

A link between severity of dry eye symptoms and the experience of ocular pain and discomfort was established (Figure 2.12 and 2.13); no other clinically significant factors were found to have any significant influence on determining the outcome of the two variables. Dry eye syndrome is multifactorial disorder; contributory factors include inflammatory medical conditions, medications containing beta-adrenergic antagonists, oxidative stress and physiological changes to ocular appendages (McGinnigle *et al.*, 2012). Prevalence of dry eye increases with age; approximately 8.4 % of the population under 60 are affected, increasing to 20 % in people 80 years or older (Moss *et al.*, 2000, Paulsen *et al.*, 2014). Symptoms vary from mild discomfort to severe irritation, pain and compromised vision (Smith *et al.*, 2007, Sharma and Hindman, 2014). In the present study 26.1 % reported experiencing symptoms of dry eyes, with 11.8 % suffering from moderate to severe dry eye related symptoms. Dry eye syndrome can be diagnosed in a domiciliary setting by assessing the tear stability using fluorescein and a cobalt blue filter (McGinnigle *et al.*, 2012) or by measuring the tear break up time using a hand-held keratoscope with a Loveridge grid (Hirji *et al.*, 1989). Although the association of ageing and prevalence of dry eye is a known concept (Ding and Sullivan, 2012), the survey illustrates that a significant proportion of the housebound population are suffering from symptoms of dry eye. Regular eye examination will enable optometrists to provide appropriate treatment modalities to the effected patients and reduce the associated symptoms.

VI can restrict peoples' participation in ADL including leisure activities (Lamoureux *et al.*, 2004), resulting in increased emotional distress (Fylan *et al.*, 2005), depression (Paz *et al.*, 2003), anxiety and worry (Scilley and Owsley, 2002), all leading to a profound impact on peoples QOL. A substantial percentage (41.5 %) of the respondents believed that the provision of perfect vision will make a small positive impact on their status of life, while 32.8 % reported their lives would be considerably better. DTA established that many factors were interlinked in influencing the outcome of each other. According to the DTA, people who reported to "notice" their eyesight were also found to "worry" about their vision and believed improved vision would make a significant positive change to their lives (figure 2.10, 2.11 and 2.14). A greater number of first time service users' reported to experiencing visual problems and they were more likely to be HH residents (figure 2.17 and 2.18); respondents suffering from visual problems were also inclined to experience irritable emotions with regards to their eyesight (figure 2.15). Therefore it can be assumed that VI has a negative impact on certain aspects of VRQOL in the housebound population. Previous studies investigating the prevalence of VI in older people have found that the majority of VI is due to uncorrected refractive error or untreated cataracts. Reidy *et al.* (1998) found, in a sample of patients aged 65 or older living London, that 30 % had VI, of which 72 % was potentially remediable by updating refractive correction or by surgical intervention. Sinclair *et al.* (2000) concluded that 54 % of VI in people over 65 is due to uncorrected refractive error. It is estimated that there are up-to 2.5 million people in England and Wales needing cataract surgeries, and up to 700, 000 die without having the surgery (Minassian *et al.*, 2000). Regular eye examination is therefore necessary to eliminate correctable VI amongst older population (Foran *et al.*, 2002).

The period of old age is often accompanied with health disorders leading to functional deficiency and VI, resulting in mobility disorders (Unsar *et al.*, 2015). However, the majority of the CE and HH respondents of this survey did not believe that their eyesight was responsible for their housebound status. Therefore other morbidities may have greater influence in limiting their mobility. A combination of different factors (long-term health conditions, sensory

impairment and CI) have been proposed as the reasons for the mobility issues in the older population (Age UK, 2014). A lack of adequate transport for the elderly may also be contributing towards older people becoming housebound (Greaves and Farbus, 2006).

In the present study, the questionnaire was distributed to housebound domiciliary eye care recipients within the metropolitan county of Merseyside. Therefore the results cannot be generalised to the rest of the UK population. It may however, be representative of similar urban areas. People from poorer socio-economic backgrounds (as measured by indicators including income, level of academia and occupation), are associated with a higher risk of general health ailments and VI (Guralnik *et al.*, 1993, Livingston *et al.*, 1997). Therefore, it would be beneficial to conduct a national study and compare the findings from different regions in the UK. The psychometric properties of the questionnaire used to collect the data was not assessed, nor was any focus group used to obtain any feedback on the design. Future studies would benefit from obtaining advice and input from fellow optometrists, carers and domiciliary service recipients to enhance the instrument's validity. The questionnaire was limited in design; the list of activities was prescriptive, compelling the respondents to choose from the limited list provided. The question relating to the PC/Internet use failed to clarify the inclusion of tablet computers and smart phones, and therefore it could have been misinterpreted by the respondents as only laptop and desktop PC use. It is conceivable that tablet computers and smart phones are becoming the primary choice of device for internet browsing due to its compact design and ease of use. Furthermore, the questionnaire required the respondents to record the amount of time spent on per activity in hours, however for meaningful analysis, the figures were converted into minutes. Therefore, questionnaires developed in the future would benefit from a minute based time scale instead of an hourly based one.

The questionnaire could be expanded to investigate the importance of instrumental ADL (IADL) in the CE and the HH population. Follow-up investigation would be required to establish the proportion of visual difficulties that were due to uncorrected refractive error or other correctable causes, for example cataract.

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2.6 Conclusion

Given that this was the first questionnaire based survey involving domiciliary eye care recipients in the UK, it was able to achieve the primary objectives of reporting on the visual experiences and general characteristics of recipients of domiciliary eye care.

The key findings of the survey include:

- Poor vision was very rarely the cause of housebound status.
- Experience of pain and discomfort is linked with prevalence of dry eye (11.8 % reported moderate to severe level of dry eye related symptoms)
- Single-vision lens design is the most frequently dispensed spectacle type. Multifocal (progressive lens design in particular) spectacles are more popular amongst the HH population compared to the CE.
- A significant and a similar number of housebound people in the CEs and the HHs (41.8 %) are experiencing visual difficulties, half of which regarded their vision as overall poor.
- The HH population were found to be keen users of PCs/ the internet.

Chapter 3. Clinical characteristics of domiciliary eye care recipients compared to practice-based GOS recipients

3.1 Introduction

Patients may seek an eye examination as a part of a routine visual assessment or in the event of experiencing abnormal visual symptoms relating to a particular abnormality (Pointer, 2014). According to the College of Optometrists guidelines, a routine eye examination should consist of a comprehensive history and symptoms; unaided monocular VA and/ or with the aid of existing refractive correction; habitual ocular muscle balance; internal and external examination using a direct ophthalmoscope as a minimum (dilate pupils if necessary); establish the prescription required and record monocular VA with the new refractive correction. Additional clinical examinations are recommended where necessary, for example IOP measurements and visual-field assessment in patients with glaucoma or with positive family history of glaucoma (The College of Optometrists, 2016).

The elderly and the housebound population are more susceptible to ocular pathologies (Gray, 1996), and as a result it is likely that their presenting visual complaints and subsequent clinical findings are diverse. VI with advancing age has a negative impact on the QOL of the older population (Andersen, 2012). Therefore optimisation of vision and maintenance of ocular health are the primary objectives of eye care practitioners (Machan *et al.*, 2013). Ocular physiological changes in older people result in a decline in visual functions, including reduced VA, contrast sensitivity and motion perception (Li *et al.*, 2000). Furthermore, loss of retinal ganglion cell density (Owsley, 2011); senile miosis; increased lenticular light absorption; reduced media transmittance and greater light scatter contribute towards lower retinal illumination and deterioration of image quality (Li *et al.*, 2000). Several population-based studies have demonstrated the link between age-related ocular pathologies and VI (Klein *et al.*, 2006, Gunnlaugsdottir *et al.*, 2008). A review involving healthy eyes in a Scandinavian population (Sjöstrand *et al.*, 2011) showed an age-related VA loss of 1.7 % per year

(equivalent to 0.1 logMAR units per 13.5 years) after 70 years of age. Furthermore, the review concluded that VA declines by approximately 0.3 logMAR units between the ages of 43 and 88 years. However, 98 % of healthy eyes maintain a VA of 0.5 logMAR or better up to the age of 88 years.

The prevalence of ocular disease-related VI is significantly higher in the older population, particularly in the 75 years and older age group (Chader and Taylor, 2013). A review (Klein and Klein, 2013) of common ocular pathologies responsible for blindness (VA of ≤6/60 in the better-seeing eye) and VI (VA of <6/12 in the better-seeing eye) amongst American residents showed susceptibility to different types of ocular disease varied with age and ethnic background. AMD primarily affected the white population, whilst glaucoma caused permanent vision loss predominantly in the Hispanic and black communities. Untreated cataract was identified as the primary cause of VI in all of the ethnic groups studied. The rate of vision loss increased exponentially after the age of 80 (Figure 3.1) across all ethnicities, meaning that the prevalence and the detrimental effects of ocular diseases on diminishing visual function becomes more evident in the oldest-old population. Given that the housebound population generally consists of the oldest individuals, prevalence of ocular disorders and therefore the number of people with VI is likely to be higher than the general population.

Figure 3.1 The effect of increasing age on the prevalence of blindness (VA of ≤6/60 in the better-seeing eye) and VI (VA of <6/12 in the better-seeing eye) in people of different ethnic backgrounds in a population based study in the USA. Data extracted from Klein and Klein (2013).

AMD (26 %), glaucoma (20.5 %) and DR (8.9 %) are the leading causes of blindness in Europe (Kocur and Resnikoff, 2002). Due to differing life expectancies, the prevalence of major eye diseases resulting in VI varies between developed Western Europe and Eastern European countries (Prokofyeva and Zrenner, 2012). For example, France (40 %) and Germany (39 %) have higher proportions of VI due to AMD compared to Bulgaria (14 %). A review of pooled data from 6 studies estimated that 3.5 % of the UK population aged 75 years and over are visually impaired (binocular VA of ≤6/18) due to late stage AMD; approximately 172,000 and 245,000 individuals have geographic atrophy and neovascular AMD, respectively (Owen *et al.*, 2003). An accurate comparison of results across the continent cannot be made because of the methodological differences between the studies. For example the definition of VI and severe sight impairment varies between different studies, in addition to the differences in the study populations in terms of age and background (e.g. community or hospital-based cohorts).

DR accounts for 4.8 % of global blindness (Resnikoff *et al.*, 2004) and it affects approximately 4 % of the European population (Simmons *et al.*, 2007). However, the prevalence of the disease varies between countries. In the UK and Spain, it is estimated that 4 % and 5.8 % of all diabetic patients have proliferative DR, respectively (Prokofyeva and Zrenner, 2012). Epidemiological data from Germany indicate that approximately 10.6 % of people over 60 with diabetes have DR and 0.5 % of them have proliferative DR. Mitchell *et al.* (1998) investigated the frequency of DR in an older Australian population and found increasing age had minimal impact on the prevalence of the disease. Therefore, it is likely that the prevalence of DR among the housebound population is similar to the general UK population.

Over 25 million people in Europe have been diagnosed with glaucoma (Michelson and Groh, 2001); the highest proprtion of diagnosed cases were made in Germany (14 %; Prokofyeva and Zrenner, 2012) and the lowest in France (3.4 %; Weinreb and Khaw, 2004) and the UK (3.3 %; Gray *et al.*, 2000). Open angle glaucoma accounts for 80 % of all glaucoma cases and it becomes more common with increasing age (Thylefors and Negrel, 1994). Glaucoma is the second most common cause of blindness; it is responsible for 11.7 % of all registered blindness in England and Wales (Kroese *et al.*, 2002).

The study of Evans *et al.* (2004) revealed that 12.5 % of people in Britain aged 75 years and older suffer from VI (binocular VA <6/18). Causes of VI included uncorrected refractive error (26 %; identified via pin-hole test); AMD (52.9 %); cataract (35.9 %); glaucoma (11.6 %); myopic degeneration (4.2 %) and DR (3.4 %). However, the true prevalence of VI is likely to be higher as the study did not involve residents of care homes and nursing homes, who are known to have a significantly higher prevalence of VI compared to community-dwelling individuals (Klein *et al.*, 1991). However, it was conclusive that the majority of VI was remediable by updating refractive correction or via cataract extraction.

Van der Pols *et al.* (2000) demonstrated the link between increasing age and the rate of VI in an ageing British cohort. The number of people with VI (VA ≤6/18 in the better eye) increased from 3.1 % in people aged 65 – 74 years to 11.6 % in the 75 – 84 years age group, and further rising to 35.5 % in those aged 85 years and over. In addition, females and residents of nursing homes were found to be 1.55 and 2.59 times more likely to have VI, respectively. Furthermore, 11.5 % of the study population reported that they were aware of the presence of cataracts negatively impacting their vision. Pinhole was used to determine the extent of refractive error related VI, and 21.2 % demonstrated an improvement of one Snellen VA line/ 0.2 log units. Although this particular study included people in CEs, no direct attempt was made to establish differences between community-dwelling residents and CE residents and only VA was considered, rather than any other clinical parameters, for example prevalence and severity of AMD or cataract. The study also excluded people with CI, which could rule out a significant proportion of nursing home residents.

The majority of domiciliary patients are elderly and they often exhibit a combination of cognitive and physical impairments (Gordon *et al.*, 2014). Hence, housebound patients are frequently considered to be "difficult" or "challenging" by ophthalmic professionals (Domiciliary Eyecare Committee, 2007). As discussed previously, several sight-threatening ocular diseases, for example glaucoma and DR, are asymptomatic in the initial stages, and are often diagnosed during a routine eye examination by an optometrist. Subsequent timely referral to the ophthalmology service is vital in avoiding irreversible vision loss (Chan *et al.*, 2014). Domiciliary eye care is an important service in detecting and managing preventable causes of VI in the vulnerable housebound population. Despite the importance of mobile eye care, there is a paucity of published data relating to the clinical characteristics of domiciliary eye care recipients compared to conventional in-practice patients. A scientific literature search in Web of Science, PubMed and Science Direct for the following keywords: domiciliary eye care; home eye care; domiciliary sight test; home sight test; NHS domiciliary and GOS domiciliary, revealed no published studies that have reported the clinical characteristics of patients

receiving domiciliary services. Currently, the predominant source of scientific information is through anecdotal materials published in professional magazines by practitioners in the field. More in-depth research into the visual characteristics of domiciliary patients would offer a valuable insight for the optometry profession and may inform strategies to enhance domiciliary eye care service provision.

The present study aims to describe clinical characteristics, including the prevalence of common ocular pathologies, levels of vision and VI, need for referrals to ophthalmological service and management strategies in CE and HH housebound domiciliary patients, compared to practice-based patients of a similar age for the first time.

3.2 Methods

The study was conducted in accordance with the tenets of the Declaration of Helsinki, with ethical approval obtained from the Aston University Life and Health Sciences Research Ethics Committee. Informed consent was not necessary since the study involved retrospective review of existing sight test records. All data remained anonymous.

This review included sight-test records relating to consecutive domiciliary (CE and HH based) and community-practice based GOS eye examinations involving adults aged 70 and over performed between March 2013 and April 2014. All eye examinations had been carried out by a single UK-registered optometrist (KR) working for an independent optical practice based in Liverpool, England. A minority of record cards (6 HH and 22 CE) were excluded from the study where a significant element of the sight-test could not be completed, for example due to CI of the patient. Table 3.1 provides a summary of data extracted from each clinical record. All data were entered on an Excel (Microsoft, Redmond, WA) spreadsheet.

Parameter	How recorded
Gender	Male/ female
Age	Years
Reason for visit	Routine/ worsening of vision/ damaged or lost spectacles/ specific complaint (detail)
Monocular distance unaided vision	logMAR
Monocular near unaided vision	logMAR
Monocular distance VA	logMAR
Monocular near VA	logMAR
Cataract	Nuclear/ Cortical/ Capsular
AMD	Graded according to AREDs
Glaucoma	Yes, with detail/ No
Other pathologies	As stated
Outcome of sight test/ management	New Rx?/ refer?/
Referral?	Reason

Table 3.1 Summary of clinical parameters recorded and subsequently compared between the three types of residential status. AREDS - AMD classification system (The Age-Related Eye Disease Study Research Group, 2001).

3.3 Pathology grading system

Grading pathological changes that are in the same continuum to that associated with age-related physiological changes is often difficult (Owsley, 2011). Changes to the appearance of the crystalline lens happen throughout life, therefore defining the existence of cataract is challenging (Xu *et al.*, 1997). Similarly, drusen may develop in older retinae, however the mere presence of drusen does not necessarily equal to the diagnosis of AMD (Vinding, 1990). Subjective description by the clinician or level of visual dissatisfaction by the subject are open to individual bias (McGwin *et al.*, 2010). VA measurement is an unreliable clinical parameter in monitoring ocular pathologies, as spatial resolution can be retained even in the presence of ocular disease such as early stages of glaucoma (Owsley, 2011). Therefore, clinicians and

optometrists alike often employ established grading scales that enable consistency in reporting and monitoring various ocular pathologies.

A validated criteria-based AMD grading system was developed by The Age-Related Eye Disease Study Research Group (2001) to classify the severity of AMD. Table 3.2 provides a summary of the AREDS grading scale.

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Table 3.2 AREDS AMD classification system. Information extracted from (The Age-Related Eye Disease Study Research Group, 2001).

An efficient and validated method of cataract grading using a direct ophthalmoscope was developed by Mehra and Minassian (1988). The technique involved visualising the red reflex through the undilated pupil using a fully charged direct ophthalmoscope, directing the light source away from the macula and towards the nasal retina (approximate angle of 25 degrees to the visual axis, thus avoiding excessive pupillary constriction) from about 33 cm from the patient's eye and assessing the area of lenticular opacity. Lenticular opacities that obscure the red reflex are graded according to Table 3.3.

Cataract grade	Lenticular Characteristics
0	Clear red reflex, no opacities
1	Few small dot opacities in the lens appearing as tiny scattered dark spots in the red reflex. Maximum area occupied by the dots 1 mm^2
2A	Lens opacity obscuring part of red reflex. Area obscured is smaller than area of clear red reflex
2B	As 2A but area obscured equal to or larger than area of clear red reflex
3	Lens opacity totally obscuring the red reflex
4	Aphakia or displaced lens
5	Unable to assess red reflex owing to corneal opacity etc.

Table 3.3 Criteria for grading lenticular opacities using a direct ophthalmoscope, developed by Mehra and Minassian (1988). All corresponding sight tests records were graded according to this scale.

The principles of AREDS AMD grading scale and the cataract grading system developed by Mehra and Minassian (1988) were employed to categorise the level of AMD and lenticular

opacity specified in the sight-test records. Both grading methodologies were retrospectively applied to written annotations and diagrams that were typically noted on record cards, and it is applicable for eye examinations carried out using a direct ophthalmoscope, which was used in all domiciliary eye examinations (and most in-practice tests) included in the review.

3.4 Data and Statistical Analyses

For the purpose of statistical analysis the monocular logMAR VA measurements were converted to binocular weighted VA figures to determine the level of visual ability. According to the algorithm of Physical Impairment of the American Medical Association (Rubin *et al.*, 2000), the weighted logMAR VA (WMAR) was calculated according to the following formula:

$$(3 * \text{better eye logMAR value} + \text{worse eye logMAR value}) / 4$$

Measurements obtained from right and left eyes of an individual are correlated, whereas statistical tests often assume the data are from independent samples. So data from both eyes cannot simply be combined (Armstrong, 2013). Although data was collected from both eyes, for the purpose of statistical analysis, one eye from each participant was selected at random to include in analyses of cataract and macular degeneration. A randomisation table (available online at https://www.randomizer.org/) was generated to determine which eye data should be selected.

A non-parametric statistical test capable of analysing three independent groups (CE patients, HH patients and in-practice patients) was required. The Kruskal-Wallis H test can be used to determine if there are statistically significant differences between two or more groups of independent variables measured at ordinal or continuous levels. A post-hoc (Dunn's pairwise) comparison test was performed to identify which group(s) was significantly different. All statistical analysis was performed using commercially-available IBM SPSS version 21. A P value of <0.05 was considered statistically significant throughout.

3.5 Results

Six hundred and fifty sight test records available for patients aged 70 and over were analysed; 250 CE, 250 HH and 150 in-practice records. In the in-practice group there were 70 (46.7 %) male and 80 (53.3 %) female patient records; in the HH group, 103 (41.2 %) male and 147 (58.8 %) female records were analysed and in the CE group 97 (38.8 %) male and 153 (61.2 %) female patient records were analysed. The median age of the in-practice patients (74.5 years) was significantly less than the HH (79.0 years) and CE (80.0 years) patients (P = <0.001).

The majority of the 650 sight tests were undertaken either as a routine recall examination or due to visual deterioration experienced by the patient. Chi squared statistical test was performed on each category of RFV to determine any differences between the 3 residential groups (P= 0.05 and Chi^2 critical value at 5.991). Patients who presented for sight tests with RFV marked as "other" significantly differed between the three residential groups (X^2= 13.192).

Residence Type	Routine (%)	Visual deterioration (%)	Damaged/ Lost Spectacles (%)	Other (%)
In-practice	33.3	42.7	8.0	16.0
HH	33.6	48.0	13.2	5.2
CE	39.6	36.8	17.2	6.4
X^2	*1.166*	*2.601*	*5.278*	*13.192*

Table 3.4 RFV cited by patients of each residential type. 150 in-practice, 250 HH and 250 CE sight-test record cards were analysed. RFV's in the "Other" category included cases of sudden onset of photopsia; diplopia; red eye; irritated and painful eye.

There was no statistically significant difference in the unaided WMAR distance and near scores recorded for all three groups of patients, however, the in-practice patients achieved significantly better corrected WMAR scores at both distance and near (both P = <0.001; Table 3.5).

Parameter	In-practice (n = 150)	HH (n = 250)	CE (n = 250)
Unaided distance WMAR			
Median	0.49	0.52	0.64
Range	0.01- 1.60	0.01- 1.33	-0.03- 1.70
P = 0.89			
Unaided near WMAR			
Median	1.00	1.00	1.06
Range	0.30- 1.70	0.30- 1.70	0.20- 1.70
P = 0.075			
Corrected distance WMAR			
Median	0.08	0.13	0.20
Range	-0.18- 0.68	-0.10- 1.00	-0.10- 1.70
P = <0.001			
Corrected near WMAR			
Median	0.30	0.32	0.40
Range	0.20- 1.15	0.30- 1.10	0.20- 1.70
P = <0.001			

Table 3.5 Unaided and corrected WMAR scores of in-practice, HH and CE patients. There was no significant difference in unaided distance (P = 0.89) and near (P = 0.075) WMAR scores. In-practice patients achieved significantly better corrected WMAR scores (P = <0.001 for distance and near) than the domiciliary groups

According to the randomisation table, the appropriate eye was selected from each patient's record card for the analysis of cataract extent. Chi squared statistical test (P= 0.05 and Chi^2 critical value at 5.991) shows that a greater number of housebound patients have cataracts and advanced lenticular opacities was more prevalent among the CE residents. There was no significant difference in the number of pseudophakic patients amongst the 3 residential groups.

Residence Type	Cataract Grade					
	0	1	2A	2B	3	IOL
In-practice (n = 150)	73 (48.7 %)	57 (38.0 %)	12 (8.0 %)	1 (0.7 %)	0 0.0 %	7 (4.6 %)
HH (n = 250)	87 (33.4 %)	113 (42.1 %)	35 (20.6 %)	8 (2.9 %)	0 0.0 %	7 (2.8 %)
CE (n = 250)	69 (27.6 %)	81 (32.4 %)	54 (21.6 %)	27 (10.8 %)	5 (2.0 %)	14 (5.6 %)
X^2	*8.418*	*3.833*	*10.275*	*20.055*	*7.903*	*2.244*

Table 3.6 Summary of lenticular status amongst in-practice, HH and CE patients aged over 70 years. IOL: pre-existing intra-ocular lens implant.

Across all patient groups, detailed macular assessment was not possible in 21 eyes, of which 18 instances were due to advanced cataract (HH $n=1$; CE $n=17$); two due to corneal dystrophy and one artificial eye. Chi squared statistical test shows (P= 0.05 and Chi^2 critical value at 5.991) a greater proportion of the housebound patients were diagnosed with AMD, and the more advanced AMD (AREDS 3 and 4) was predominantly prevalent among the CE residents.

Residence Type	AREDS 0	AREDS 1	AREDS 2	AREDS 3	AREDS 4
In-practice (n = 150)	106 (70.7 %)	31 (20.7 %)	11 (7.3 %)	2 (1.3 %)	0
HH (n = 250)	155 (62.0 %)	42 (16.8 %)	43 (17.2 %)	9 (3.6 %)	1 (0.4 %)
CE (n=241)	132 (54.8 %)	41 (17.0 %)	36 (14.9 %)	20 (8.3 %)	12 (5.0 %)
X^2	3.163	0.919	6.062	9.422	15.538

Table 3.7 Prevalence of AMD and accompanying AREDS grading relating to in-practice, HH and CE patients. AREDS: The Age-Related Eye Disease Study Research Group (2001)

Thirteen (8.7 %) in-practice patients, 14 (5.6 %) HH and 22 (8.8 %) CE residents were diagnosed glaucoma patients. Residential status did not influence the prevalence of diagnosed glaucoma (P = 0.387). Other ocular abnormalities noted during the analysis of record cards are detailed in Table 3.8.

Ocular Disorder	In-practice (n)	HH (n)	CE (n)
DR	3	7	5
Amblyopia	3	2	7
Blepharitis	3*	2*	7*
Ectropion	-	1*	3
Trichiasis	1*	-	-
6th Nerve Palsy	1*	1*	-
Nystagmus	1	-	-
Corneal dystrophy	-	-	2
MS	1	-	-
TED	-	1	-
AION	-	1*	4
CRAO	-	-	1*
CAG	-	-	1*

Table 3.8 Prevalence of other ocular disorders. MS: multiple sclerosis; TED: thyroid eye disease; AION: anterior ischaemic optic neuropathy; CRAO: central retinal artery occlusion; CAG: closed angle glaucoma. *Diagnosed at the time of sight test.

The outcome/ management of each sight test was categorised into four groups based on what was deemed as the key recommendation. A hierarchical system was employed where "referral" was regarded as the most important outcome followed by "new refractive correction", "advice on lid care and/ eye drops" and lastly "no change required". Issuing of new refractive correction was based on either a change in prescription or on the basis of condition of existing spectacles (Table 3.9). Chi squared statistical analysis found residential status had no bearing on the sight-test outcome (P= 0.05 and Chi^2 critical value at 5.991).

Outcome/ Management	In-practice	HH	CE	X^2
New refractive correction	78.7 %	74 %	76.8 %	0.165
No change required	14 %	18.4 %	14.4 %	1.440
Advised on lid care and/ eye drops	2.7 %	4 %	4 %	0.540
Referred	4.7 %	3.6 %	4.8 %	0.458

Table 3.9 The outcome/ advice given to patients following the sight-test as per record card. A hierarchy system was used to decide which the key outcome was: "referral" > "new refractive correction" > "advice on lid care and/ eye drops" > "no change required".

From the 650 record cards, 29 (4.5 %) patients were referred (4.7 % of in-practice patients, 3.6 % of HH patients and 5.2 % of CE patients) to the ophthalmology department for various reasons (Table 3.10). Collectively 11 (37.9 %) referrals were made for cataracts and 9 (31 %) for suspect glaucoma.

Ocular Disorder	In-practice (n)	HH (n)	CE (n)
Cataract	3	1	7
Glaucoma	1	4	4
YAG LASER	-	1	-
Trichiasis	1	-	-
6th Nerve Palsy	1	1	-
Multiple Sclerosis	1	-	-
AION	-	1	-
CRAO	-	-	1
CAG	-	-	1
LVA service	-	1	-

Table 3.10 The reason for referral as per sight-test record card. AION: anterior ischaemic optic neuropathy; CRAO: central retinal artery occlusion; CAG: closed angle glaucoma; LVA: low vision aid.

Residential status was significantly associated with the prevalence of VI (P= <0.001). Using the WHO guideline for VI (VA of <6/18 or equivalent logMAR score of <0.5 in the better eye), 8.8 % of the CE patients were visually impaired compared to 0.4 % of HH residents and no in-practice patients.

3.6 Discussion

The aim of this study was to establish the clinical similarities and differences between domiciliary eye care recipients and conventional in-practice patients aged 70 years and over. Currently, there is no published literature related to detailed clinical characteristics of the housebound population receiving domiciliary eye care. Sight-test records relating to consecutive eye examinations conducted on people over the age of 70 years from each residential background (care-homes, household domiciliary and non-housebound in-practice patients) were analysed.

A greater proportion of females were included across all patient groups, with the gender disparity being the least in the in-practice population (46.7 % males and 53.3 % females) and

the greatest in the CE group (38.8 % males compared to 61.2 % females). CE patients were also found to be significantly older (median age 80 years) than the in-practice patients (median age 74.5 years). The findings reflect the longer female life expectancy (Office for National Statistics, 2014c) and the gender demographics of CE population (Office for National Statistics, 2013); given that approximately 73 % of the CE population are females.

The majority of eye examinations were conducted as a result of a routine recall and no significant difference for sight test requested for a specific was found between the three groups. However, a higher percentage of the CE population (17.2 %) stated a loss or damage incurred to the existing spectacles compared to the in-practice patients (8 %). Physical limitations and disabilities are more frequent within the housebound community (Parker *et al.*, 1997), which may contribute towards the poorer handling of the glasses. There is a greater likelihood of people living in CEs accidently mixing their spectacles up with those belonging to fellow residents. Therefore there is a greater need for labelling/ engraving the spectacle frames to allow easier identification.

Unaided distance and near WMAR was similar across all patient groups. However, the corrected distance and near WMAR was significantly better in the in-practice group (median WMAR of 0.08 at distance and 0.3 at near) compared to the CE group (median WMARs of 0.2 at distance and 0.4 at near). The median WMAR of the HH patients (0.13 at distance and 0.32 at near) appears to be at an intermediary level between in-practice and CE patients. The decline in corrected VA may be attributed to age related deterioration (Klein and Klein, 2013) or secondary to development of ocular pathologies, for example AMD and cataracts (Bergman *et al.*, 1999, Sjöstrand *et al.*, 2011).

The severity of cataract was found to be significantly higher in CE residents compared to HH and in-practice patients. Morphological changes to the crystalline lens and development of cataract is primarily related to ageing (Adamsons *et al.*, 1991). Other risk factors include general health ailments and systemic medications. For example, DM and use of

corticosteroids, which is associated with development of posterior sub-capsular and nuclear cataract (Cumming *et al.*, 1997). A combination of these factors are the likely reasons for the higher prevalence of cataracts observed in the CE population. Additionally, the CE patients may be unwilling to undergo cataract surgery due to their poor overall health, hence contributing towards the higher rate. The US-based study of Van der Pols *et al.* (2000) revealed that 11.5 % of visually impaired care home and nursing home residents were aware of presence of cataracts but surgical treatment was not sought. Although "cataract" is strictly defined as a development of any opacity in the natural crystalline lens, the term is typically used to describe lenticular opacity that is detrimental to the vision (Royal College of Ophthalmologists, 2015), and therefore individual visual demands and level of visual satisfaction/ desire for treatment often dictates timing of surgical treatment. Accurately predicting the prevalence of the condition is difficult due to the absence of universally-accepted standardised criteria for defining the presence of cataracts, which hinders the possibility of direct comparisons between different studies. For example, some studies have used monocular data (the better or the worse eye) whilst others used binocular data. In addition, the cataract grading system varied between use of lenticular opacity and/ or associated VA deterioration (Acosta *et al.*, 2006). The Beaver Dam Eye Study reported a prevalence of 5 % based on the best eye and 14.2 % on assessment of the worst eye. When age and gender was adjusted, the prevalence increased to 38.8 % and 45.9 % for males and females older than 75 years, respectively (Klein *et al.*, 1992). The North London Eye Study reported cataract prevalence as 30 % in a population group aged 65 and over (Reidy *et al.*, 1998). Assuming cataract grade of 2A as the minimum level of lenticular opacity that defines a cataract, the prevalence of cataract among the in-practice group was 8.7 %, compared to 17.2 % and 30.4 % amongst the HH and CE populations, respectively. The findings of the present study suggests that the prevalence of cataract in the in-practice and HH group were below that estimated in previous studies. Differences in study design and criteria used to define cataract may be the reasons for this.

Prevalence of early AMD (AREDS 1- 3) was 29.3 %, 38.0 % and 45.2 % for the in-practice, the HH and the CE groups, respectively. Advanced AMD (AREDS 4) was found in domiciliary patients only; 0.4 % of HH and 5.0 % of CE patients. The findings suggest that the domiciliary eye care recipients, particularly the residents of CEs, are more likely to suffer from an advanced level of AMD, compared to patients attending community-based practices. Residents of CEs are associated with a greater number of AMD risk factors, which include older age; female-dominated population (Office for National Statistics, 2013) and presence of other systemic ailments such as CVDs, HTN and DM (The Royal College of Ophthalmologists, 2013).

AMD refers to age-related changes to the central retina where in the early stages lipid material accumulates as deposits beneath RPE and the Bruch's membrane; focal collection of lipid materials leads to drusen. The RPE also undergoes morphological changes leading to hyper and hypopigmentation (Ferris iii *et al.*, 2013). The development of drusen and alteration to pigmentation of RPE does not always result in an adverse effect on vision; between 12.9% and 17.8 % of the people with these changes develop GA or neovascular AMD, leading to VI (Klein *et al.*, 2007). A study of pooled epidemiological data in the UK estimated that 4.8 % of people aged 65 and over suffer from advanced AMD, which increases to 12.2 % in people aged 80 years and older (Owen *et al.*, 2003, Owen *et al.*, 2012). However, the findings of the present study indicated a lower prevalence of advanced AMD (0- 5 %) in the groups studied. Potential reasons for the findings include the fact that people with advanced AMD are likely to be under ophthalmological care, and are therefore less likely seek optometric eye examination. Furthermore, the present study consisted of a relatively small sample based in one region of the UK only.

The prevalence of glaucoma was 8.7 %, 5.6 % and 8.8 % amongst the in-practice, the HH and the CE groups, respectively. According to the RNIB there are approximately 293,733 people in the UK diagnosed with glaucoma, although estimates suggest that there are a total of 503,828 people suffering from the condition. Therefore, only 58 % of the people with glaucoma

are actually diagnosed (RNIB, 2009). According to previous epidemiological studies, glaucoma is found to affect between 1.2- 3 % of people aged 40- 89 years (Kroese *et al.*, 2002, Owen *et al.*, 2006), which increases to 5 % when considering people aged 80 and over exclusively (Kroese *et al.*, 2002). The findings of the present review identified slightly higher prevalence of glaucoma. However, given that almost half of the people with glaucoma in the UK are undiagnosed (RNIB, 2009), the findings can be assumed to be representative of the wider population. Furthermore, the prevalence of diagnosed glaucoma was similar for in-practice and housebound patients.

Similar percentages of individuals in all three review groups had signs of DR (2 % of in-practice and CE population and 2.8 % of HH population). In the UK there are about 3 million people who suffer from DM (RNIB, 2009) and 38 - 52 % of them are likely to develop DR (Prokofyeva and Zrenner, 2012). Approximately 3- 4.1 % of the European population are affected by DR with the highest prevalence in the UK (Resnikoff *et al.*, 2004, Simmons *et al.*, 2007). Although the number of people showing signs of DR in the present study was low, progression of DR has been associated with ageing along with hyperglycaemia and smoking (Stratton *et al.*, 2001).

Other ocular disorders that were diagnosed during the eye examination varied from eye-lid disorders to sight threatening ocular pathologies such as CRAO and CAG, which required an immediate referral to ophthalmological care (Table 3.7). However, the serious cases were isolated episodes. Pre-existing optic neuropathy caused by AION and MS was present in 2.4 % of the CE population. Ischemic optic neuropathy is one of the major causes of VI in the older population, and the risk increases with advancing age (Hayreh, 2009). The study of Danesh-Meyer *et al.* (2001) found, in a cohort aged 60- 93, that the median age of people who first suffered from AION was 77 years. Furthermore, systemic risk factors include HTN, CVD and DM (Hayreh, 2009). Therefore older housebound patients with associated general health problems are at a higher risk of suffering from ischemic optic neuropathies.

The incidence of anterior eye disorders involving the lids (blepharitis, ectropion and trichiasis) was greater in the CE group (4 %) compared to the in-practice (2.7 %) and the HH (1.2 %) based patients. Blepharitis is a very common disorder; some studies have suggested prevalence of 37 - 47 % among patients who suffer from MGD (Lemp and Nichols, 2009) and seborrheic blepharitis usually affects the older population (Jackson, 2008). Compared to other population based studies, the number of people with blepharitis in the present study is exceptionally low. This may be because in cases where patients are asymptomatic, practitioners are often found to fail to record the presence of the condition (McDonald, 2009). Furthermore, the condition may be difficult to detect in asymptomatic patients without the use of a slitlamp, which is not typically available during domiciliary eye examinations.

The outcome of sight-tests was categorised into four groups; the majority of patients across all three residential types chose to update their spectacles, presumably either on the basis of new refractive correction or on the condition of their existing glasses. The proportion of patients who required no action or who were given advice on the use of ocular drops and/ lid care management were similar in patients of all residential backgrounds.

In total, 4.5 % of the patients were referred for further investigation and/ or treatment. The most common reason for referral was for routine cataract surgery (37.9 %) followed by patients with suspicious glaucomatous signs and/ changes (31 %). Pierscionek *et al.* (2009) concluded that most of the optometric referrals to ophthalmological service relate to cataracts followed by retinal or vitreal disease and glaucoma. A review of 15 research studies in which optometrists' referral rates were indicated or could be inferred showed on average 3.83 % of patients were referred to an ophthalmologist and a total of 5.5 % referred to all providers (Brin and Griffin, 1995). However, in 1999 the government reintroduced free sight-test for people aged 60 and over, which had an immediate impact on the number of older people attending for eye examinations and led to a 34 % increase in GOS funded sight-tests conducted the following year (RNIB, 2007). Therefore, it is likely that the increased volume of eye

examinations involving older people has affected the number and reason for referrals made to the hospital eye care services.

Housebound status was significantly associated with prevalence of VI (P = <0.001); a possible combination of factors including advanced ageing and higher prevalence of ocular diseases (cataracts and AMD) may have contributed towards 8.8 % of CE residents meeting the WHO guidelines for VI (VA <6/18 in the better eye). The recent PrOVIDe study (Hancock *et al.*, 2015) undertaken by the College of Optometrists investigated the prevalence of VI in people with CI. It recommended the development of a Dementia Eye Care Pathway (DECP) in order to reduce the risk of VI in people with dementia. A significant proportion of care-home and older community-dwelling residents suffer from CI, and many family members and care workers are unaware that an examination is possible even in the presence of advanced dementia. Therefore, a large proportion of housebound people are possibly living with undiagnosed correctable VI, and unnecessarily experiencing visual difficulties. The detrimental effect of suffering from VI and CI simultaneously is much more severe than suffering from either condition on its own (Trigg and Jones, 2007). Therefore, the College of Optometrists recommended provision of information to patients and their carers to encourage them to have regular sight-tests. Given the ageing population, it is inevitable that optometrists will encounter patients with CI, and even though the present study included record cards of patients with mild dementia, it would be beneficial for future studies to include advanced dementia patients and report on their ocular clinical characteristics. It will enhance the optometric professional knowledge and serve as a useful reference for optometrists involved in domiciliary eye care. Extending the geographical location would also include a wider selection of patients with diverse ethnicity and socio-economic background, which may elicit other significant clinical characteristics that may have remained undetected in the present study. It would be prudent for future study designs to be prospective, as that will allow pathology grading to be done in real time or through the use of photographs, which will

minimise grading errors. Prospective study design will also allow recruitment of equal number of age matched participants in each respective groups.

3.7 Conclusion

This is the first known study to have analysed and compared clinical data relating to the housebound (CE and HH) domiciliary eye care recipients and conventional in-practice patients. Domiciliary eye care recipients were found to be significantly older than in-practice patients. As a result, a greater number of housebound people were detected with age-related ocular pathologies (cataract and AMD), which may have contributed towards the poorer visual outcome and the greater prevalence of VI found, particularly in the CE patients. Housebound people should be encouraged to have regular eye examinations, which will allow timely referral to ophthalmological care for treatment of sight-threatening ocular diseases and reduce the burden of VI. Furthermore, sight-tests by an optometrist should not be viewed as a means for new spectacles only, as almost 1 in 10 patients were either referred to the HES or needed advice and/ supply of topical eye drops for management of ocular surface disorders, which can have a significant impact on QOL.

The present study revealed that the prevalence of cataracts is highest amongst the domiciliary patients, particularly CE residents. Furthermore, the most common reason for referring a patient to ophthalmological care was related to possible treatment for cataracts. Linked to this, the next chapter will investigate the changes in self-reported visual function following cataract surgery in domiciliary patients compared to in-practice patients. The benefits of cataract surgery are well known. However, presently it is unclear if housebound individuals would experience similar improvements in patient-reported outcomes as non-housebound individuals.

Chapter 4. Self-reported visual function changes post cataract surgery in GOS domiciliary patients compared to conventional in-practice patients

4.1 Introduction

Cataract and uncorrected refractive error are the leading causes of curable VI worldwide (Abraham. *et al.*, 2006, World Health Organisation, 2010) affecting around 10 % and 20 % of UK adults aged 65- 74 years, and 75 years and over, respectively (Evans and Rowlands, 2004). The retrospective review of sight-test records in chapter 3 highlighted that the prevalence of untreated cataracts is higher in patients receiving domiciliary eye care compared to in-practice patients. Approximately 1 in every 5 HH and 1 in every 3 CE patients had with significant levels of lenticular opacity, compared to less than a tenth of in-practice patients. Additionally, 8.8 % of CE residents were visually impaired (better eye VA equivalent <6/18 Snellen) compared to 0.4 % of HH and no in-practice patients. Therefore, it is likely that a significant proportion of VI in the CE population is due to untreated cataracts. Prevalence of VI in nursing-home residents in the USA was estimated to be 3- 15 times higher than community-dwelling older adults (Owsley *et al.*, 2007a), and between one and two thirds of the VI was due to untreated cataracts (Owsley *et al.*, 2007b). The residents who underwent cataract surgery experienced a significant improvement in their VRQOL and vision; mean corrected distance visual acuity (CDVA) improved from 0.74 to 0.25 logMAR and near vision improved from 0.89 to 0.43 logMAR. The study was limited to nursing home residents only, and did not assess the impact of surgery on visual function in community-dwelling housebound patients. Furthermore, it was based on the US healthcare system, which operates very differently to the NHS.

Cataract is predominantly associated with ageing; the median age for patients undergoing first eye surgery in the UK is approximately 77 years (Day *et al.*, 2015). Other cataract risk factors that may also be associated with the housebound population include female sex; DM and use

systemic medications containing corticosteroids (Prokofyeva *et al.*, 2013). Older adults who lack a nutritious diet, or smoke and/ or suffer from obesity are also at a higher risk of developing cataract (Leske *et al.*, 1991). Cataract surgery is currently the most frequently performed NHS surgical procedure, with around 330,000 operations per annum in England (Day *et al.*, 2015) Clinical visual outcomes are usually excellent, with recent European registry data indicating that around 90 % of patients achieve a post-operative CDVA of 0.0 logMAR (6/ 6 Snellen) or better (Lundstrom *et al.*, 2013). With the ageing population, it is likely that the demand for surgery will increase in coming years.

VI has been strongly associated with an increased risk of falls and fall related injuries resulting in disability and mortality. It is estimated that around 30% of people aged 65 and over, living independently, fall at least once a year and up to half of them suffer from repeated falls (De-Boer *et al.*, 2004b). Mortality figures suggest about 14,000 people die annually in the UK as a result of osteoporotic hip fracture (Department of Health, 2001). It has been estimated that a 14 % reduction in falls in elderly population could be achieved by treating VI (Cummings, 1996). Moreover, cataract surgery correcting moderate to severe VI has been found to reduce long-term mortality risk (assessed after 5 years) compared to patients whose VI persisted postoperatively due to other ocular morbidity (Fong *et al.*, 2014).

Detection and subsequent referral for cataract surgery is usually made following a sight test, and the condition is the most common reason for optometric referral into ophthalmological care (Lash *et al.*, 2006, Pierscionek *et al.*, 2009). CDVA is the habitual objective measurement used when considering referral for cataract surgery, despite it being well-established that there may be a poor correlation between VA and visual function (Morris *et al.*, 2007). For example, a standard VA chart would fail to elicit glare-related visual disability caused by increased light scattering (Fujikado *et al.*, 2004), or the visual difficulty experienced by patients under low light levels due to reduced contrast sensitivity (Rouhiainen *et al.*, 1996). Standard VA charts usually employ high contrast optotypes in a well-lit room, which is unrepresentative of real-life conditions. However, available visual tests that can quantify the deficiency in contrast

sensitivity, for example the Pelli-Robson chart, are rarely utilised in general practice due to time constraints and practicality issues (Williamson *et al.*, 1992). Therefore, it has become common practice to select potential patients for cataract surgery based on their visual functional symptoms, rather than purely on VA measurements (Morris *et al.*, 2007). The most frequent self-reported visual problem linked to cataract involves difficulty in reading small print/ newspaper print (Chew *et al.*, 2012), and night driving (Pager, 2004).

The efficacy of cataract surgery is often described in terms of VA achieved post-surgery, although in recent years, there has been an increase in the use of PRO measures (Khadka *et al.*, 2013). There are many ophthalmic PRO instruments (questionnaires) available, relevant to a range of ophthalmic conditions (Table 1.3). PRO instruments may be superior to isolated clinical measures as they evaluate the impact of a condition, or its treatment, on patients' functional abilities and well-being (Wiklund, 2004). A rigorously-tested and well established PRO instrument is ideal for a comprehensive assessment of visual function (Chiang *et al.*, 2011). The VF-14 (Steinberg *et al.*, 1994b) and the Catquest-9SF (Lundstrom and Pesudovs, 2009) questionnaires are patient-perspective questionnaires, which subjectively quantify the type and the severity of VI caused by cataract and evaluate the need for, and the success of surgery (Pan *et al.*, 2015). The VF-14 instrument has been successfully implemented by many previous studies investigating VRQOL and visual function following cataract surgery (e.g. Pager, 2004, Pomberg and Miller, 2004, Garcia-Gutierrez *et al.*, 2012).

There is strong evidence that cataract surgery provides significant improvements in functional abilities and QOL amongst the general population (Steinberg *et al.*, 1994a, Mangione *et al.*, 1994, Javitt *et al.*, 1993, Groessl *et al.*, 2013), although the impact of the procedure for housebound people is less clear. Domiciliary patients are likely to suffer from some form of physical or mental disability, which has resulted in their housebound status. Given the restrictive nature of their environment, it is conceivable that their range of visual tasks is more limited. United States-based researchers have suggested that the attitudes of these patients,

their families and healthcare providers, along with ophthalmologists' concerns of whether the procedure is in the best interests of very elderly individuals, may all contribute to a higher rate of cataract-related VI amongst housebound individuals, compared to the wider population (Keller *et al.*, 2001, Friedman *et al.*, 2005, Owsley *et al.*, 2007a).

Although the domiciliary eye care sector is growing in the UK, minimal research attention has been directed at this specific patient group. The aim of the present study was to determine whether domiciliary eye care recipients living in either HH or CE experience similar improvements in self-reported visual function with cataract surgery as conventional in-practice patients. Housebound patients are often physically limited by illnesses and/ or disabilities, meaning that they may participate in a restricted number of visual activities compared to conventional practice based patients. Therefore it may be hypothesised that they may not experience the same level of visual functional improvement compared to an able-bodied person who is involved in a wider spectrum of daily activities.

4.2 Methods

The study was conducted in accordance with the tenets of the Declaration of Helsinki, with ethical approval obtained from the Aston University Life and Health Sciences Research Ethics Committee.

The study was conducted in the Merseyside region of North-West England. Consecutive individuals referred for cataract surgery following a complete eye examination (either in-practice, or domiciliary) were invited to participate if they met the following inclusion criteria:

- English-speaking and able to give informed consent for participation in the study;

- Aged 55 years or over;

- Cataract in one or both eyes causing significant visual problems for the patient;

- Able to complete a relatively short visual function questionnaire, either in writing, or verbally with the referring optometrist.

Eligible consenting patients underwent baseline assessment at the stage of the initial eye examination, and follow-up assessment approximately 3 months after cataract surgery, when participants had been using their new refractive correction for circa 6- 8 weeks, which would provide sufficient time for the patients to become accustomed to the change in vision following the cataract surgery. If both eyes were undergoing cataract extraction, then the post-operative assessment was conducted following second-eye surgery. Participants were assigned to one of three groups: those referred for cataract surgery following conventional in-practice eye examinations and patients referred following domiciliary sight tests- either those residing in HH or in CEs.

At the baseline assessment, each participant's gender, age and monocular corrected distance and near logMAR visual acuities were recorded. Cataracts were graded using the criteria detailed in Table 4.1, which were initially described by Mehra and Minassian (1988). This facilitated grading of clinically significant cataract using the direct ophthalmoscope, which is relevant to the present study. Conventional slitlamp examination of the anterior segment and grading with the more widely used LOCS III system (Chylack *et al.*, 1993) was not possible for domiciliary patients.

A comprehensive post-operative follow-up sight test was conducted once the patient was discharged from the ophthalmological care and were dispensed with appropriate distance and near refractive correction where necessary. The patients were requested to complete another VF-14 questionnaire after a further 8- 10 weeks.

Cataract grade	Lenticular Characteristics
0	Clear red reflex, no opacities
1	Few small dot opacities in the lens appearing as tiny scattered dark spots in the red reflex. Maximum area occupied by the dots 1 mm^2
2A	Lens opacity obscuring part of red reflex. Area obscured is smaller than area of clear red reflex
2B	As 2A but area obscured equal to or larger than area of clear red reflex
3	Lens opacity totally obscuring the red reflex
4	Aphakia or displaced lens
5	Unable to assess red reflex owing to corneal opacity etc.

Table 4.1 Criteria for grading lens opacities employed in the present study (Mehra and Minassian, 1988). The grading technique is performed with a direct ophthalmoscope rather than slitlamp examination.

The VF-14 instrument was developed by Steinberg and colleagues in 1994 (Steinberg *et al.*, 1994b) for the assessment of self-reported visual function in patients with cataract. It is simple to execute, has been demonstrated to be valid, reliable (Steinberg *et al.*, 1994b, Alonso *et al.*, 1997), and sensitive to change with surgery (Cassard *et al.*, 1995), and consequently, has been widely used in the research field. The instrument consists of 14 items (questions) related to common activities of daily living (see table 4.2). Individuals are required to indicate the level of difficulty (on a 5 point Likert scale from *none at all* to *unable to do*) experienced with each activity, due to their vision. If particular questions are not relevant to the individual, this is indicated using the *n/a* option. The overall VF-14 score is scaled from 0 to 100, where 0 indicates that the individual is unable to perform any activities, and 100 indicating no difficulty at all with applicable activities. Although widely used in its original format, the VF-14 has been modified and revalidated by numerous authors using Rasch methodology to evaluate its psychometric properties (e.g. Mallinson *et al.*, 2004, Lamoureux *et al.*, 2009, Gothwal *et al.*, 2010c). A disadvantage of the original VF-14 is the native ordinal (Likert scale) scoring system

which is based on the improper assumption that the spacing between response options is equal and that all items are identical in terms of difficulty. Of the revised versions, the VF-8R (8 items, Rasch analysed; see table 4.2 for items included in the VF-8R) has been identified as the optimum tool for assessment of cataract surgery outcomes (Gothwal *et al.*, 2010c) due to its uni-dimensionality (ability to measure a single trait, i.e. activity limitation) and greater precision in discriminating outcomes of surgery. The VF-8R has been validated amongst older cataract patients in Australia (Gothwal *et al.*, 2010c), a cultural setting similar to the UK.

Item	Item description in VF-14 instrument	Included in VF-8R?
1	Reading small print such as labels on medicine bottles, a telephone book, food labels	Yes
2	Reading a newspaper or book	Yes
3	Reading a large print book or large print newspaper or numbers on a telephone	No
4	Recognising people when they are close to you	No
5	Seeing steps, stairs or curbs	Yes
6	Reading traffic signs, street signs or store signs	Yes
7	Doing fine handwork, such as sewing, knitting, crocheting, carpentry	Yes
8	Writing checks or filling out forms	Yes
9	Playing games, such as bingo, dominos, card games, or mah-jong	Yes
10	Taking part in sports like bowling, handball, tennis, golf	No
11	Cooking	No
12	Watching television	Yes
13	Driving during the day	No
14	Driving at night	No

Table 4.2 Item content of the VF-14 questionnaire (Steinberg *et al.*, 1994b) with indication of the items included in the Rasch-analysed VF-8R version (Gothwal *et al.*, 2010c). For each item, individuals are required to rate the level of difficulty they experience due to their vision when performing each task of daily living.

4.3 Data and statistical analyses

Weighted average distance logMAR (WMAR) VA was calculated pre- and post-operatively for each participant, and gives weightings of 0.75 and 0.25 to the better and worse eye, respectively (Scott *et al.*, 1994).

VF-14 data obtained in the present study were analysed using the original scoring system (on a 0-100 scale, where 0 represents severe disability and 100 indicates no difficulty with visual tasks), to enable comparison with previously published work. Rasch-scoring of the relevant VF-8R questions was also performed using the spreadsheet developed by Gothwal and colleagues (Gothwal *et al.*, 2010c), where scores are reported in logits and more negative scores represent better visual function.

One-way ANOVA with Tukey's post hoc test was performed to identify any significant differences in age between the three patient groups, and one-way ANOVA on ranks with Dunn's pairwise comparison for WMAR scores, which were not normally-distributed. Spearman correlation was used to determine the relationship between VF-14 scores and WMAR values. All data was stored using Microsoft Excel; statistical analysis was performed using commercially-available IBM SPSS version 21 and a P value of <0.05 was considered significant throughout.

4.4. Results

Eighty four patients (26 in-practice; 24 HH and 34 CE) being referred for cataract surgery consented to participate and underwent baseline examination. Of these, six did not undergo cataract surgery following ophthalmological assessment (2 HH and 4 CE) due to co-existing age-related macular degeneration (AMD; n = 5) or poor vision in the fellow eye (n = 1); these individuals were excluded from all analyses. Table 4.3 provides summary baseline characteristics for the 78 participants included in the whole study.

All 78 participants completed both the pre- and post-operative assessments. Ocular comorbidity was present in 10 of the 78 participants (4 AMD; 4 amblyopia and 2 open angle glaucoma). Post-operative complications were observed in 1 participant (1.3 %, corneal oedema). WMAR scores improved following cataract surgery in 25 out of 26 in-practice (96.2 %), 21 out of 22 HH (95.5 %) and 30 out of 30 (100 %) of CE patients. Of the two participants who showed no improvement in WMAR, it remained the same as the pre-operative level in both. Table 4.3 provides general characteristics of the subjects and pre-op baseline measurements.

Parameter	In-practice (n = 26)	HH (n = 22)	CE (n = 30)
Mean age and SD, years	73.4 ± 5.6	78.6 ± 4.7	82.7 ± 5.8
Gender, n (%)			
Female	15 (57.7)	13 (59.1)	20 (66.7)
Male	11 (42.3)	9 (40.9)	10 (33.3)
Mean logMAR distance VA and SD			
Better eye	0.20 ± 0.11	0.31 ± 0.24	0.60 ±0.40
Worse eye	0.33 ± 0.18	0.40 ± 0.23	0.89 ± 0.62
WMAR	0.23 ± 0.11	0.33 ± 0.24	0.67 ± 0.39
Cataract grade (%)			
Grade 1	26.9	22.7	6.7
2A	53.8	40.9	33.3
2B	19.3	27.3	26.7
3	0	9.1	33.3
4	0	0	0
5	0	0	0
Ocular comorbidity (%)	11.5	9.1	16.7

Table 4.3 Baseline characteristics of patients enrolled in the study. There was a significant difference in mean age between all three groups (In-practice vs HH $p = 0.004$; In-practice vs CE $p <0.001$; HH vs CE $p = 0.025$, ANOVA). Cataract grade stated is that of the worse eye. Baseline distance WMAR scores varied significantly with residential status ($P <0.001$) with CE residents having poorer WMAR than the in-practice and HH group (both $P <0.05$).

Parameter	In-practice (n = 26)	HH (n = 22)	CE (n = 30)
Distance WMAR			
Mean ± SD pre-op	0.23 ± 0.11	0.33 ± 0.24	0.67 ± 0.39
Post-op	0.02 ± 0.08	0.12 ± 0.20	0.25 ± 0.19
Median (range) pre-op	0.22 (0.07- 0.49)	0.28 (0.08-0.89)	0.64 (0.11-1.7)
Post-op	0.01 (-0.1- 0.2)	0.03 (-0.08- 0.67)	0.22 (0.00-0.65)
Near WMAR			
Mean ± SD pre-op	0.40 ± 0.11	0.56 ± 0.28	0.89 ± 0.44
Post-op	0.31 ± 0.08	0.37 ± 0.15	0.48 ± 0.19
Median (range) pre-op	0.35 (0.30- 0.65)	0.48 (0.30- 1.2)	0.80 (0.33- 1.7)
Post-op	0.30 (0.20- 0.53)	0.30 (0.30- 0.8)	0.40 (0.30- 0.86)
P value (pre vs post op)	<0.001*	<0.001*	<0.001**
VF14 score			
Mean ± SD pre-op	81.6 ± 8.5	77.3 ± 12.7	62.9 ± 20.7
Post-op	98.0 ± 2.9	95.6 ± 7.6	89.0 ± 10.2
Median (range) pre-op	84.6 (58.3- 93.8)	79.0 (50.0-96.9)	69.3 (10.0- 85.7)
Post-op	98.9 (87.5- 100.0)	97.6 (66.7- 100.0)	89.0 (55.0- 100.0)
Mean ± SD change	16.4 ± 8.2	18.3 ± 9.4	26.1 ± 14.2
Median (range) change	14.1 (5.0- 41.7)	17.2 (3.1- 42.9)	23.4 (12.5-55.0)
P value (pre vs post op)	<0.001*	<0.001*	<0.001*
VF-8R score (Logits)			
Mean ± SD pre-op	-3.50 ± 1.03	-2.77 ± 1.22	-2.55 ± 0.66
Post-op	-4.60 ± 0.22	-4.37 ± 0.55	-4.06 ± 0.58
Median (range) pre-op	-4.01 (-1.31 to -4.40)	-3.08 (-0.87 to -4.54)	-2.60 (-1.33 to -3.75)
Post-op	-4.68 (-3.61 to -4.68)	-4.54 (-2.57 to -4.68)	-4.25 (-2.66 to -4.68)
Mean ± SD change	-1.10 ± 0.98	-1.60 ± 0.98	-1.51 ± 0.48
Median (range) change	-0.60 (-0.28 to -3.09)	-1.43 (-0.14 to -3.55)	-1.52 (-0.65 to -2.42)
P value (pre vs post op)	<0.001**	<0.001**	<0.001**

Table 4.4 Collective VF-14 and VF-8R results. All groups showed a significant improvement in distance WMAR, VF-14 and VF-8R scores with surgery. * = Paired t-test; ** = Wilcoxon signed rank test correct.

Monocular surgery was performed on 6 (23.1 %) in-practice patients - 2 subjects had co-exiting morbidity in the fellow eye; 8 (36.4 %) HH patients - 1 patient had co-exiting morbidity in the fellow eye and 13 (43.3 %) CE patients - 4 of whom had co-exiting morbidity in the fellow eye. Table 4.5 shows the extent of lenticular opacity in the un-treated fellow eyes without comorbidity.

Cataract grade	In-practice (n)	HH (n)	CE (n)
1	4	5	3
2A	0	2	4
2B	0	0	1
3	0	0	1

Table 4.5 Extent of lens opacity in the untreated fellow eye with no other co-existing ocular morbidity.
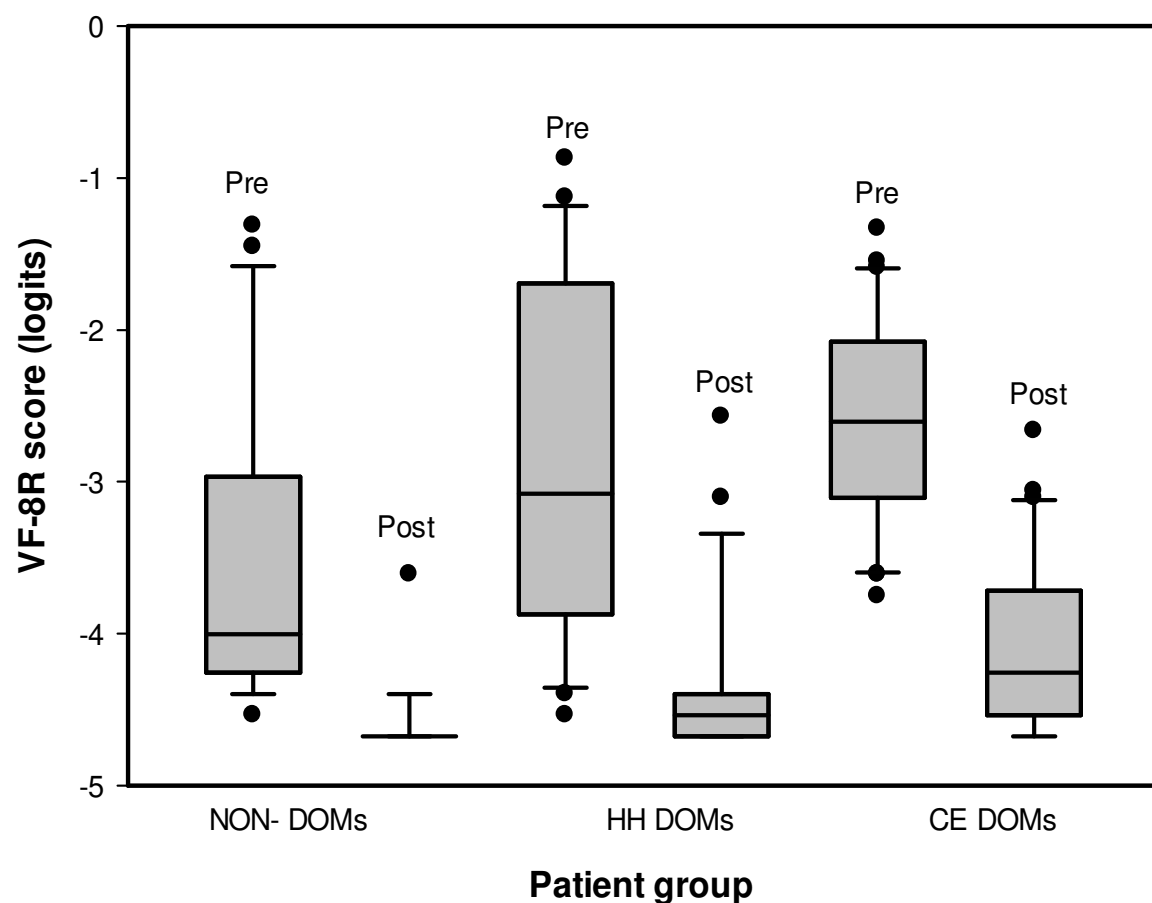
Figure 4.1 Box and whisker plot of pre- and post-operative VF-8R scores across the three patient groups. Lower, more negative scores signify improved visual function, with the best possible score being -4.67 logits. The boxes represent the interquartile range, with the line across each box indicating the median. Dot symbols represent outliers. All three patient groups saw a significant improvement in median score following cataract surgery (Wilcoxon signed rank test; all $P < 0.001$).
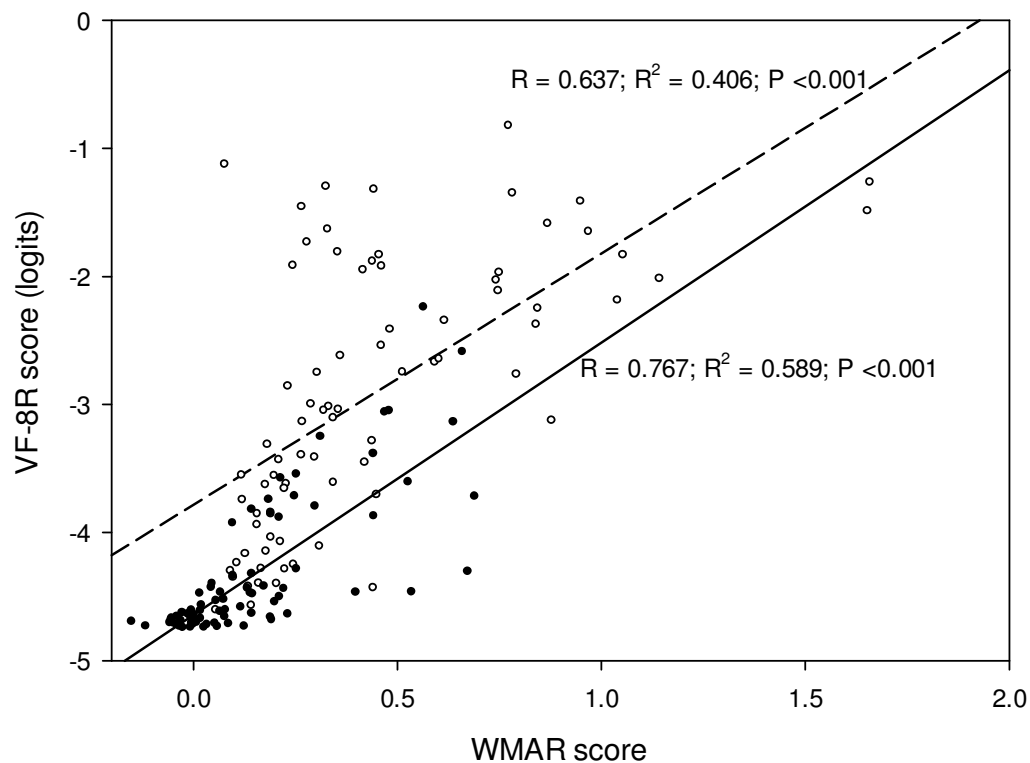
Figure 4.2 Relationship between WMAR and VF-8R scores pre-operatively (open circles and dashed regression line) and post-operatively (filled circles and solid regression line) amongst all 78 participants in the study. Data have been jittered (Cleveland, 1993) to make individual points more discernible.

The median scores for each VF-14 item were determined to demonstrate which activity was most affected pre-surgery, and the improvement following the surgery (Figures 4.3- 4.5). The items that were not performed by any patient in a group, for example driving in CE and HH residents, was not included in the illustration. Table 4.7 provides a summary of the proportion of patients per residence type that stated "n/a" with regards to a particular item on the VF-14 questionnaire. It highlights the insignificance of certain activities in specific residential type.
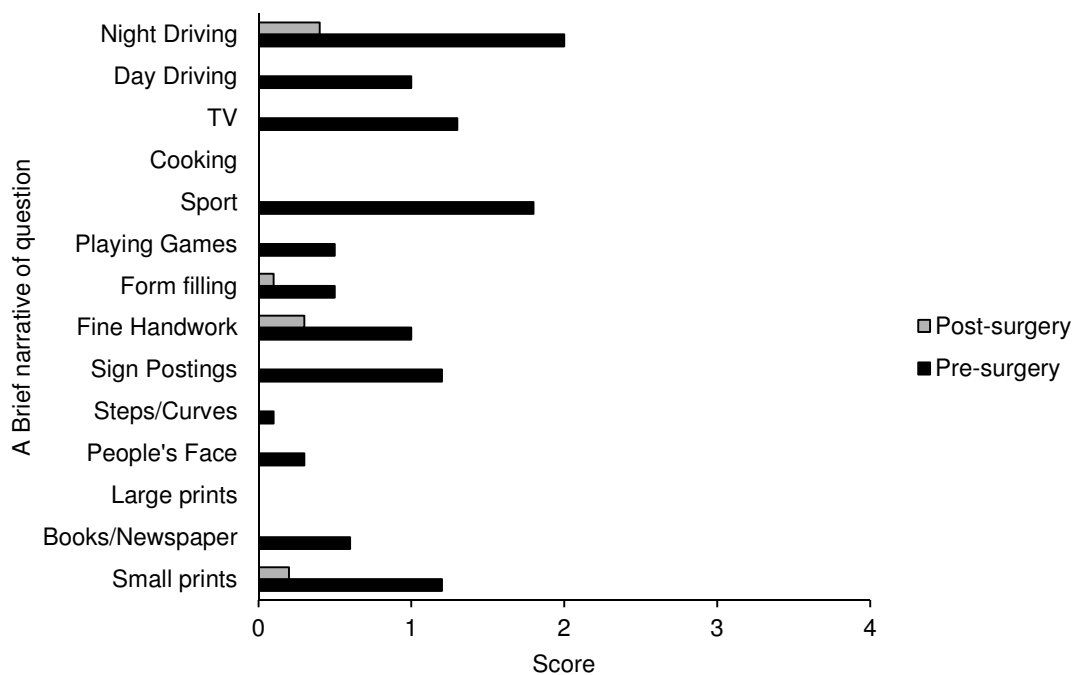
Figure 4.3 Median scores of the in-practice patients to individual VF-14 questions. 0: No difficulty; 4: Unable to-do.
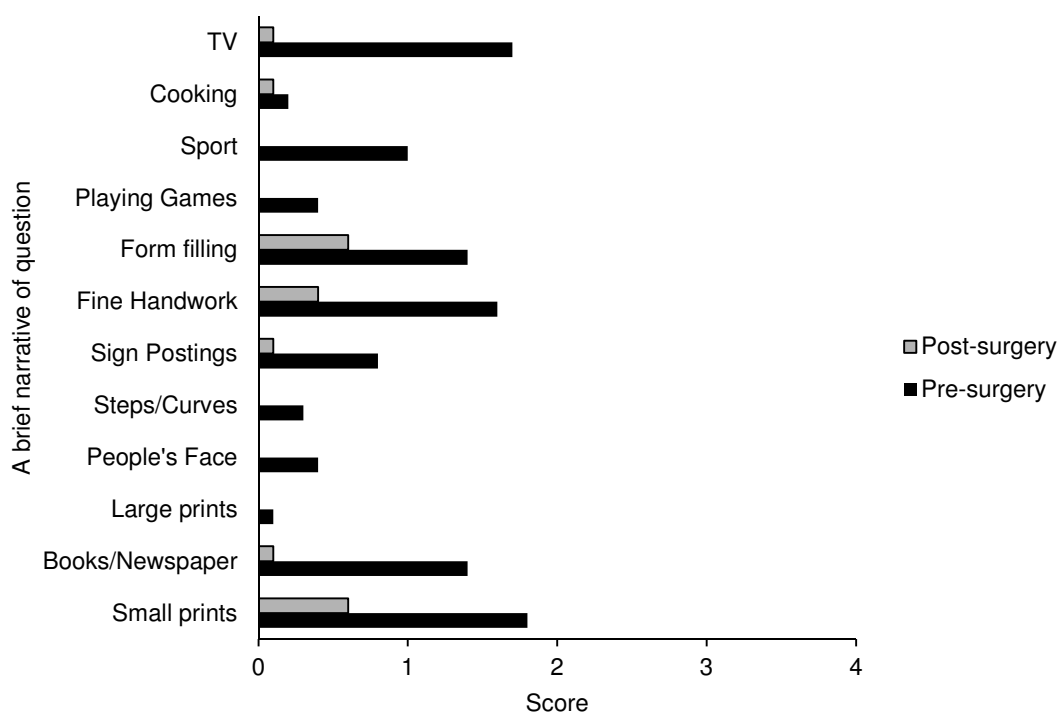
Figure 4.4 Median scores of the HH patients to individual VF-14 questions. 0: No difficulty; 4: Unable to-do.
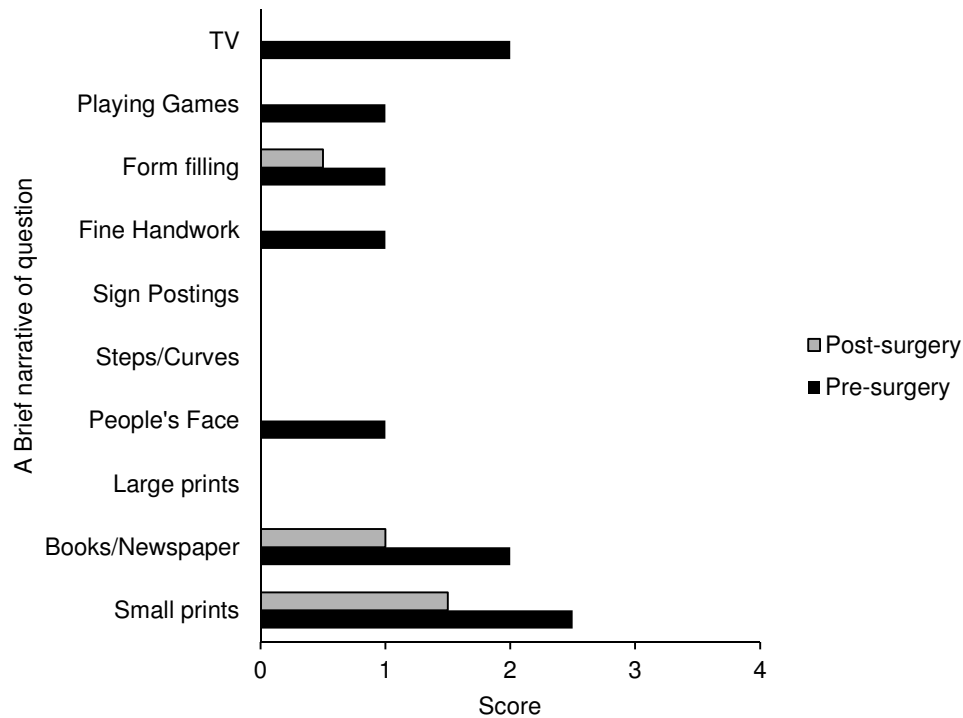
Figure 4.5 Median scores of the CE patients to individual VF-14 questions. 0: No difficulty; 4: Unable to-do.

Brief narrative of question	In-practice (%)	HH (%)	CE (%)
Small print	0	0	2 (6.7)
Book/ Newspaper	0	0	0
Large prints	0*	1 (4.5)*	2 (6.7)*
People's face	0*	0*	0*
Steps/ curves	0*	0*	1 (3.3)*
Sign postings	0	2 (9)	15 (50.0)
Fine handwork	18 (69.2)	15 (68.2)	24 (80.0)
Form filling	0	6 (27.3)	26 (86.7)
Playing games	22 (84.6)*	17 (77.3)*	20 (66.7)
Sport	18 (69.2)	21 (95.5)*	30 (100)
Cooking	3 (11.5)*	3 (13.6)*	29 (96.7)*
TV	0	0	0
Day driving	3 (11.5)	22 (100)	30 (100)
Night driving	3 (11.5)	22 (100)	30 (100)

Table 4.6 Summary of VF-14 items that were stated as "n/a" by patients of each residential type. * = ≥90 % of patients experienced no visual difficulty in performing the task.

Post-surgery improvement in VF-14 score across residential cohorts were compared using Kruskal-Wallis H test and post-hoc Dunn's pairwise comparison. The difference in VF-14 score achieved by the CE residents was significantly higher than that achieved by the practice cohort (P = 0.043). However, there was no significant difference in the level of improvement in VF-14 score achieved by the practice patients compared to the HH residents (P = 1.0) and CE residents compared to HH residents (P=0.057).

4.5 Discussion

The key aims of the present study were to determine whether housebound patients with cataract in the UK (residing in either HH or CE) experience significant gains in visual function with cataract surgery, despite their limitations in daily activities, and to compare these gains with cataract surgery patients referred from conventional practice-based settings. Although the domiciliary optometry sector is growing in the UK, with this trend seeming set to continue in coming years, very little research attention has been directed to this specific patient group, who typically have significant health and care needs in addition to increased dependency on carers and family members (Gowing and Robinson, 2015). The study provides the first data on patient-reported visual function outcomes in UK domiciliary optometry patients referred for cataract surgery.

Mean WMAR scores, which reflect the greater contribution of the better eye to the patient's visual experience, improved significantly in all three patient groups following cataract surgery. Pre-operatively and post-operatively, mean WMAR scores were highest in the in-practice group, with the CE residents demonstrating the poorest mean WMAR scores at the pre- and post- surgery assessments. The CE patients had significantly worse grades of cataract, compared to the in-practice and HH patients, which along with the greater mean age of this group (82.7 years, compared to 78.6 and 73.4 years, respectively), may explain the poorer pre-operative WMAR scores. A large-scale study investigating the causes of VI in people aged

75 years and over in Great Britain identified cataract as a major cause of visual loss in older age groups- in individuals aged 75-79 years, 23.7 % of low vision was attributed to cataract, rising to 32.3 % in the 85-89 years category (Evans *et al.*, 2004b). The overall incidence of low vision was 12.5 % amongst the 14,403 participants studied, with refractive error being the key cause of reduced vision in individuals aged 75-84 years. With a mean age of 82.7 years in the CE group in the present study, an increased incidence of more severe grades of cataract would be expected compared to the in-practice (mean age 73.4 years) and HH residents (mean age 78.6 years). Therefore, the baseline findings indicate that the housebound patients were possibly content with the deterioration in their vision caused by cataracts for a much longer period of time compared to the in-practice patients. It is likely that the housebound patients were able to maintain a satisfactory level of functional vision during the earlier stages of lens opacification, and therefore did not require a surgical intervention sooner (Asbell *et al.*, 2005b); whereas the in-practice patients who are more likely to engage in a wider spectrum of activities required an optimum level of vision, for example to meet the legal requirement for driving. Further reasons may include reluctance to recommend surgical intervention by healthcare providers or because housebound patients have not been examined for a substantial period of time.

Although significantly improved compared to baseline, mean post-operative logMAR VA in the operated eye (for monocular surgeries) or better eye (for bilateral surgery) was worse in the CE group (0.19 ± 0.14 logMAR) compared to the in-practice (0.00 ± 0.07 logMAR, $P = 0.038$) and HH groups (0.08 ± 0.16 logMAR, $P = 0.038$). However, even in the CE group, VA outcomes were in line with recent data published by the Royal College of Ophthalmologists (Day *et al.*, 2015) describing outcomes of NHS cataract surgery across the UK. Here, the median age for cataract surgery was 77.1 years, and mean post-operative VA was 0.16 ± 0.30 logMAR. Furthermore, from the fifth decade of life, VA has been shown to decrease with advancing age, even in healthy eyes, purportedly due to changes in foveal and/ or central

visual pathway structures (Elliot *et al.*, 1995, Sjöstrand *et al.*, 2011), meaning that some reduction in VA in the older, CE residents is to be expected.

The median VF-14 score was significantly worse in the CE group compared to the HH and in-practice patients before and after the surgery (P <0.001). However the CE residents experienced a significantly greater improvement in visual function post-surgery (improvement of 23.4 VF-14 points/ 1.51 VF-8R Logits) compared to the in-practice (improvement of 14.1 VF-14 points/ 1.1 VF-8R Logits) and HH (improvement of 17.2 VF-14 points/ 1.6 VF-8R Logits) patients. A VF-14 score of 100 is regarded as a perfect outcome, however, a score of ≥96.1 and/ or a gain of 11 points is considered to be a success (Pager, 2004). Previous studies that have used VF-14 questionnaire to determine the effect of cataract surgery on visual function have reported a wide range in change of scores before and after the surgery. For example, De Mendonca *et al.* (2014) reported a mean change of 47.1 points, compared to 5.1 points found by Pager (2004).

Reading small print, newspaper print and watching television were considered the most difficult visual tasks by the majority of domiciliary patients (Figure 4.4 and 4.5); whereas the majority of in-practice patients regarded driving - particularly at night, as the primary visual complaint, followed by watching television and reading (Figure 4.3). Improvements in median VF-14 score were noted for every question across all three groups; however, the CE (mean near WMAR 0.48 ± 0.19) and HH (mean near WMAR 0.37± 0.15) residents continued to experience difficulties with reading activities, particularly with small print. Post-operative patient-reported visual function could be adversely affected by the presence of ocular comorbidities for example AMD and glaucoma (Grimfors *et al.*, 2014), or it may be linked with the post-operative results not meeting pre-surgery expectations (Pager, 2004). Furthermore, reading ability is affected by the degree of illumination, which can vary profoundly between different home settings. The median level of ambient lighting in home environments may be as low as 10 % of that in general clinic settings (Dickinson, 1998).

Six (17.6 %) CE residents who had monocular surgery had substantial cataract (grade 2A or above) in the fellow eye with no other ocular comorbidity, compared to 8.3 % of HH and no in-practice patient (Table 4.5). It is possible that the acting ophthalmologist based their opinion on the overall age and general-health status of the patient when deciding against performing a bilateral surgery. Patients suffering from other ailments, for example deafness, poor mobility and cognitive deficiencies are found to be at higher risk of post-operative complications (Wong, 2001). The study of Gollogly *et al.* (2013) investigated the age of people undergoing cataract surgery in the USA; 21.8 % were aged 60- 69 years, 39.1 % were aged 70- 79 years and 25.1 % were aged 80- 89 years. Therefore, indicating that upon approaching the oldest-old age category people are less likely to seek surgical intervention as a vision correcting method. Undergoing cataract surgery can be emotionally and physically stressful experience for older people, however, it may be instrumental in restoring functional vision and improving VRQOL. Zuo *et al.* (2015) compared VRQOL in older Chinese adults following either monocular or binocular cataract surgery. Patients of both groups reported similar levels of improvement in VRQOL. Harwood *et al.* (2005) found monocular cataract surgery was effective in reducing the rate of falls and fall-related injuries by 34 % in older adults. Therefore, older adults with advanced binocular cataracts should consider monocular surgery as a minimum attempt to restore vision. A potential problem with the capacity to consent was identified in the ProVIDe study (Hancock *et al.*, 2015), where the individual would prefer to have the surgery, yet the immediate family would be reluctant to proceed citing physical and emotional demand placed on the individual. This indicates the need of providing accurate information to potential patient and family members explaining the benefits of cataract surgery. Better patient education may lead to a greater uptake of cataract surgery by housebound people, which will reduce cataract related VI. The questionnaire survey in Chapter 2 found that the domiciliary patients spend the majority of their leisure time watching television and reading. A good angular resolution (minimum of 0.3- 0.4 logMAR) and contrast sensitivity is necessary for comfortable television viewing (Bergman and Sjöstrand, 1992). Furthermore, if VA drops below 0.4 logMAR, then contrast sensitivity, glare sensitivity and visual field defects

play a greater role in determining the visual function (Mönestam and Wachtmeister, 1997). Near visual ability typically refers to reading fluency and reading speed, which is dependent on acuity reserve, contrast reserve and field of view. Acuity reserve of 3:1 is required for high fluent reading (160 words per minute), therefore to be able to read standard newspaper print (0.4 logMAR at 40 cm) an acuity reserve of 0.2 logMAR is required (Jackson and Wolffsohn, 2007). Lenticular opacification is known to diminish VA and contrast sensitivity (Rouhiainen *et al.*, 1996), therefore further emphasising the advantages of having cataract surgery.

It is evident from the outcome of the study that the VF-14 instrument is not fully suitable for domiciliary eye care recipients. There are many items on the instrument that are not applicable for housebound settings, for example driving or playing sports. Furthermore, inappropriate questions may have also led to confusion in some cases; for example "sign postings" can be interpreted by some patients as road signs, whereas others may understand it as signs that are usually displayed in CEs to direct residents towards certain areas of the building, for example the dining room. As a result 50 % of CE residents have stated "n/a" while the remaining 50 % have acknowledged it as an item of interest. There were certain items, for example cooking, that were found to be important to HH residents, but not applicable in CE environment. Therefore, future studies would benefit from PRO instruments that are specifically designed for HH and CE residents; each instrument consisting of items that are relevant to the individual environment. However, any new instrument would require validation and approval before it can be implemented in a large scale study. Removal of certain items from the VF-14 questionnaire that were either only relevant to ≤10 % of the participants or ≥90 % of subjects had no difficulty in performing the task (Table 4.6) would avoid the ceiling effect (Friedman *et al.*, 2002, Gothwal *et al.*, 2010c), in which almost all participants are at the top of the scale and therefore surgery would make no further improvement. The ceiling effect was particularly evident in the in-practice group, which resulted in the vast majority of patients achieving a post-operative score close to 100.

The current study analysed the immediate improvement in visual function following the surgery; it would be beneficial to determine if the gains in visual function can be sustained over a period of time, which would allow the evaluation of long-term advantages/ disadvantages of undergoing a surgery in housebound patients. Previous longitudinal study of patients who underwent cataract surgery, found insignificant deterioration in CDVA (median decline of 0.06 logMAR units) after 10 years post-surgery and 77 % of the patients reported a decline of 10 points or less on the VF-14 score over the same period (Mönestam and Lundqvist, 2012). Even though the study cohort was not based on housebound patients, it does demonstrate the encouraging long-term prognosis of cataract surgery.

4.6 Conclusion

The efficacy of cataract surgery in improving functional vision in older people has been well documented in the past. The present study has established that cataract surgery is effective in improving and restoring functional vision in older housebound people. VI primarily caused by significant untreated cataract was mostly prevalent in the CE population. Prior to the findings of the present study, it could have been hypothesised that domiciliary eye care recipients would not benefit from having cataract surgery due to coexisting physical and mental disabilities. However, the results clearly indicate that housebound patients experienced a greater improvement in functional vision compared to in-practice patients. Given the outcome of the study, it would be advisable for optometrists to refer housebound people diagnosed cataract to the HES for possible surgery, providing it is in the best interest of the patient and there is a realistic possibility of improving visual function.

Chapter 5. General Discussion

Given the ageing UK population, the number of elderly housebound people is likely to increase further in the coming years. To date, there has been a lack of scientific publications relating to domiciliary eye care, therefore the aim of the thesis was to investigate and report on various vision-related aspects of domiciliary eye care patients. The experimental chapters of this study were set out to answer the following questions:

- What are the visual experiences and demands of domiciliary eye care recipients?

- What are the clinical characteristics of domiciliary eye care recipients compared to conventional practice based GOS recipients?

- Does self-reported visual function improve similarly following cataract surgery in housebound and in-practice patients?

Housebound participants were divided into two categories according to their type of residence (CE/ HH), and compared to conventional in-practice patients, where appropriate. It was important to analyse the two different types of housebound people individually, particularly since people residing in CEs are likely to have visual demands catered to their restricted environment as opposed to those living in their own homes who have greater degree of freedom and control over their surroundings. Furthermore, CE residents are more likely to have greater health-care needs (Office for National Statistics, 2013), which may be linked with the manifestations of the various types and extent of ocular pathologies, resulting in differing clinical outcomes compared to the HH residents. In addition, residence status may have an impact on the way the domiciliary eye care service is delivered.

The results of the first experimental study (Chapter 2), revealed many interesting findings regarding domiciliary eye care recipients. Contrary to the possible expectation that housebound people with disabilities and VI (Wolffsohn *et al.*, 2000) may not wish to (or be

able to) participate in a research survey, a substantial percentage (50.7 %) of the survey respondents completed the questionnaire, meaning a larger-scale survey involving the housebound population in the future is viable. Estimates suggest that there are a far greater number of housebound people (Domiciliary Eyecare Committee, 2007) compared to the number of domiciliary eye examinations completed per annum (Health and Social Care Information Centre, 2015). Therefore a substantial proportion of housebound people are not having regular eye examinations currently. For a large majority of the HH respondents, professional intervention was necessary for the initial contact to be made between the patient and the domiciliary eye care service provider, either in the form of being contacted by the former optical practice where the patient was registered to (39.7 %) or the patient was referred by the community nurse (30.9 %). As such, unawareness of the service appears to be a major reason for the under access/ uptake of the service. Domiciliary eye care is a specialist service within the optometric profession. However, it is now widely available since national optical chains are providing the service. Therefore, inability to access the facility can no longer be assumed as a reason for the low uptake. Maintaining an adequate level of vision is important in preserving independence and reducing the risk of trips and falls, a huge financial burden on the NHS (Black and Wood, 2005). Increasing awareness of the service availability is vital to ensure all eligible patients are regularly receiving an eye examination and thereby reducing the number of people suffering from correctable VI. Perhaps promoting the availability of domiciliary vision-care through other primary health-care services may lead to an increased uptake. For example, through registered GP surgeries or pharmacies who offer prescription home delivery service for the housebound people. Some of the larger optical companies are attempting to raise the awareness by investing in marketing the availability of GOS funded domiciliary eye care services through the use of direct mail and multimedia.

The survey provided information on the type of leisure activities that the housebound people receiving domiciliary eye care engage in. One of the primary objectives of a sight-test should be to ensure visual difficulties with those specific tasks are minimised. Therefore, a domiciliary

sight test may benefit from a task orientated eye examination, instead of the sole use of the traditional reading of optotypes on a VA chart. Future larger-scale surveys could be improved by including a wider variety of leisure activities and ADL. The present questionnaire employed a prescribed set of activities for the respondent to choose from. As a result, the survey may have overlooked certain activities that are important to the housebound people, for example DIY activities, gardening or playing musical instruments. A substantial proportion of the respondents (41.8 %) reported being visually dissatisfied at various working distances, and a further 26.1 % indicated experiencing dry-eye associated ocular discomfort. Although poor vision was not cited as the reason for the participants becoming housebound, up to 74.3 % of respondents suggested that the provision of perfect vision would make a positive difference to their lives, indicating the significance of vision in the overall QOL status. It will be prudent for future research to determine the proportion of complaints resolved by optometric intervention, typically via the provision of updated spectacles and prescribing of ocular lubricants. Previous research indicates that up-to a quarter of the VI in people aged 75 years and over is due to uncorrected refractive error (Evans *et al.*, 2004a) and the impact of dry eye on QOL has been rated similar to moderate angina (Schiffman *et al.*, 2003). Therefore domiciliary eye care professionals may play a pivotal role in improving VRQOL in the housebound population. Furthermore, currently, domiciliary low-vision services are not widely available, despite the considerable visual benefits they offer to visually impaired patients (Lamoureux *et al.*, 2007). However optometrists are in a prime position to incorporate the provision of LVAs and offer advice on lighting and/ other vision enhancing methods to potential patients.

The retrospective analysis of sight-test records (Chapter 3) revealed that the prevalence of AMD and cataracts were higher in the domiciliary eye care recipients (particularly in the CE residents) compared to the in-practice patients. Guidance provided by the optometrists, for example dietary recommendations and advice to stop smoking, may help preserve useful vision for longer (Seddon *et al.*, 2006), especially where alternative treatment is not viable. Moreover, despite the limited activities undertaken by the housebound patients, the findings

of Chapter 4 showed a strong evidence of domiciliary patients experiencing a substantial gain in their self-reported visual function following cataract surgery. Cataract operations are the most frequently performed NHS surgery and the phacoemulsification technique is regarded as a safe surgical method with a proven record of restoring functional vision (Royal College of Ophthalmologists, 2010). In cases where cataract surgery appears to be in the best interests of the patient, then the surgical option should be discussed with the patient and patient's family/ carer where appropriate.

Given that the entire body of the data collection was undertaken in the metropolitan county of Merseyside in the North-West of England, the outcome of the study may not be applicable to the whole of the nation. People from poorer socio-economic backgrounds, as measured by indicators including income, level of academia and occupation, are associated with higher degrees of general health ailments, VI and shorter life expectancy (Guralnik *et al.*, 1993, Livingston *et al.*, 1997). Such factors may influence patients' motivations and goals. To establish the true demographics of the housebound domiciliary eye care recipients, a large-scale population-based study would be required. However this would require substantial funding to support it and cooperation of multiple researchers across the nation. A limitation relating to the cataract study is that a number of VF-14 questions (for example driving/ playing sports) were irrelevant to housebound patients. Future research in this field could look at developing a specific questionnaire uniquely designed to assess cataract surgery outcome in housebound people. However, any such PRO instrument would require thorough testing and validation prior to research use. It will also be prudent for future research to investigate the prolonged effect of cataract surgery in the housebound patients, and examine if the initial substantial gains in visual function are sustained over a period of one to two years. This is of interest because there is evidence to suggest that the removal of the crystalline lens leads to development/ acceleration of AMD (Wang *et al.*, 2003). The present study included patients with mild/ moderate CI. In future, the body of research can be expanded to objectively investigate the visual requirements, ocular clinical parameters and prevalence of ocular

diseases in housebound patients who are diagnosed with advanced dementia. This research would provide valuable data, as it is estimated that the prevalence of dementia related disorders will increase with the ageing population (Alzheimer's Society, 2015).

5.1 Conclusion

The outcome of the research presented in this thesis provides domiciliary eye care professionals with background knowledge of the housebound population, along with their visual requirements and clinical presentations. The research highlights the shortcomings of the provision/ uptake of the service by prospective clients and the potentially significant level of VI that exists within the housebound community. The recommendations made within the thesis aim to help optometrists better serve domiciliary eye care recipients. The key findings of the thesis were:

- Domiciliary eye care recipients have leisure interests that are similar to the general population of similar age; watching television and reading were the most frequently performed activities.

- The majority of domiciliary eye care recipients considered that provision of perfect vision would have a positive impact on their QOL. However, poor vision was not responsible for their housebound status.

- A significant proportion of the survey respondents (Chapter 1) reported dry eye symptoms (11.8 %); the review of clinical records (Chapter 2) showed 8 % of domiciliary patients were advised on eye lid care and use of ocular lubricants. Therefore, dry-eye syndrome affects a significant proportion of housebound patients which possibly remains underdiagnosed.

- There was a greater prevalence of age-related ocular pathologies (AMD and cataracts) in the housebound patients, particularly among CE residents, resulting in a higher rate of VI.

- Despite their limited involvement in activities due to their housebound status, domiciliary eye care recipients experienced substantial gains in their self-reported visual function following cataract surgery. Therefore, housebound individuals diagnosed with cataract will benefit from a referral to ophthalmological care at the earliest opportunity to discuss the possibility of a surgery, provided it is in the best interest of the patient.

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Memo

Life and Health Sciences Research Ethics Committee's Decision Letter

To :	Dr Amy Sheppard
Cc:	Rachel Giles, administrator to the Life and Health Sciences Research Ethics Committee
From:	Dr Robert Morse
	Chair of the Life and Health Sciences Research Ethics Committee
Date:	26/3/2013
Subject:	Clinical characteristics of domiciliary eye examination patients and vision related quality of life post cataract surgery in the United Kingdom

Thank you for the additional information in your email of March 12th. The additional information for the above proposal has been considered by the Chair of the LHS Research Ethics Committee. Please see below for details of the decision and the approved documents:

Reviewer's recommendation: Approved.
Please see the tabled list below of approved documents:

Documentation	Version/s	Date	Approved
Risk Assessment	N/A		
Questionnaires	#444 Questionnaire V2	15/03/2013	√
	Vf-14-qol-questionnaire	19/02/2013	
Other (please detail)	#444 Cover letter V2	15/03/2013	√

After starting your research please notify the LHS Research Ethics Committee of any of the following:

Substantial amendments. Any amendment should be sent as a Word document, with the amendment highlighted. The amendment request must be accompanied by all amended documents, e.g. protocols, participant information sheets, consent forms etc. Please include a version number and amended date to the file name of any amended documentation (e.g. "Ethics Application #100 Protocol v2 amended 17/02/12.doc").

New Investigators

The end of the study

Please email all notifications and reports to lhs_ethics@aston.ac.uk and quote the original project reference number with all correspondence.

Ethics documents can be downloaded from: http://www.ethics.aston.ac.uk/documents-all. Please note that these documents can ONLY be opened using Mozilla Firefox or the latest Internet Explorer version (IE9).

Statement of Compliance

The Committee is constituted in accordance with the Government Arrangements for Research Ethics
Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK. In accord with University Regulation REG/11/203(2), this application was considered to have low potential risk and was reviewed by three appropriately qualified members, including the Chair of the Life and Health Sciences Research Ethics Committee. Yours sincerely

Dr Robert Morse
Chair of the LHS Research Ethics Committee

Appendix 2

School of Life and Health Sciences
Aston University
Birmingham, B4 7ET
United Kingdom

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web: www.aston.ac.uk
email: A.Sheppard@aston.ac.uk

Dear Patient,

In the Optometry Department at Aston University, Birmingham, we are carrying out some research investigating the clinical characteristics and visual needs of patients receiving home eye care services. It is hoped that the information collected as part of the study will inform developments and improvements in domiciliary eye care in the United Kingdom.

Attached is a questionnaire, which we would be very grateful if you could complete. You have been asked to complete the questionnaire as you are having a home eye test. Completion of the questionnaire is totally voluntary, and will not affect the eye care service you receive in any way. The questionnaire does not contain any information which could be used to identify you, and is completely confidential.

The completed questionnaire can be posted back to the researcher Mr Khaled Rashid in the provided envelope, or handed back at a spectacle collection visit. If you would like any further information, please speak to the person who gave you this questionnaire.

Many thanks

Dr Amy Sheppard
Lecturer in Optometry
Principal Investigator

Visual needs and experiences of domiciliary eye care patients

If you wish, you may use the help of friend or family member to read out the questions or in filling out the form.

Is this your first home eye test?

☐ Yes
☐ No

How did you find out about the home eye test service?

☐ Word of mouth
☐ Internet
☐ From being previous in-practice patient
☐ Community nurse
☐ Other. Please state

…………………………………………………………………..

Do you undertake any of the activities listed below? If yes, indicate how any hours per day (approximately).

Activity day	Yes/No	Hours per
Watching television	-----------	----------------
Reading books	-----------	----------------
Reading newspapers	-----------	----------------
Sewing/ knitting	-----------	----------------
Cooking	-----------	----------------
Computer/Internet	-----------	----------------

Do you have any vision problems currently? Yes ☐ No ☐

 If "Yes," with which activity?

…………………………………………………………………………………………………

Do you use any of the following visual aids? Please tick all that apply
☐ Distance glasses
☐ Reading glasses
☐ Bifocal glasses
☐ Varifocal glasses
☐ Magnifiers

How often do you worry about your eyesight or vision?

☐ Never
☐ Rarely
☐ Occasionally
☐ Sometimes
☐ All of the time

How often do you notice or think about your eyesight or vision?

☐ Never
☐ Rarely
☐ Occasionally
☐ Sometimes
☐ All of the time

How often do you experience pain or discomfort in and around your eyes (for
example, burning, itching, or aching)?

- ☐ Never
- ☐ Rarely
- ☐ Occasionally
- ☐ Sometimes
- ☐ All of the time

How much does dryness in your eyes bother you?

- ☐ Don't have dryness
- ☐ Not at all
- ☐ Very little
- ☐ Moderately
- ☐ Quite a bit
- ☐ A lot

If you had perfect vision without glasses, contact lenses, or any
other type of vision correction, how different would your life be?

- ☐ No difference
- ☐ Small difference for the better
- ☐ Large difference for the better
- ☐ I have this already

The final question is about how you deal with your vision. For each statement, please circle the number to indicate whether for you it is <u>definitely true</u>; <u>mostly true</u>; <u>mostly false</u>; <u>definitely false</u> for you or you are <u>not sure</u>.

	Definitely true	Mostly true	Not sure	Mostly false	Definitely false
I am often irritable because of my eyesight	1	2	3	4	5
I don't go out of my home alone because of my eyesight	1	2	3	4	5

Many thanks for taking the time to complete this questionnaire. Please return your completed questionnaire in the envelope provided, or hand it to the optometrist who gave this to you.