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Review Article

Correctable visual impairment in older people: a major unmet need

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Abstract

This review seeks to determine the prevalence of correctable visual impairment (VI) in older people in the UK, to discover what proportion of these cases are undetected, to suggest reasons for the poor detection and to make recommendations for improving the detection. To establish the context of these issues, the review will also touch on the general prevalence and causes of VI in older people in developed countries and on the impact of VI in older people. Typically, studies suggest that VI affects about 10% of people aged 65–75, and 20% of those aged 75 or older. There is a strong relationship between impaired vision in older people and both reduced quality of life and increased risk of accidents, particularly falls. The literature suggests that those with low vision are about two times more likely to have falls than fully sighted people, and the annual UK cost of treating falls directly attributable to VI is £128 million. The literature on the prevalence of undetected reduced vision in older people reveals that between 20 and 50% of older people have undetected reduced vision. The majority of these people have correctable visual problems (refractive errors or cataract). It is particularly startling that, in 'developed countries', between 7 and 34% of older people have VI that could simply be cured by appropriate spectacles. The reasons why so many cases of treatable VI remain untreated are discussed, and suggestions are made for improving the detection of these cases. We conclude that there should be better publicity encouraging older people to attend for regular optometric eye examinations. A complementary approach is annual visual screening of the elderly, possibly as part of GPs annual health check on people aged 75 years and older. Recommendations are made for evaluating new approaches to screening and for improving the management of cases detected by screening.

Keywords: cataract, correctable visual impairment, low vision, older people, refractive error

Objectives and methodology of review

The focus of this review is to answer the following primary questions: 'What is the prevalence of correctable visual impairment (VI) in older people in the UK?' and 'What proportion of these cases are undetected?' (*Table 1*). Although the review concentrates on UK studies, some particularly pertinent studies from other developed countries have been included.

In addition, we sought information on some secondary questions. To provide context for the primary questions, major population-based epidemiological studies evaluating the prevalence of VI in developed countries are reviewed to answer the secondary questions 'What is the prevalence and what are the main causes of VI in developed countries'. These studies also allowed a comment on the effect of age on VI. To determine the impact of VI, the secondary question 'What are the major consequences of VI in older people?' is also investigated, concentrating on quality of life, depression, and falls.

Two further secondary questions, 'Why are cases of treatable VI in older people so prevalent?' and 'How

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Table 1. Objectives (key questions) and methodology of review

Question	Rationale/detail	Initial search and keywords
Primary questions		
What is the prevalence of correctable VI in older people in the UK?	Correctable is taken to mean refractive errors and cataracts. Particularly pertinent studies from other developed countries are included	PubMed for: (low vision OR visual impairment) AND prevalence AND UK.
What proportion of these cases are undetected?	Relevant data are extracted from the studies identified in the search described above	
Secondary questions		
What are the prevalence and main causes of VI in older people in developed countries?	To establish the context of the answer to the primary question	Epidemiological studies with $N > 200$ selected from citations in UK surveys and reviews identified from above search
What are the major consequences of VI in older people?	To establish the significance of the answer to the primary question, concentrating on quality of life, depression, and falls. Controlled studies (see text)	PubMed for: (low vision OR visual impairment) AND (quality of life OR falls OR depression) AND control

might the detection of treatable VI in older people be improved?' are mainly conjectural with relatively little available research to review. These issues are considered in the discussion.

This review is confined to publications in English and the initial search method and keywords are summarised in *Table 1*. After applying the search criteria, publications that were obviously inappropriate to the review (e.g. of children) were excluded by viewing the abstract. For the remaining publications, the full manuscript was studied and other relevant publications were identified from the bibliographies. The review concentrates on papers in refereed journals, but any relevant manuscripts that were discovered from other sources have also been included.

For the secondary question, 'What are the major consequences of VI in older people?', an initial literature search (using [low vision OR visual impairment] AND [quality of life OR falls OR depression]) revealed over 500 publications, several of which were expert opinion or anecdotal comments. The additional term 'control' was therefore added to refine this search by concentrating on case–control studies or cohort or cross-sectional studies which controlled for confounding variables. This secondary question is based on an assumption that the major consequences of VI in older people are quality of life, falls, and depression. Many of the papers under review commented on general consequences of VI in older people, and these comments confirmed that this assumption is appropriate.

Introduction: prevalence and main causes of visual impairment and the effect of age

The definitions of low vision, visual impairment, and blindness are discussed by Dickinson (1998). This author also reviewed the incidence, causes, and treatment of low vision and the measurement of visual performance.

Several major studies have investigated the prevalence of visual problems in older people, and three commonly cited early studies are summarised in *Table 2*. These studies have tended to primarily investigate the four eye diseases considered to be the major causes of adult

Table 2. Summary of some early landmark epidemiological studies on visual impairment

Parameter/study	Kahn *et al.* (1977)	Martinez *et al.* (1982)	Gibson *et al.* (1985)
Location	Framingham, USA	Gisborne, NZ	Melton Mowbray, UK
Participants	2477, aged 52–85	481, aged 65+	484, aged 76+
Response rate (%)	84	86	71.5
Cataract (%)	15.5	30.1	46.1
AMD (%)	8.8	6.4	41.5
Glaucoma (%)	3.3	3.6	6.6
Diabetic retinopathy (%)	3.1	0.5	0.4
Best corrected VA 6/9+	92%[a] aged 65–74 69%[a] aged 75–85	81% ♂, 68.8% ♀	

[a]Acuities in the Framingham study were not the presenting acuities but were best corrected (after refraction if pinhole test suggested that presenting acuities could be improved).

blindness in the USA, but the Framingham study actually found that more than one-third of blindness occurred in eyes not known to be affected by these four diseases (Leibowitz *et al*., 1980).

Martinez *et al*. (1982) noted that their study differed from the Framingham study in the diagnosis of the conditions studied and that Martinez *et al*. (1982) tested under optimal lighting conditions and with optimal refractive correction. Therefore, the data of Martinez *et al*. (1982) is likely to represent an over-estimate of visual function in everyday life. Differences between the results obtained by Martinez *et al*. (1982) and Gibson *et al*. (1985) can be at least in part accounted for by the different ages of the populations. For example, the prevalence of glaucoma increases with age (although this effect was only apparent in women in the Martinez *et al*. study).

The Framingham eye study (Kahn *et al*., 1977; Leibowitz *et al*., 1980), although often cited, has been criticised for involving mainly white middle class Americans (Wormald *et al*., 1992). The effect of race was highlighted by Tielsch *et al*. (1990) in the Baltimore Eye Survey. This involved 5300 people; 2395 of African descent and 2913 Caucasians. Those of African descent had, on average, a twofold greater prevalence of blindness and VI than Caucasians. This effect of race was more marked in the younger participants.

Klein *et al*. (1991) reported on the Beaver Dam Eye Study. Visual acuity was measured after refraction, using standardized protocols, on 4926 people between the ages of 43 and 86 years. Rates of any VI (6/12 or worse in the better eye) or legal blindness (6/60 or worse in the better eye), increased from 0.8 and 0.1%, respectively, in people between the ages of 43 and 54 years, to 21.1 and 2.0%, respectively, in people aged 75 or older. Multivariate analyses showed both gender (women) and age (older) to be significant and independent predictors of poorer visual acuity.

Wormald *et al*. (1992) examined 207 subjects sampled at random from the database of people aged 65 years and over at an inner London health centre. Binocular Snellen acuity was assessed with any spectacles that were usually worn and central visual fields were tested. The prevalence of blindness was 1% by the WHO criteria and 3.9% by the American criteria. The prevalence of low vision (WHO criteria; worse than 6/18) was 7.7%. The prevalence of VI (American criteria; worse than 6/12) was 10.6%. Cataract accounted for 75% of cases of low vision and it was argued that 27% of participants would probably have benefited from refraction (see below).

Van der Pols *et al*. (2000) measured visual acuity in 1362 randomly selected people aged 65 and over who were not mentally impaired. VI (WHO criteria) was present in 14.3%.

Massof (2002) reviewed studies on the prevalence rates of low vision and blindness in the US to evaluate the sources of disagreement among studies. The main sources of disagreement were found to be the differing criteria for low vision and blindness and the different age ranges of the study populations. The authors also noted that although in the age group 40–60 years low vision and blindness are more common in people of African descent, this race difference may be reversed in older age-groups. This conclusion is supported by data from Tielsch *et al*. (1990).

In a large-scale MRC study, Evans *et al*. (2002) investigated the prevalence of VI in people aged 75 years and older in Britain. Acuities were measured with Glasgow acuity cards, using any spectacles that were habitually worn. The sample was obtained from 53 practices in the MRC general practice framework, and out of 21 241 people who were invited to participate, visual acuity measurements were available for 14 600 (69%). Of these, 12% had a binocular visual acuity worse than 6/18 (WHO criterion), of whom 10% had a binocular visual acuity between 6/18 and 3/60 (low vision) and 2% worse than 3/60 (blind). Even when age was controlled for, women had worse acuity than men. Overall, 19.9% of study participants had a binocular VA worse than 6/12 (the American definition of VI). The risk of VI increased markedly with age: for example, at ages 75–79 years, 5.6% had low vision; compared with 30.0% at ages of 90 years or older. Using mid-2001 population estimates for the UK, the authors estimated that approximately 506 000 people are living in the community with low vision in the UK. The authors noted that their estimates of the prevalence of VI in older people are likely to be an underestimate. In particular, they did not measure visual fields and excluded patients in nursing homes. Taylor *et al*. (1997) found that three times more people have VI because of visual field loss than visual acuity loss and Klein *et al*. (1991) showed that people who are resident in nursing homes are 3.3 times more likely to have VI than those not residing in a nursing home.

Although undoubtedly a very impressive study, one limitation of Evans *et al*.'s (2002) data is that the study population were selected through GPs practices. There may be a subpopulation of older people with visual disability who are not active participants in health care services and have accepted low vision as an inevitable consequence of ageing and thus not sought optometric or ophthalmological services. In addition, some may be deterred from seeking health care through social or economic factors (discussed below).

The Blue Mountains Eye Study evaluated the change in visual acuity and incidence of VI in a population-based cohort, aged 49 years or older, near Sydney in Australia (Foran *et al*., 2003). Of 3654 initial

participants, 2335 (64%) were available for re-examination after 5 years. VI was defined as visual acuity worse than 6/12 and severe VI as visual acuity worse than 6/60. Monocular VI developed in 7.1% and binocular VI in 1.9%. The figures for the incidence of severe VI were 2.1 and 0.1% for monocular and binocular respectively.

It is difficult to pool the data from different studies because of methodological differences. However, the studies reviewed here suggest that VI typically affects about 10% of people aged 65–75, and about 20% of those aged 75 or older. Most (Leibowitz *et al*., 1980; Martinez *et al*., 1982; Klein *et al*., 1991; Jack *et al*., 1995; Taylor *et al*., 1997; Sinclair *et al*., 2000; Van der Pols *et al*., 2000; Evans *et al*., 2002), but not all (Tielsch *et al*., 1990) studies have found worse vision in women than men.

The effects of visual impairment in older people

Quality of life and activities of daily living. Research on the impact of visual impairment in older people on quality of life and on activities of daily living is summarised in *Table 3*. These studies provide experimental evidence to support the intuitive notion that clinical vision impairment measures are highly correlated with the capacity to perform activities associated with everyday life. Furthermore, VI is strongly associated with impaired quality of life.

Depression. A condition that can adversely influence the quality of life is depression and this frequently accompanies low vision in older people (Rovner and Shmuely-Dulitzki, 1997; Shmuely-Dulitzki and Rovner, 1997; Brody *et al*., 2001; Warnecke, 2003). The depression can be particularly acute when a non-visual disability is also present (Rovner *et al*., 1996, 2002), including hearing loss (Heine and Browning, 2002). In older men the co-existence of vision and hearing impairments is associated with a significant increase in mortality (Appollonio *et al*., 1995). Griffith and Ryan (2000) cautioned that depressive symptoms in older people may be misattributed to the process of ageing and not treated, whereas evidence suggests that depression is a function of disability and not age *per se*.

Depression should not be taken for granted as an inevitable consequence of low vision in older people. Donohue *et al*. (1995) described a social skills training programme for the treatment of depressed, visually impaired, older adults. Furthermore, depression diminishes when visual acuity is improved, for example following cataract surgery (Fagerstrom, 1994).

Depression is not the only mental health issue in older people with visual problems. Livingston *et al*. (2001) found that the prevalence of psychotic illness in people aged 65 and over was at least 5.6%, and persecutory symptoms and perceptual disturbance were 2.8 times more likely to be present if the person was visually impaired.

Surprisingly, McGwin *et al*. (2003) found that cataract surgery did not seem to have a significant effect on reducing depressive symptoms in older people. There is a need for more research on the effect of visual interventions on depression in older people with correctable VI.

Falls and other accidents. The National Service Framework for Older People recognises the burden caused by falls on patients, their carers, and the NHS. Every year, over 400 000 older people in England attend Accident and Emergency (A & E) Departments following an accident. Reduction in the number and severity of falls is an NHS target (Department of Health, 2001).

Several researchers have attempted to investigate the factors, both visual and other, which are associated with an increased likelihood of falls in older people. A difficulty with this type of research design is that falls are multi-factorial (Boulgarides *et al*., 2003): there are so many factors that may be associated with falls that the outcome of research studies inevitably will be limited by the variables that are studied. Research on this subject, summarised in *Table 4*, reveals that VI in older people significantly increases the risk of falls, typically by a factor of about two. A limitation of much of the research in this field is a tendency to only consider visual acuity. Some studies suggest that other measures of visual function should also be assessed (e.g. depth perception, contrast sensitivity, visual fields, and possibly glare recovery) (see below).

Undetected correctable visual impairment in older people. So far, this review has established that low vision is very prevalent in older people and that this causes a significant worsening of quality of life and is associated with an increased risk of falls. In view of this, it is important to know whether there is a very large group of older people with low vision who are not receiving the care that they need.

Before reviewing the literature on this topic (which is summarised in *Table 5*), two methodological issues will be briefly discussed: the use of the pinhole test, and participant selection. Several studies have measured visual acuity with and without a pinhole, arguing that if the vision improves significantly with a pinhole then the patient would be likely to benefit from a refraction. However, this assumption is unsafe because the pinhole test is prone to errors from imprecise positioning, non-uniform cataracts (Rabbetts, 2000, p. 45), and luminance effects (Eagan *et al*., 1999). Eagan *et al*. (1999) found that pinhole test results were enormously variable, underestimating and overestimating

Table 3. Summary of some studies on the impact of visual impairment (VI) on quality of life (QoL) and activities of daily living (ADL). VA, visual acuity; CS, contrast sensitivity; ages are in years

Authors	Study design/goals/methods	Participants	Results/conclusions/comment
Mangione *et al.* (1992)	Developed Activities of Daily Vision Scale (ADVS) to evaluate visual function in people with cataracts	100 patients aged ≥65 awaiting cataract surgery	ADVS provides information on visual disability that is not captured by routine visual testing. But, the only visual parameter assessed by the authors was VA.
Wolffsohn and Cochrane (2000)	Developed Low Vision Quality of Life Questionnaire (LVQOL)	150 low vision patients	The LVQOL was shown to have good internal consistency and reliability. Population with low vision scored significantly worse than controls and improved with low vision rehabilitation.
Wolffsohn *et al.* (2000)	Evaluated different methods (post, telephone, in person) of administering the LVQOL	117 low vision patients	No significant differences between methods, but results not the same for each method, so if QoL measures used to monitor change then should be consistently implemented in same way. LVQOL had high internal consistency and reliability.
Haymes (2001)	Evaluated Melbourne Low Vision ADL Index	97 vision impaired adults	The instrument provided information that is additional to that obtained by traditional clinical vision measures, such as VA and visual fields.
Frost *et al.* (2001a)	Evaluated VCM1 vision-related QoL questionnaire	96 (post) and 92 (telephone)	Compared with postal reporting, telephone interviewing caused a general bias towards under-reporting of visual problems. VCM1 is well validated and has high reliability.
Frost *et al.* (2001b)	Cross-sectional population-based study with VCM1	1846 individuals aged over 55	Decrease in vision-related QoL was significantly associated with: increasing age, decreasing social class, increasing material deprivation.
Mangione *et al.* (2001)	Prospective cohort study with 25-item version of National Eye Institute Visual Function Questionnaire (NEI VFQ-25)	Adults with eye diseases or VI	The reliability of the 25-item version is comparable with the full 51-version field test NEI VFQ.
Massof and Rubin (2001)	Thorough review of visual function assessment questionnaires	Literature review	Most of these instruments average ordinal patient ratings, which is inappropriate unless converted to interval scales. This has only been done for three instruments: activity level of the blind, activity breakdown structure, independent mobility questionnaire.
West *et al.* (2002)	Population-based cross-sectional study of relationship between performance on everyday tasks and impaired VA and CS	1638 older African-American and white participants	Both VA and CS loss were associated with decrements at everyday tasks. For visually intensive tasks, like reading, VA worse than 6/9 was disabling. VA and CS loss each contributed independently to decrements in performance.
Haymes *et al.* (2002)	Cross-sectional study of relationship between VI and ability to perform activities of daily living, measured with Melbourne Low Vision ADL Index (MLVAI)	120 VI adults, mean age 70 (range 20–89)	All vision measures significantly correlated with MLVAI total score. Together, age, near word acuity, contrast sensitivity, and visual field accounted for 82% of variance in MLVAI score.

Table 3. (Continued)

Authors	**Study design/goals/methods**	**Participants**	**Results/conclusions/comment**
Hays *et al.* (2003)	Cross-sectional survey to investigate the impact of refractive error and its correction on everyday life, using the National Eye Institute-Refractive Error Quality of Life survey (NEI-RQL)	667 myopes, 380 hyperopes, 114 emmetropes; good corrected VA	Emmetropes scored significantly better than myopes and hyperopes. Results support the reliability and construct validity of the NEI-RQL and is useful for comparing people with different types of refractive error.
Chia *et al.* (2003)	Cross-sectional population-based study of relationship between unilateral VI and health-related QoL, using SF-36 health survey	3108 older people in Blue Mountains Eye Study	Moderate to severe non-correctable unilateral VI (including cataract) associated with poorer SF-36 profiles, even after controlling for the effect of age and gender. Conclude second eye cataract surgery is beneficial.

post-refraction visual acuity. They cautioned that 'the pinhole test result should not be used as a dichotomizer for clinical decisions regarding the need for a refraction'. These factors may explain why some studies reviewed below have reported difficulties in using the pinhole test in older people (Evans *et al.*, 2002; Smeeth *et al.*, 2003).

Several studies have investigated people who are already receiving low vision services. For example, Yap and Weatherill (1989) carried out a retrospective review of BD8 (blind registration) forms, Leat and Rumney (1990) investigated people attending a university-based low vision clinic, and Ryan and McCloughan (1999) administered a questionnaire to 90 people recruited from voluntary societies or social services. Although these types of studies are important to help improve current services, they will not be reviewed here as the present review aims to concentrate on people who are not receiving appropriate care. This highlights a challenge for research on this topic: the study population needs to be a representative sample of the general population. For example, it would be inappropriate to investigate those attending an eye clinic as these patients would to some extent be self-selected as having visual problems. Investigating people attending a GPs surgery might also be misleading, as there is likely to be a body of older people who avoid health care services generally. This group would 'escape the system', and there may be several reasons why people would fall into such a group. They might be wary of health care services, assume that visual or other deterioration is an untreatable consequence of ageing, or have language or ethnic reasons (Lindesay *et al.*, 1997) for avoiding NHS consultations. Detecting these people would be very difficult. Even surveying people in the street or at community centres may not be an adequate method of sampling the population: older people with low vision might tend to avoid going out. The various studies of undetected low vision in older people have attempted to address this challenge of participant selection in different ways.

McMurdo and Baines (1988) investigated visual acuities, visual fields, pupillary reactions, and fundi of 50 patients attending a geriatric day hospital. Severe, unexpected visual problems were found in 32%, more than half of which were remediable by cataract extraction. The authors noted that most of the patients were under the direct care of several medical practitioners, yet undetected visual problems were prevalent.

Tielsch *et al.* (1990), in a population-based sample of 5300 people in Baltimore, USA, found a 'striking difference between presenting and best corrected visual acuity'. In their sample 54% of people improved their presenting vision after refractive correction, with 7.5% improving three or more lines on a letter chart. These authors concluded that 'there is a significant burden of visually impairing ocular disease in the community. A

Table 4. Summary of studies on the impact of visual impairment (VI) on falls and related topics. VA, visual acuity; CS, contrast sensitivity; RTA, road traffic accident; AMD, age-related macular degeneration; MF, multifocal spectacles; ages are in years

Reference	Study design/goals/methods	Participants completing study	Results/conclusions/comment
Felson *et al.* (1989)	Population-based prospective cohort study investigating correlation between corrected VA (after refraction) and falls, controlling for age, relative weight, oestrogen use, alcohol consumption.	2633 participants in Framingham study (aged 52–85) followed for 10 years	110 suffered hip fractures, invariably from falls. Mean age at fracture 72 ± 8 years. VI increased risk of fracture by threefold to 9% of those with VI. Relationship between VI and hip fracture stronger over age 75. Worse vision associated with greater risk of fracture. 18% of hip fractures attributable to impaired vision. Those with VI in one eye only had higher risk of fracture than those with VI in both eyes.
Grisso *et al.* (1991)	Case–control study comparing vision in patients with hip fracture to controls from general surgical and orthopaedic hospital services.	174 women (median age 80) and age-matched controls	VI increased the risk of hip fracture by five times. Other factors associated with hip fracture (with odds ratios in parentheses): lower-limb dysfunction (2), previous stroke (2), Parkinson's disease (9), and long-acting barbiturates (5).
Lord *et al.* (1991)	Cohort study to assess predictors of falls over 1 year. Assessed VA, low contrast VA, CS.	95 people (age 59–97) from hostel for the aged	52% reported one or more falls in a year. CS was significantly poorer in those who subsequently had a fall. Poor VA and CS were significantly associated with increased sway when standing on foam (not carpet).
Gresset and Meyer (1994)	Case–control study comparing drivers with RTA in their 70th year with controls.	1400 RTA cf. 2636 non-accident age-matched controls	Slightly reduced VA (6/12–6/15) was only associated with increased risk of RTA if stereoacuity was also reduced to 200 sec arc or worse.
Elliott *et al.* (1995)	Case–control study comparing patients with AMD with controls. Evaluated balance control.	16 patients with AMD (aged 65–85) and 19 controls	In the normal standing condition, the kinesthetic and vestibular systems compensated for the lack of visual information in ARM subjects. It is when more than one sensory system is compromised that the postural control is compromised. There was a weak but significant correlation between postural stability and contrast sensitivity.
Dargent-Molina *et al.* (1996)	Cohort study of relationship (over 2 years) between hip fracture and corrected VA, mobility and physical capacity, and use of medication.	7575 women aged ≥75 with no history of hip fracture	Three variables, including poor VA, were significantly related to hip fracture, even after controlling for age and bone mass density.
Lord and Menz (2000)	Cross-sectional study of visual influences on postural stability. Visual tests included high and low contrast VA, CS, stereopsis, fields.	156 community-dwelling people aged 63–90	CS and stereopsis are important in the control of posture under challenging conditions.

Table 4. (Continued)

Reference	Study design/goals/methods	Participants completing study	Results/conclusions/comment
Ivers *et al.* (2000)	Case–control study of patients hospitalised with hip fracture and controls matched for aged and gender	911 with hip fracture aged ≥60 and controls	VA worse than 6/18, poor stereopsis, and not wearing glasses at time of fall all associated with hip fracture after adjusting for age, gender, activity, and height. The population-attributable risk of hip fracture due to poor visual acuity or stereopsis was 40%. Increasing time since the last eye examination was significantly associated with risk of fracture.
Harwood (2001)	Review. Notes that there are four sensory mechanisms detecting perturbations of balance: vision, vestibular apparatus, neck and limb proprioreception, tactile sensation in feet		Conclude that VI is a risk factor for falls, approx. doubling falls risk. Main visual correlates of falls are VA, CS, stereopsis. Although no RCTs, author felt that the relationship between falls and VI is almost certainly causal. As vision accounts for perhaps 25% of all falls, author advocates treating refractive errors and cataracts.
Lord and Dayhew (2001)	Cohort study of community dwelling people for 1 year	148, aged 63–90.	43% reported falling. VI is an important and independent risk factor for falls. Stereopsis and CS particularly important.
Lord *et al.* (2002)	1. Cross-sectional study of effect of multifocal spectacles (MF) on distance stereopsis and CS 2. Cohort study of effect of MF on risk of falls	156 community-dwelling people aged 63–90	56% of sample wore multifocals. These participants performed worse at stereopsis and CS when forced to view test through reading portion of MF. MF wearers twice as likely to fall than non-MF wearers when adjusting for age, VA, limb sensation and strength, reaction time, and postural sway.
Day *et al.* (2002)	Randomised factorial trial of the effect of three interventions (exercise, home hazard management, vision improvement) on falls over 18 months	1090 people aged ≥70 living at home	Exercise alone showed a significant effect on falls, but strongest effect was for all three interventions combined giving estimated 14% reduction in annual fall rate. Effect of interventions was additive, not interactive.
Anand *et al.* (2002)	Cross-sectional study of effect of refractive blur on postural stability	Four young people with normal vision	Even in this sample, optimal refractive correction was important for postural stability, particularly where input from somatosensory and/or vestibular systems are disrupted.
Legood *et al.* (2002)	Review to calculate risks and types of injuries associated with VI		20 of 31 studies assessed falls (mostly with older people), eight traffic-related injuries, three occupational injuries. People with reduced VA (cf. good VA) are 1.7 times more likely to have falls and 1.9 times more likely to have multiple falls.

Scuffham *et al.* (2003)	Review to assess cost of falls associated with VI in UK		Risk of hip fracture 1.5–2.4 times greater if reduced VA cf. good VA. 47% of falls in people with VI are attributable to VI. In 1999, NHS and long-term institutional care providers spent £128 million on treating falls directly attributable to VI.
Anand *et al.* (2003)	Cross-sectional study of factors influencing postural stability	15 people (mean age 71) with normal vision and no history of falls	Greatest increases in postural instability were due to disruptions of somatosensory and vestibular systems. Refractive blur (like removing spectacles) significantly increased postural instability. Conclude factors causing postural instability are cumulative and correcting refractive errors could prevent falls.
Klein *et al.* (2003)	Population-based cohort study in Beaver Dam eye study investigating visual predictors of falls and fractures over 5 years	2962 people aged 48–91	People with poor binocular VA were twice as likely to have a fracture or history of two or more falls in the last year. This relationship did not appear to be due to lack of awareness of their limitations.
Ivers *et al.* (2003)	Population-based cohort study in Blue Mountains eye study investigating visual predictorsof hip fracture over 5 years	2326 people aged ≥49	VI was strongly associated with risk of hip fracture over 2 years but not over longer intervals. Impaired VA, visual field loss, and posterior sub-capsular cataract were all associated with markedly increased risk of hip fracture. Advocate regular eye exams and cataract treatment.
Abdelhafiz and Austin (2003)	Review of relationship between visual factors and falls or hip fractures		Conclude that VI is an important risk factor for falls and hip fracture in older people. Interventions (e.g. glasses or cataract extraction) may have the potential for preventing falls.
Brannan *et al.* (2003)	Controlled trial of the effect of the intervention of cataract surgery. Compared number of falls in the periods 6 months before and 6 months after surgery	84 patients with cataracts	Number of falls post-surgery (6) significantly fewer than the number (31) before surgery.

Table 5. Summary of key studies of correctable visual impairment (VI), % VI (<6/12), proportion of the sample with presenting visual acuities of 6/12 or worse. Correctable VI, proportion of study population with VI resulting from cataract and uncorrected refractive errors. Correctable with glasses, proportion of study population with VI resulting from uncorrected refractive errors. Helped by new glasses, proportion of study population who would have been helped by new spectacles

Reference	Place	*N*	Age	% VI (<6/12)	Correctable VI (%)	Correctable with glasses (%)	Helped by new glasses (%)	Cataract (%)
Tielsch *et al.* (1990)	Baltimore, USA	5300	≥40	10[d]	NA	7.2	NA	NA
	Inner London, UK	207	≥65	11	NA	NA	27[a]	5.8
Reinstein *et al.* (1993) Wormald *et al.* (1992)	London, socially deprived area	136	≥65	NA	NA	34[a,b]	NA	NA
Jack *et al.* (1995)	Liverpool, UK	200	≥65	51	40	20	20	19
Taylor *et al.* (1997)	Melbourne, Australia	3271	≥40	4[c]	NA	NA	60	NA
Reidy *et al.* (1998)	North London	1547	≥65	30	22	9[b]	NA	30[b]
Liou *et al.* (1999)	Victoria, Australia	4735	≥40	NA	NA	10	NA	NA
Sinclair *et al.* (2000)	Wales, UK	385	≥65	31	NA	NA	17[a]	NA
Van der Pols *et al.* (2000)	Mainland UK	1362	≥65	28	NA	NA	21[a]	NA
Foran *et al.* (2002) (2 cohorts)	Blue Mountains in Australia	3654	≥49	11.1	NA	7.5	NA	NA
		3509		8.3	NA	5.6	NA	NA
Smeeth *et al.* (2003)	UK	4340	≥75	29	NA	NA	5[a]	NA

NA, data not available. Ages are in years. [a]Used pinhole test, not full refraction; visual acuities are binocular except: [b]one or both eyes, [c]best eye, [d]not stated but presumed to be best eye.

significant proportion of this population requires only refractive services.'

Wormald *et al.* (1992), in a study described above, examined 207 participants sampled at random from the database of people aged 65 years and over at an inner London health centre. Binocular Snellen acuity was assessed with any spectacles that were usually worn. Cataract accounted for 75% of cases of low vision and it was argued that 27% of participants would probably have benefited from refraction. This latter conclusion is based on testing with a pinhole, and the limitations of this have been discussed above. Wormald *et al.* (1992) found that only half the patients with low vision were known by their GP to have an eye problem.

One approach to sampling a cross-section of older people is to investigate those attending an A & E department. It could be hypothesised that even people who would not normally participate in health care services would, in an emergency, attend an A & E department. A disadvantage of this approach is that the association between falls and VI (*Table 4*) could cause studies using this approach to overestimate the prevalence of VI. Reinstein *et al.* (1993) investigated patients aged 65 and older attending the A & E department of a hospital in a socially deprived area of London. A number of patients (196) were not included because they attended at times when there were too few staff or the hospital was too busy. Unfortunately, Reinstein *et al.*'s method of detecting 'correctable undetected visual acuity deficit (CUVAD)' was to use a pinhole screening method. The limitations of this test are discussed above. Of 136 patients, 36% were found to have a CUVAD in one or both eyes of two lines or more. Indeed, 34% of participants would have met the 6/12 definition of partial sight because of CUVAD. Despite the fact that 43% of the patients attended their GP at least once a month, 87% reported that their GP had never checked their eyes or vision. Half the patients with significant CUVAD had not attended an optometrist for 2 years mainly because of cost. This study was carried out during a period when primary care NHS eye examinations for older people were not routinely available on the NHS (NHS funding for these was subsequently re-introduced). Nonetheless, anecdotal comments from patients suggest that there are still many older people who view a visit to an eyecare practice as an expensive event, and it may be avoided for this reason (Smeeth, 1998).

A similar approach to subject selection was taken by Jack *et al.* (1995). They investigated 200 consecutive patients aged 65 years and over who were admitted to the Department of Geriatric Medicine at the Royal Liverpool University Hospital with an acute medical illness. Using distance Snellen acuities with any distance glasses that were usually worn, 50.5% were found to have impaired vision (binocular acuity 6/18 or worse). This figure rose to 66% for those over the age of 85 years. The patients with impaired vision were given a full eye examination. Of the 101 patients with impaired vision, 79% had a reversible cause, and there was a higher prevalence of low vision than in community studies. In the group with refractive errors, 59.5% had not visited an optometrist in the past 3 years. The prevalence of uncorrected refractive errors contributing

to the impaired vision was 40%. These authors found a particularly high prevalence (76%) of VI in people who were admitted with falls. This concurs with research reviewed in *Table 4*.

Taylor *et al*. (1997) carried out a door-to-door census in the Melbourne area of Australia to identify non-institutionalised residents aged 40 or over, who were invited to attend a clinic for an eye examination. Of those eligible, 83% (3271) participated and the eye examination included a refraction and visual field testing. Refraction improved the best eye's acuity by at least one Snellen line in 60% of people. It should be noted that one line is not a very demanding criterion, and is close to the test–retest confidence intervals for some individuals (Lovie-Kitchin and Brown, 2000). Taylor *et al*. (1997) concluded that 'it is quite extraordinary that the number of people with VI could be halved simply by the provision of new spectacle correction', despite refraction in Australia being covered by a national health insurance system. This study is likely to have under-estimated the prevalence of VI, as people in nursing homes were excluded and these people are 3.3 times more likely to have VI than those not residing in a nursing home (Klein *et al*., 1991).

A detailed study of the prevalence of VI in North London was carried out by Reidy *et al*. (1998). These authors sampled patients aged 65 or older registered with general medical practices, and managed to obtain data from 84% of those contacted. The authors assessed the effect of refractive errors using a pinhole and with an autorefractor, but it is not clear how they used these data to determine which cases of VI were remediable by spectacles. In the study population of 1547, the prevalence of bilateral VI (visual acuity $<6/12$) was 30%, of which 72% was potentially remediable (by spectacles or surgery). In other words, the unmet visual need in this population-based study was 22% of the population aged 65 or over. Overall, 87% of those with VI or glaucoma were not in touch with eye care services. Three quarters of the people with definite glaucoma were not known to the eye care services.

Liou *et al*. (1999) carried out a large population-based study in an Australian (Victoria) population. They obtained an 84% participation rate, with a total of 4735 participants. These authors found that 10% of the study population could have been improved by one or more lines of a Snellen chart with updated refractive correction. The risk of under-corrected refractive error increased by 1.8 times for every decade of life starting at 40 years of age.

Another approach to detecting the true prevalence of low vision in older people is to assess the visual function of older people in their homes. Sinclair *et al*. (2000) screened for impaired distance visual acuity in people aged 65 years or older living at home in three districts of Wales. They compared 385 people with diabetes mellitus with 385 age and gender matched controls. Not surprisingly, a high proportion (40%) of those with diabetes had impaired visual acuity, but impairment was also found in 31% of controls. The pinhole test suggested that refraction might improve visual acuity for 54% of the controls with a VI.

Van der Pols *et al*. (2000) measured visual acuity with and without a pinhole in 1362 randomly selected people aged 65 and over who were not mentally impaired. Vision improved 0.2 log units or more (typically, 2 Snellen lines) with a pinhole in 21% of participants.

An epidemiological study by Minassian *et al*. (2000) looked at the unmet need for the treatment of one specific cause of low vision in older people: cataract. They estimated that 2.5 million people are waiting for cataract surgery, and an additional 700 000 die with impaired vision from un-operated cataract in England and Wales. In passing, it is worth noting that Owsley *et al*. (2002) found that older adult drivers with cataract who underwent cataract surgery and intraocular lens implantation had half the rate of crash involvement during the follow-up period compared with cataract patients who did not undergo surgery.

Foran *et al*. (2002) described data from the Blue Mountains Eye Study (near Sydney, Australia) which initially evaluated 3654 (a participation rate of 82%) non-institutionalised permanent residents aged 49 years or older. After 5 years another cross-section of the population was examined, comprising 3509 persons, 2335 of whom were in the original cohort and 1174 of whom had moved into the area and age-group. The eye examination included distance visual acuity with any glasses and testing with an auto-refractor. VI was defined as acuity worse than 6/12. Despite the relatively young age of the study population, in the initial cross-section, 7.5% of participants had correctable VI and 3.6% had non-correctable impairment. The corresponding rates in the second cross-section were 5.6 and 2.7%. Correctable VI was associated with poorer general health, living alone, and lower socio-economic status and/or increasing dependency. Uncorrected refractive errors accounted for over two-thirds of cases of VI in both cohorts. This study is likely to have under-estimated the prevalence of VI, as people in nursing homes were excluded and these people are 3.3 times more likely to have VI than those not residing in a nursing home (Klein *et al*., 1991). Foran *et al*. (2002) advocated recommending regular eye examinations to older people.

Smeeth *et al*. (2003) investigated 4340 home-dwelling people aged 75 years or over randomly selected from the lists of 20 general practices. Distance visual acuity testing revealed 29% to have a presenting acuity of worse than 6/18 in either eye. Of these, 17% had a

pinhole-corrected acuity of better than 6/18, suggesting that the reduced vision could be at least partly attributed to refractive error. However, the authors note the proportion attributable to refractive error will have been under-estimated because many people did not complete a pinhole assessment, reporting that it was difficult to use.

Not all authors agree about the level of undetected VI. A review of the service need and provision for age-related macular degeneration (AMD) by Fletcher *et al.* (2001) argued that there is no 'hidden iceberg' of undetected VI due to AMD. Their most conservative estimate of people with undetected visually impairing AMD would suggest that 35% are unknown to their GP. However, these authors also note that it cannot be assumed that because people with vision loss were known to their GP, this means that their vision rehabilitation was adequately managed. Fletcher *et al.* (2001) argued that the fundamental large-scale re-structuring of the primary health care sector may hinder rather than help efforts to tackle and resolve the inequity and fragmentation of low vision service provision.

Table 5 gives an overview of the key studies described in this section. In summary, overwhelming evidence suggests that there is a large group, between 20 and 50%, of older people who have reduced vision that is undetected. The majority of these people have treatable visual problems, such as refractive errors and cataract. Undetected glaucoma is also likely to be prevalent and, although the visual loss from glaucoma is not reversible, the condition should be treated to prevent further visual loss (Madeiros and Weinreb, 2002). It is particularly startling that, in so-called developed countries, between 7 and 34% of older people have VI that could simply be cured by appropriate spectacles. Indeed, in several studies more than half of cases of VI could be accounted for by under-corrected refractive errors.

Discussion

Why is correctable visual impairment so prevalent?

Why do so many older people have correctable but untreated visual impairment? There has been little research to address this question, but some of the likely issues are discussed below.

Older patients with low vision may not seek low vision services because they assume that nothing can be done (Reidy *et al.*, 1998) or because they have been told or led to believe that nothing can be done to improve their sight (Ryan and McCloughan, 1999). Others may have simply giving up waiting for a low vision assessment (Reidy *et al.*, 1998), as the wait for these can be anything up to a year (Ryan and Culham, 1999). According to one audit, a quarter of patients who should be attending the hospital eye service are lost to follow-up (Hillman, 1994). The patients who were 'retrieved' had suffered appreciable morbidity. Feedback from the patients led the author to emphasise the need for allowing more time for older people and making sure that instructions are fully understood. It should be acknowledged that it is also possible that people with VI who do not seek ophthalmic services might not feel that their VI is greatly interfering with their quality of life and that this is why they do not seek ophthalmic care. However, in the present authors' opinion the adverse effects of VI on quality of life are both well-supported by the available literature and have considerable face validity.

Some older people with low vision may also have mobility problems or cognitive impairment and this is another reason why some individuals may not avail themselves of low vision services. Ryan and McCloughan (1999) noted the need for a safety net to provide for the care of those with low vision who do not self-refer into the system. Another problem is inappropriate criteria that are sometimes applied before people can access low vision services (Ryan and Culham, 1999).

Pollard *et al.* (2003) used interviews and focus groups to investigate the factors that Australian adults with low vision felt were barriers to accessing low vision services. The perceived barriers related to awareness of services among the general public and eye care professionals, understanding of low vision and the services available, acceptance of low vision as a consequence of ageing, the referral process, and transport.

One important factor that has not been fully investigated is the effect of ethnicity. For example, in the study of Reidy *et al.* (1998) in north London, 94.3% of the participants were Caucasian. This figure is not representative of the inner London population (of which approximately half the population are Caucasian; Campbell *et al.*, 2001), and is certainly not representative, for example, of inner south London.

Lindesay *et al.* (1997) interviewed 150 Hindu Gujarati people and 152 Caucasian people in Leicester randomly sampled by a computerized linguistic analysis of the patient's name on a district health authority list. The authors found clear evidence of a lower uptake of services by elderly Asian Gujarati people. This was not the result of better health but may be explained by greater family support together with a lack of knowledge of and dissatisfaction with what is available. Higher rates of diabetes and impaired vision were evident in the people of Asian Gujariti background. This is supported by a recent study (Pardhan and Mahomed, 2002), which found an under-representation of Asian people in the Low Vision Register in Bradford, despite the fact that VI is particularly common in people

of Indo-Asian racial origin (Hayward *et al.*, 2002). Reidy *et al.* (1998) found a suggestion of an association between some ophthalmic problems and degree of under-privilege, which may be very relevant to some areas of the country.

Some older people with diabetes may have poor vision despite passing 'vision' screening tests. Many of the protocols that screen for eye disease in diabetes only involve a photographic analysis of the retina, which is the screening method currently favoured in the UK (National Institute for Clinical Excellence, 2002). Whilst this will often detect significant diabetic retinopathy, people with diabetes are predisposed to a variety of ocular pathologies (Leibowitz *et al.*, 1980). The majority of VI in those with diabetes is not due to diabetic retinopathy (Rhatigan *et al.*, 1999; Prasad *et al.*, 2001), so many patients with low vision will be missed by this type of screening.

Improving the detection of visual problems in older people

Is screening for visual problems in older people justified? At present, it seems to be often assumed that older people with low vision will automatically detect their problems and seek optometric and/or medical care. The present review shows that this is very often not the case. Two different (but not mutually exclusive) approaches to improving the detection of visual problems in older people are to better publicise the need for regular optometric eye examinations and to screen for visual problems in older people. Only a few studies have evaluated screening and these will now be summarised.

Smeeth (1998) applied Wilson's criteria (Wilson and Junger, 1968), developed specifically for reviewing the evidence around community screening programmes, to assess the likely effectiveness of screening older people for impaired vision in primary care. They concluded that 'on present evidence, screening cannot be recommended'. This interesting paper included a review of studies comparing questions about visual problems with visual acuity measurements. This showed that single questions are generally poor at detecting clinically significant reductions in acuity. Unfortunately, the only 'screening tests' that the author considered were distance acuity, the pinhole test, reading charts, and questions about vision.

Smeeth (1998) noted that little is known about the needs of older people who have not previously reported a visual problem, but are found to have VI on screening. The effects of treating such unreported VI have not been evaluated. Although this is true, the present review suggests that many of these cases will have readily treatable visual problems such as cataract and refractive errors. It would seem likely that most people would appreciate the improvements (e.g. in quality of life and reduced risk of falls) that would be associated with treatment. Smeeth called for more research to assess the needs of older people with unreported visual problems.

Smeeth and Iliffe (1998) reported a systematic review of evidence from randomised controlled trials on the effectiveness of screening older people for impaired vision in a community setting. An updated version of this review was published in 2003 as a Cochrane review and is discussed below.

Increases in longevity will involve a significant increase in the number of drivers who are older people. It might be hypothesised that vision screening of older people might therefore help to improve driving safety. However, Brayne *et al.* (2000) found that older drivers' self-reports indicated that a process of self-selection takes place among older drivers to limit the number who are likely to have VI. It should be noted that these authors did not actually measure distance visual acuity (although they did measure near acuity).

Langley-Hawthorne (2003) used prevalence estimates from the North London Eye Study (Reidy *et al.*, 1998) to estimate the annual cost associated with vision impairment in people over the age of 65 years. She suggested that if an early screening programme could reduce the prevalence of cataract by 10% (to a prevalence of 20% in the elderly), the UK government could save £3.1 billion annually. Although the present review concentrates on *correctable* VI, it should be noted that Langley-Hawthorne (2003) also commented on glaucoma. The calculations suggested that if only 10% of the glaucoma population received earlier treatment that arrested the development of VI then this kind of programme could save the government between £555 million and £1 billion.

Smeeth and Iliffe (2003) carried out a Cochrane review of double-masked randomised controlled trials of community screening for VI in older people. The outcome measure was the level of VI in the population at the end of the trial, at least 6 months after screening. Only five such trials were found, and amazingly in all five trials the 'vision screening' was simply questions about vision and the outcome was assessed by an interview or postal questionnaire. A similar proportion of participants in the screened and non-screened groups reported visual problems at follow-up, so the reviewers concluded that there is no evidence that community-based screening of asymptomatic older people results in improvements in vision. The reviewers note several possible explanations for the lack of effectiveness: the visual assessment was just one component of multiphasic screening; vision screening would only be expected to bring about an improvement in vision if there were effective interventions that were acted upon following screening; participants may not have perceived a need for intervention; and questions about vision have been shown to have a poor sensitivity for

detecting VI. To the present authors, this is the most important point: none of the trials used any clinical assessment of visual function.

Scuffham *et al.* (2003) investigated the cost of falls attributable to VI in the UK. The cost per annum in the UK was found to be more than £1/4 billion. The authors felt that a campaign to reduce the incidence of falls in the visually impaired population may be cost-saving, but because at least 65% of those with VI are not registered as blind or partially sighted, a population-wide campaign is preferable. For a similar reason, they also advocated widespread screening for VI.

Clearly, there are many questions that remain to be answered about vision screening for older people. Two of these will now be discussed: who is best placed to screen and what tools might be most appropriate for screening?

Who is best placed to screen for visual problems in older people? Screening by general medical practitioners has the potential for reaching the vast majority of older people; 98.5% patients aged 65 years and over who attended an A & E Department were registered with a GP (Reinstein *et al.*, 1993). Bulpitt *et al.* (1990) reviewed the history of health screening in older people and concluded that screening by general practitioners may be worthwhile for VI. Reinstein *et al.* (1993) felt that a pinhole test would be a useful procedure for GPs to carry out as part of their general older health screen to detect CUVADs. However, as noted above there are limitations to the usefulness of the pinhole test. Evans *et al.* (2002), in a large-scale study that was described earlier in this paper, attempted to use a pinhole test to detect uncorrected refractive errors. They noted that the pinhole test was not easily used in their population. Indeed, only 62% of people with visual acuity less than 6/18 in either eye completed a pinhole test satisfactorily, and this aspect of the study could not be described as a success. Smeeth *et al.* (2003) also reported that many people with reduced acuity could not complete a pinhole assessment.

Smeeth (1998) noted that although attendance rates for the over-75 GP screening is reported to be 48–63%, a total of 90% of people in the over 75 age group see their GP at least one a year, making high coverage rates feasible. On the other hand, doubts about the usefulness of screening for visual problems by GPs have been raised by Mangione *et al.* (1992) and Brabyn *et al.* (2001). Where opportunistic screening of vision occurs, for example during a consultation with a GP, this typically consists of measuring high contrast distance visual acuity. Several studies confirm that this is of limited use as an indicator of visual function in older people. Additionally, this approach to vision screening would not be likely to detect the visual problems that are most likely to be associated with falls, as outlined above.

Smeeth *et al.* (2003) described a cluster randomised trial of 20 general practices in the UK in which 4340 home-dwelling people aged 75 years or over were randomly sampled from the practices. These people had their visual acuity tested and those with VI were referred to eye services. The distance visual acuity was tested binocularly and monocularly and, if below 6/18, with a pinhole. Three to five years after screening the relative risk for visual acuity less than 6/18 in either eye comparing universal with targeted screening was 1.07 (95% confidence interval 0.84 to 1.36, $p = 0.58$). At this time, the mean composite score in the National Eye Institute Visual Function Questionnaire was very similar in the screened to the unscreened control group. Smeeth *et al.* (2003) concluded that further research into strategies to improve vision of older people is needed. The present authors would suggest that an investigation is needed of the most appropriate tests for screening since, as Smeeth *et al.* (2003) found, visual acuity alone is unlikely to be adequate.

Annual health checks for older people, including at least verbal questioning about visual health, have been part of the general medical practitioners' statutory requirements under the current GP contract (Department of Health, 1989). This is, however, about to be superseded by a new contract that makes no mention of screening for health problems in older people (Department of Health, 2003). Similarly the National Service Framework for Older People, whilst it contains targets for reducing the number of falls experienced by older people and aims to promote health and active life in older age, makes no specific reference to screening for visual problems (Department of Health, 2001). Given this, and the opportunity for better integration of primary care services offered by the latest reorganisation of health services (Department of Health, 2000), it may be that screening for VI can be best offered by those primary care practitioners with specialist skills and equipment, namely optometrists. However, Smeeth (1998) noted that fear of costs is consistently cited by a proportion of older people in studies looking at reasons for non-attendance at optometrists. More research is needed to determine the best personnel to use for screening for visual problems in older people.

Screening methods to detect visual problems in older people. It was noted earlier in this review that falls are a major problem in older people, and that visual problems can increase the risk of an older person having falls. Several authors have therefore attempted to determine a screening test battery that will detect these visual problems. Lord and Dayhew (2001) investigated which screening tests are most predictive of falls in older people. They evaluated a range of visual tests (high and low contrast visual acuity, edge contrast sensitivity,

depth perception, visual fields) and non-visual tests (measures of sensation, strength, reaction time, balance). Visual parameters were associated with increased risk of falls, with the strongest visual risk factors being impaired depth perception, contrast sensitivity, and low-contrast visual acuity.

The desirability of an assessment of visual field was highlighted by Taylor *et al.* (1997), who evaluated 3271 residents (83% of those eligible) aged 40–98 years. These authors found that nearly three times more people had VI because of visual field loss than visual acuity loss. Wormald *et al.* (1992) found that visual field testing on a modern automated instrument was possible with 81% of unselected people aged 65 years and over. Taylor *et al.* (1997) managed to carry out automated perimetry on 89% of those aged 40 years or over.

A large study by Brabyn *et al.* (2001), which investigated 900 participants, listed as one of its goals the establishment of a practical test protocol for vision in older people. The results indicated that spatial vision of individuals cannot be well predicted from acuity measurements alone. This highlights the importance of incorporating additional vision tests, and particularly those that more closely resemble everyday viewing conditions.

The performance of people with VI at everyday tasks, like recognising faces or facial expressions, can be improved with magnification devices (Tejeria *et al.*, 2002). Interestingly, Tejeria *et al.* (2002) discovered little evidence for a correlation between self-rated difficulty in face recognition and measured performance at recognising faces or facial expressions. The authors concluded that further work is needed to explore the complex relation between the perception of disability and measured performance.

Smeeth and Iliffe's (2003) review (described above), suggests that an effective screening programme must do more than just asking questions about vision and Smeeth *et al.* (2003) study implies that simple visual acuity measurement with and without a pinhole is also inadequate. However, there has been relatively little research on which tests might be most appropriate for vision screening of older people. Indeed, Ivers *et al.* (2001) found that current vision tests were not particularly good at detecting eye disease compared with the gold standard of a full eye examination. There is a definite need for more research to evaluate whether a visual screening tool can be developed with adequate sensitivity and specificity. If it cannot, then it would seem to be more appropriate to devote resources to increasing the number of older people having full eye examinations with optometrists on an annual basis.

Many of the studies reviewed in this paper allow some inferences to be drawn about which vision tests might *potentially* be most useful in vision screening of older people. These will now be listed although it is noted that further work will be required to evaluate which combination of these tests would constitute the optimum trade-off between sensitivity, specificity, time, equipment and personnel. The literature suggests that a vision screening system for VI in older people might usefully test the following functions: visual acuity (Felson *et al.*, 1989; Lord *et al.*, 1991; Harwood, 2001; Legood *et al.*, 2002; West *et al.*, 2002; Ivers *et al.*, 2003) preferably using a logMAR type of test (Bailey and Lovie, 1976) [probably only monocular readings are necessary (Rubin *et al.*, 2000)], contrast sensitivity (Lord *et al.*, 1991; Harwood, 2001; Lord and Dayhew, 2001; Haymes *et al.*, 2002; West *et al.*, 2002) and/or low contrast acuity (Lord and Dayhew, 2001), stereo-acuity (Felson *et al.*, 1989; Gresset and Meyer, 1994; Harwood, 2001), and visual fields (Taylor *et al.*, 1997; Haymes *et al.*, 2002; Ivers *et al.*, 2003). Although the present review is primarily concerned with correctable visual problems, an advantage of including visual field testing is that this would also allow some cases of glaucoma to be detected.

When reduced vision is detected, the first step should be referral to an optometrist (Wormald *et al.*, 1992). The optometric eye examination would detect the many cases where visual acuity can be improved by refractive correction alone (Tielsch *et al.*, 1990; Taylor *et al.*, 1997; Liou *et al.*, 1999; Foran *et al.*, 2002). Additionally, more than 40% of older eyes with ocular pathology have more than one type of pathology (Leibowitz *et al.*, 1980), and the optometrist can diagnose the disease(s) and prioritise the referral.

Recently, computerised methods of automated vision testing and reporting have been used with success in occupational vision screening (Thomson, 1994) and in children's vision screening (Thomson and Evans, 1999, 2001; Thomson, 2002). A combination of the tests described above could be included in a computerised program. Such a system might be an effective method of screening for visual problems in older people, for example, in GP surgeries and falls clinics.

Recommendations. The Low Vision Services Consensus Group (1999) recommended that low vision services should be available in the form of support and information immediately following diagnosis of an ocular condition, and then the assessment and provision of elements of low vision services should begin within 6 weeks. They also stressed that continued support is essential, with clients being able to return to any part of the service without the need for re-referral. In some low vision clinics, people are only allowed access to the clinic if they have followed a prescribed referral pathway (typically, optometrist $\rightarrow$ GP $\rightarrow$ ophthalmologist). Ideally, it would seem preferable to adopt a more flexible approach, where people could gain access to low

vision clinics on the basis of need. If people could easily self-refer to such a clinic then this might help to detect otherwise unknown cases of low vision. The clinic may then need to refer to a community optometrist or an ophthalmologist, so that the referral pathway would become bi-directional. This would improve the detection of cases of correctable VI, as highlighted in this review. Although harder to administer than the conventional clinic, such a 'client-led' system would be more likely to meet the public's needs.

Primary care optometric services are widely available in the community. There must be very few, if any, towns in the UK where an NHS eye examination with an optometrist could not be arranged within a matter of days, often hours. Eyecare services are widely publicised and advertised, although the emphasis on products rather than care may be counterproductive in some cases. Nonetheless, it seems very likely that all sectors of society know of the existence and function of community optometrists and opticians. Yet, this review clearly shows that many older people have undetected poor vision. It would seem therefore desirable that research should be carried out to identify the optimum method of screening for visual problems in older people (as outlined in the previous section). If a sufficiently sensitive, specific, and cost-effective screening tool can be developed then ideally all older people could undergo periodic vision screening. If this is not attainable, then the literature allows certain conclusions about population groups who should be targeted. Klein *et al.* (1991) found that 60% of people resident in nursing homes had some form of VI, and these people were 3.3 times more likely to have VI than those not residing in a nursing home (Klein *et al.*, 1991).

People with physical handicaps are 6–8 times more likely to have VI, and those with learning disabilities are 12–23 times more likely to have VI (Giltrow-Tyler, 1997). People with learning disabilities, or other forms of intellectual impairment, may suffer an additional disadvantage as high IQ can help people to overcome some of the difficulties associated with VI (Dickinson and Rabbitt, 1991).

People with diabetes should also be targeted, even if they already participate in screening involving fundus photography. This is because diabetics are more prone to other ocular conditions in addition to diabetic retinopathy (Rhatigan *et al.*, 1999; Prasad *et al.*, 2001), and this risk increases with duration of diabetes (Leibowitz *et al.*, 1980). Compared with age-matched controls, people with diabetes are twice as likely to have age-related macular degeneration, 1.65 times more likely to have cataract, and 1.33 times more likely to have glaucoma (Leibowitz *et al.*, 1980). Overall, Hayward *et al.* (2002) calculated a threefold increase in the risk of VI in the diabetic as compared with the general population.

Vision screening is one approach that we believe should be investigated with further research. A complementary approach is to better publicise the optometric eye examination as an essential yearly health check for all older people.

It was noted above, that some authors have expressed concern that the fundamental large-scale re-structuring of the primary health care sector may hinder rather than help efforts to tackle and resolve the inequity and fragmentation of low vision service provision (Fletcher *et al.*, 2001). It seems quite likely that the burgeoning number of local initiatives will lead to a greater diversity of standards, to the advantage of people in some localities and the disadvantage of others. On the other hand, the new models of commissioning and delivering multi-professional patient-centred care give great scope for recognising and addressing correctable vision problems in older people and through doing so reduce the levels of morbidity and improve the quality of life of a group currently under-served by the NHS. A major challenge will be to ensure a uniform standard of care across the country.

Conclusions

There is overwhelming evidence that there is a very large population of older people with low vision who are not receiving appropriate health care. The evidence also suggests that many of these people could be helped greatly by refractive correction or cataract surgery. These problems are more likely to be present in disadvantaged members of society: those from lower socio-economic groups and those with physical and/or learning disabilities. These findings are not just abstract visual data: the observed inequalities have an important impact on quality of life and are associated with substantially increased risk of falls. In addition to the pain and distress that these cause, they also represent a considerable drain on resources, both of the NHS and of care providers.

The notion that older people with poor vision will all regularly attend optometrists for refractive corrections and the detection of ocular pathology is clearly little more than just an ideal. Even the cases where pathology is diagnosed and who are seen by an ophthalmologist often fail to receive appropriate low vision services. Properly funded publicity may help to encourage more of the older population to view optometric care as an essential annual health check. A complementary approach is annual visual screening of the elderly, possibly as part of GPs annual health check on people aged 75 years and older. The new integration of primary health care services can be used as an opportunity to develop more acceptable and patient-centred eye care for older people, especially those not presently in contact with the NHS.

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References

Abdelhafiz, A. H. and Austin, C. A. (2003) Visual factors should be assessed in older people presenting with falls or hip fractures. *Age Ageing* **32,** 26–30.

Anand, V., Buckley, J., Scally, A. and Elliott, D. B. (2002) The effect of refractive blur on postural stability. *Ophthal. Physiol. Opt*. **22,** 528–534.

Anand, V., Buckley, J. G., Scally, A. and Elliott, D. B. (2003) Postural stability in the elderly during sensory perturbations and dual tasking: the influence of refractive blur. *Invest. Ophthalmol. Vis. Sci.* **44,** 2885–2891.

Appollonio, I., Carabellese, C., Magni, E., Frattola, L. and Trabucchi, M. (1995) Sensory impairments and mortality in an elderly community population: a six year follow up study. *Age Ageing* **24,** 30–36.

Bailey, I. L. and Lovie, J. E. (1976) New design principles for visual acuity letter charts. *Am. J. Optom. Physiol. Opt*. **53,** 740–745.

Boulgarides, L. K., McGinty, S. M., Willett, J. A. and Barnes, C. W. (2003) Use of clinical and impairment-based tests to predict falls by community-dwelling older adults. *Phys. Ther*. **83,** 328–339.

Brabyn, J., Schneck, M., Haegerstrom-Portnoy, G. and Lott, L. (2001) The Smith-Kettlewell Institute (SKI) longitudinal study of vision function and its impact among the elderly: an overview. *Optom. Vis. Sci*. **78,** 264–269.

Brannan, S., Dewar, C., Sen, J., Clarke, D., Marshall, T. and Murray, P. I. (2003) A prospective study of the rate of falls before and after cataract surgery. *Br. J. Ophthalmol*. **87,** 560–562.

Brayne, C., Dufouil, C., Ahmed, A., Dening, T. R., Chi, L. Y., McGee, M. and Huppert, F. A. (2000) Very old drivers: findings from a population cohort of people aged 84 and over. *Int. J. Epidemiol*. **29,** 704–707.

Brody, B. L., Garnst, A. C., Williams, R. A., Smith, A. R., Lau, P. W., Dolnak, D., Raportot, M. H., Kaplan, R. M. and Brown, S. I. (2001) Depression, visual acuity, comorbidity, and disability associated with age-related macular degeneration. *Ophthalmology* **108,** 1893–1900.

Bulpitt, C. J., Benos, A. S., Nicholl, C. G. and Fletcher, A. E. (1990) Should medical screening of the elderly population be promoted? *Gerontology* **36,** 230–245.

Campbell, J. L., Ramsay, J. and Green, J. (2001) Age, gender, socioeconomic, and ethnic differences in patients' assessments of primary health care. *Qual. Health Care* **10,** 90–95.

Chia, E. M., Mitchell, P., Rochtchina, E., Foran, S. and Wang, J. J. (2003) Unilateral visual impairment and health related quality of life: the Blue Mountains Eye Study. *Br. J. Ophthalmol*. **87,** 392–395.

Dargent-Molina, P., Favier, F., Grandjean, H., Baudoin, C., Schott, A. M., Hausherr, E., Meunier, P. J. and Breart, G., (1996) Fall-related factors and risk of hip fracture: the EPIDOS prospective study. *Lancet* **348,** 145–149.

Day, L., Fildes, B., Gordon, I., Fitzharris, M., Flamer, H. and Lord, S. (2002) Randomised factorial trial of falls prevention among older people living in their own homes. *Br. Med. J*. **325,** 128–134.

Department of Health (1989) *Working for Patients*. HMSO, London.

Department of Health (2000) *The NHS Plan: a Plan for Investment a Plan for Reform*. HMSO, London.

Department of Health (2001) *The National Service Framework for Older People*. HMSO, London.

Department of Health (2003) *Investing in General Practice. The New General Medical Services Contract*. HMSO, London.

Dickinson, C. (1998) *Low Vision. Principles and Practice*. Butterworth-Heinemann, Oxford.

Dickinson, C. M. and Rabbitt, P. M. A. (1991) Simulated visual impairment – effects on text comprehension and reading speed. *Clin. Vis. Sci.* **6,** 301–308.

Donohue, B., Acierno, R., Hersen, M. and Van Hasselt, V. B. (1995) Social skills training for depressed, visually impaired older adults. A treatment manual. *Behav. Modif*. **19,** 379–424.

Eagan, S. M., Jacobs, R. J. and Demers-Turco, P. L. (1999) Study of luminance effects on pinhole test results for visually impaired patients. *Optom. Vis. Sci*. **76,** 50–58.

Elliott, D. B., Patla, A. E., Flanagan, J. G., Spaulding, S., Rietdyk, S., Strong, G. and Brown, S. (1995) The Waterloo Vision and Mobility Study: postural control strategies in subjects with ARM. *Ophthal. Physiol. Opt*. **15,** 553–559.

Evans, J. R., Fletcher, A. E., Wormald, R. P. L., Siu-Woon Ng, E., Stirling, S., Smeeth, L., Breeze, E., Bulpitt, J., Nunes, M., Jones, D. and Tulloch, A. (2002) Prevalence of visual impairment in people aged 75 years and older in Britain: results from the MRC trial of assessment and management of older people in the community. *Br. J. Ophthalmol*. **86,** 795–800.

Fagerstrom, R. (1994) Correlation between depression and vision in aged patients before and after cataract operations. *Psychol. Rep*. **75,** 115–125.

Felson, D. T., Anderson, J. J., Hannan, M. T., Milton, R. C., Wilson, P. W. and Kiel, D. P. (1989) Impaired vision and hip fracture. The Framingham Study. *J. Am. Geriatr. Soc*. **37,** 495–500.

Fletcher, A., Donoghue, M. and Owen, C. (2001) Low vision services for people with age-related macular degeneration in the UK: a review of service need and provision. *The Macular Disease Society, London*.

Foran, S., Rose, K., Wang, J. J. and Mitchell, P. (2002) Correctable visual impairment in an older population: the Blue Mountains Study. *Am. J. Ophthalmol*. **134,** 712–719.

Foran, S., Mitchell, P. and Wang, J. J. (2003) Five-year change in visual acuity and incidence of visual impairment: the Blue Mountains Eye Study. *Ophthalmology* **110,** 41–50.

Frost, N. A., Sparrow, J. M., Hopper, C. D. and Peters, T. J. (2001a) Reliability of the VCM1 Questionnaire when administered by post and by telephone. *Ophthalmic Epidemiol*. **8,** 1–11.

Frost, A., Eachus, J., Sparrow, J., Peters, T. J., Hopper, C., Davey-Smith, G. and Frankel, S. (2001b) Vision-related quality of life impairment in an elderly UK population: associations with age, sex, social class and material deprivation. *Eye* **15,** 739–744.

Gibson, J. M., Rosenthal, A. R. and Lavery, J. (1985) A study of the prevalence of eye disease in the elderly in an English community. *Trans. Ophthalmol. Soc.* **104,** 196–203.

Giltrow-Tyler, F. (1997) Eyecare for the intellectually handicapped. *Optom. Today* **28,** 38–41.

Gresset, J. A. and Meyer, F. M. (1994) Risk of accidents among elderly car drivers with visual acuity equal to 6/12 or 6/15 and lack of binocular vision. *Ophthal. Physiol. Opt.* **14,** 33–37.

Griffith, R. and Ryan, B. (2000) Psychosocial factors in patients with age-related macular degeneration. *CE Optom.* **3,** 108–111.

Grisso, J. A., Kelsey, J. L., Strom, B. L., Chiu, G. Y., Maislin, G., O'Brien, L. A., Hoffman, S. and Kaplan, F. (1991) Risk factors for falls as a cause of hip fracture in women. The Northeast Hip Fracture Study Group. *N. Engl. J. Med.* **324,** 1326–1331.

Harwood, R. H. (2001) Visual problems and falls. *Age Ageing* **30,** 13–18.

Haymes, S. A. (2001) Weighted version of the Melbourne low-vision ADL index: a measure of disability impact. *Optom. Vis. Sci.* **78,** 565–579.

Haymes, S. A., Johnston, A. W. and Heyes, A. D. (2002) Relationship between vision impairment and ability to perform activities of daily living. *Ophthal. Physiol. Opt.* **22,** 79–91.

Hays, R. D., Mangione, C. M., Ellwein, L., Lindblad, A. S., Spritzer, K. L. and McDonnell, P. J. (2003) Psychometric properties of the national eye institute refractive error quality of life instrument. *Ophthalmology* **110,** 2292–2301.

Hayward, L. M., Burden, M. L., Burden, A. C., Blackledge, H., Raymond, N. T., Botha, J. L., Karwatowski, W. S., Duke, T. and Chang, Y. F. (2002) What is the prevalence of visual impairment in the general and diabetic populations: are there ethnic and gender differences?. *Diabet. Med.* **19,** 27–34.

Heine, C. and Browning, C. J. (2002) Communication and psychosocial consequences of sensory loss in older adults: overview and rehabilitation directions. *Disabil. Rehabil.* **24,** 763–773.

Hillman, J. G. (1994) Audit of elderly people's eye problems and non-attendance at hospital eye service. *BMJ* **308,** 953.

Ivers, R. Q., Norton, R., Cumming, R. G., Butler, M. and Campbell, A. J. (2000) Visual impairment and risk of hip fracture. *Am. J. Epidemiol.* **152,** 633–639.

Ivers, R. Q., Optom, B., Macaskill, P., Cumming, R. G. and Mitchell, P. (2001) Sensitivity and specificity of tests to detect eye disease in an older population. *Ophthalmology* **108,** 968–975.

Ivers, R. Q., Cumming, R. G., Mitchell, P., Simpson, J. M. and Peduto, A. J. (2003) Visual risk factors for hip fracture in older people. *Journal American Geriatric Society* **51,** 356–363.

Jack, C. I., Smith, T., Neoh, C., Lye, M. and McGalliard, J. N. (1995) Prevalence of low vision in elderly patients admitted to an acute geriatric unit in Liverpool: elderly people who fall are more likely to have low vision. *Gerontology* **41,** 280–285.

Kahn, H. A., Leibowitz, H. M., Ganley, J. P., Kini, M. M., Colton, T., Nickerson, R. S. and Dawber, T. R. (1977) The Framingham Eye Study. I. Outline and major prevalence findings. *Am. J. Epidemiol.* **106,** 17–32.

Klein, R., Klein, B. E. K., Linton, K. L. P. and De Mets, D. L. (1991) The Beaver Dam eye study: visual acuity. *Ophthalmology* **98,** 1310–1315.

Klein, B. E., Moss, S. E., Klein, R., Lee, K. E. and Cruickshanks, K. J. (2003) Associations of visual function with physical outcomes and limitations 5 years later in an older population: the Beaver Dam eye study. *Ophthalmology* **110,** 644–650.

Langley-Hawthorne, C. (2003) *The Cost of Blindness*. Ethical Strategies Ltd, Kingston-upon-Thames.

Leat, S. J. and Rumney, N. J. (1990) The experience of a university-based low vision clinic. *Ophthal. Physiol. Opt.* **10,** 8–15.

Legood, R., Scuffham, P. and Cryer, C. (2002) Are we blind to injuries in the visually impaired? A review of the literature. *Inj. Prev.* **8,** 155–160.

Leibowitz, H. M., Krueger, D. E., Maunder, L. R., Milton, R. C., Kini, M. M., Kahn, H. A., Nickerson, R. J., Pool, J., Colton, T. L., Ganley, J. P., Loewenstein, J. I. and Dawber, T. R. (1980) The Framingham Eye Study monograph: an ophthalmological and epidemiological study of cataract, glaucoma, diabetic retinopathy, macular degeneration, and visual acuity in a general population of 2631 adults, 1973–1975. *Surv. Ophthalmol.* **24** (Suppl.)**,** 335–610.

Lindesay, J., Jagger, C., Hibbett, M. J., Peet, S. M. and Moledina, F. (1997) Knowledge, uptake and availability of health and social services among Asian Gujarati and white elderly persons. *Ethn. Health* **2,** 59–69.

Liou, H. L., McCarty, C. A., Jin, C. L. and Taylor, H. R. (1999) Prevalence and predictors of undercorrected refractive errors in the Victorian population. *Am. J. Ophthalmol.* **127,** 590–596.

Livingston, G., Kitchen, G., Manela, M., Katona, C. and Copeland, J. (2001) Persecutory symptoms and perceptual disturbance in a community sample of older people: the Islington study. *Int. J. Geriatr. Psychiatry* **16,** 462–468.

Lord, S. R. and Dayhew, J. (2001) Visual risk factors for falls in older people. *J. Am. Geriatr. Soc.* **49,** 508–515.

Lord, S. R. and Menz, H. B. (2000) Visual contributions to postural stability in older adults. *Gerontology* **46,** 306–310.

Lord, S. R., Clark, R. D. and Webster, I. W. (1991) Visual acuity and contrast sensitivity in relation to falls in an elderly population. *Age Ageing* **20,** 175–181.

Lord, S. R., Dayhew, J. and Howland, A. (2002) Multifocal glasses impair edge-contrast sensitivity and depth perception and increase the risk of falls in older people. *J. Am. Geriatr. Soc.* **50,** 1760–1766.

Lovie-Kitchin, J. E. and Brown, B. (2000) Repeatability and intercorrelations of standard vision tests as a function of age. *Optom. Vis. Sci.* **77,** 412–420.

Low Vision Services Consensus Group (1999) *Low Vision Services: Recommendations for Future Service Delivery in the UK*. RNIB, London.

McGwin, G., Li, J., McNeal, S. and Owsley, C. (2003) The impact of cataract surgery on depression among older adults. *Ophthalmic Epidemiol*. **10,** 303–313.

McMurdo, M. E. T. and Baines, P. S. (1988) The detection of visual disability in the elderly. *Health Bull. (Edin.)* **46,** 327–329.

Madeiros, F. A. and Weinreb, R. N. (2002) Medical backgrounders: glaucoma. *Drugs Today (Barc.)* **38,** 563–570.

Mangione, C. M., Phillips, R. S., Seddon, J. M., Lawrence, M. G., Cook, E. F., Dailey, R. and Goldman, L. (1992) Development of the 'Activities of Daily Vision Scale'. *Med. Care* **30,** 1111–1126.

Mangione, C. M., Lee, P. P., Gutierrez, P. R., Spritzer, K., Berry, S. and Hays, R. D. (2001) Development of the 25-item National Eye Institute Visual Function Questionnaire. *Arch. Ophthalmol*. **119,** 1050–1058.

Martinez, G. S., Campbell, A. J., Reinken, J. and Allan, B. C. (1982) Prevalence of ocular disease in a population study of subjects 65 years old and older. *Br. J. Ophthalmol*. **94,** 181–189.

Massof, R. W. (2002) A model of the prevalence and incidence of low vision and blindness among adults in the U.S. *Optom. Vis. Sci*. **79,** 31–38.

Massof, R. W. and Rubin, G. S. (2001) Visual function assessment questionnaires. *Surv. Ophthalmol*. **45,** 531–548.

Minassian, D. C., Reidy, A., Desai, P., Farrow, S., Vafidis, G. and Minassian, A. (2000) The deficit in cataract surgery in England and Wales and the escalating problem of visual impairment: epidemiological modelling of the population dynamics of cataract. *Br. J. Ophthalmol*. **84,** 4–8.

National Institute for Clinical Excellence (2002) *Clinical Guideline. Management of Type 2 diabetes. Retinopathy – Screening and Early Management*. http://www.nice.org.uk/pdf/diabetesretinopathyguideline.pdf

Owsley, C., McGwin, G., Sloane, M., Wells, J., Stalvey, B. T. and Gauthreaux, S. (2002) Impact of cataract surgery on motor vehicle crash involvement by older adults. *J. Am. Med. Assoc*. **288,** 847–849.

Pardhan, S. and Mahomed, I. (2002) The clinical characteristics of Asian and Caucasian patients on Bradford's Low Vision Register. *Eye* **16,** 572–576.

Pollard, T. L., Simpson, J. A., Lamoureux, E. L. and Keeffe, J. E. (2003) Barriers to accessing low vision services. *Ophthal. Physiol. Opt*. **23,** 321–328.

Prasad, S., Kamath, G. G., Jones, K., Clearkin, L. G. and Phillips, R. P. (2001) Prevalence of blindness and visual impairment in a population of people with diabetes. *Eye* **15,** 640–643.

Rabbetts, R. B. (2000) *Bennett & Rabbetts*' Clinical Visual Optics. Butterworth Heinemann, Oxford.

Reidy, A., Minassian, D. C., Valfidis, G., Joseph, J., Wu, J., Desai, P. and Connoly, A. (1998) Prevalence of serious eye disease and visual impairment in North London: population based, cross sectional study. *Br. Med. J*. **316,** 1643–1646.

Reinstein, D. Z., Dorward, N. L., Wormald, R. P., Graham, A., O'Connor, I., Charlton, R. M., Yeatman, M., Dodenhoff, R., Touquet, R. and Challoner, T. (1993) Correctable undetected visual acuity deficit in patients aged 65 and over attending an accident and emergency department. *Br. J. Ophthalmol*. **77,** 293–296.

Rhatigan, M. C., Leese, G. P., Ellis, J., Ellingford, A., Morris, A. D., Newton, R. W. and Roxburgh, S. T. (1999) Blindness in patients with diabetes who have been screened for eye disease. *Eye* **13,** 166–169.

Rovner, B. W. and Shmuely-Dulitzki, Y. (1997) Screening for depression in low-vision elderly. *Int. J. Geriatr. Psychiatry* **12,** 955–959.

Rovner, B. W., Zisselman, P. M. and Shmuely-Dulitzki, Y. (1996) Depression and disability in older people with impaired vision: a follow-up study. *J. Am. Geriatr. Soc*. **44,** 181–184.

Rovner, B. W., Casten, R. J. and Tasman, W. S. (2002) Effect of depression on vision function in age-related macular degeneration. *Arch .Ophthalmol*. **120,** 1041–1044.

Rubin, G. S., Munoz, B., Bandeen-Roche, K. and West, S. K. (2000) Monocular versus binocular visual acuity as measures of vision impairment and predictors of visual disability. *Invest. Ophthalmol. Vis. Sci*. **41,** 3327–3334.

Ryan, B. and Culham, L. (1999) *Fragmented Vision: Survey of Low Vision Services in the UK*. RNIB, London.

Ryan, B. and McCloughan, L. (1999) *Our Better Vision*. RNIB, London.

Scuffham, P. A., Legood, R. and Wilson, E. C. F. (2002) The incidence and cost of injurious falls associated with visual impairment in the UK. *Visual Impairment Research* **4,** 1–14.

Shmuely-Dulitzki, Y. and Rovner, B. W. (1997) Screening for depression in older persons with low vision. Somatic eye symptoms and the Geriatric Depression Scale. *Am. J. Geriatr. Psychiatry* **5,** 216–220.

Sinclair, A. J., Bayer, A. J., Girling, A. J. and Woodhouse, K. W. (2000) Older adults, diabetes mellitus and visual acuity: a community-based case-control study. *Age Ageing* **29,** 335–339.

Smeeth, L. (1998) Assessing the likely effectiveness of screening older people for impaired vision in primary care. *Fam. Pract*. **15,** S24–S29.

Smeeth, L. and Iliffe, S. (1998) Effectiveness of screening older people for impaired vision in community setting: systematic review of evidence from randomised controlled trials. *BMJ* **316,** 660–663.

Smeeth, L. and Iliffe, S. (2003) Community screening for visual impairment in the elderly (Cochrane Review). In: *The Cochrane Library*, Issue 2, Oxford, Update Software.

Smeeth, L., Fletcher, A. E., Hanciles, S., Evans, J. and Wormald, R. (2003) Screening older people for impaired vision in primary care: a cluster randomised trial. *BMJ* **327,** 1027–1032.

Taylor, H. R., Livingston, P. M., Stanislavsky, Y. L. and McCarthy, C. A. (1997) Visual impairment in Australia: distance visual acuity, near vision and visual field findings of the Melbourne visual impairment project. *Am. J. Ophthalmol*. **123,** 328–337.

Tejeria, L., Harper, R. A., Artes, P. H. and Dickinson, C. M. (2002) Face recognition in age related macular degeneration:

perceived disability, measured disability, and performance with a bioptic device. *Br. J. Ophthalmol.* **86,** 1019–1026.
Thomson, D. (1994) A new approach to screening VDU users. *Optician* **207,** 23–28.
Thomson, D. (2002) Child vision screening survey. *Optician* **224,** 16–20.
Thomson, W. D. and Evans, B. (1999) A new approach to vision screening in schools. *Ophthal. Physiol. Opt.* **19,** 196–209.
Thomson, W. D. and Evans, B. (2001) Authors' reply. *Ophthal. Physiol. Opt.* **21,** 422–423.
Tielsch, J. M., Sommer, A., Witt, K., Katz, J. and Royall, R. M. (1990) Blindness and visual impairment in an American urban population. *Arch. Ophthalmol.* **108,** 286–290.
Van der Pols, J. C., Bates, J. C., McGraw, J. R., Thompson, J. R., Reacher, M., Prentwice, A. and Finch, S. (2000) Visual acuity measurements in a national sample of British elderly people. *Br. J. Ophthalmol.* **84,** 165–170.
Warnecke, P. (2003) A caregiver's eye on elders with low vision. *Caring* **22,** 12–15.
West, S. K., Rubin, G. S., Broman, A. T., Munoz, B., Bandeen-Roche, K. and Turano, K., SEE project team (2002) How does visual impairment affect performance on tasks of everyday life? *Arch. Ophthalmol.* **120,** 774–780.
Wilson, J. M. and Junger, G. (1968) *The Principles and Practice of Screening for Disease*. Public Health Papers 34. WHO, Geneva.
Wolffsohn, J. S. and Cochrane, A. L. (2000) Design of the low vision quality of life questionnaire (LVQOL) and measuring the outcome of low vision rehabilitation. *Am. J. Ophthalmol.* **130,** 793–802.
Wolffsohn, J. S., Cochrane, A. L. and Watt, N. A. (2000) Implementation methods for vision related quality of life questionnaires. *Br. J. Ophthalmol.* **84,** 1035–1040.
Wormald, R. P. L., Wright, L. A., Courtney, P., Beaumont, B. and Haines, A. P. (1992) Visual problems in the elderly population and implications for services. *Br. Med. J.* **304,** 1226–1229.
Yap, M. and Weatherill, J. (1989) Causes of blindness and partial sight in the Bradford Metropolitan District from 1980 to 1985. *Ophthal. Physiol. Opt.* **9,** 289–292.