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Screening for Diabetic Retinopathy by Optometrists: Effectiveness and Cost-Effectiveness.

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DISCUSSION PAPER 137

SCREENING FOR DIABETIC RETINOPATHY BY OPTOMETRISTS: EFFECTIVENESS AND COST-EFFECTIVENESS.

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Abstract

This report examines the effectiveness and cost-effectiveness of screening for diabetic retinopathy by optometrists.

There are strong arguments for screening. Diabetic retinopathy is an important public health problem, there is an effective treatment, the natural history of the disease is well understood, adequate and acceptable screening exists and the cost of case finding is small in relation to overall expenditure on the disease (Section 2).

The major unresolved issue concerns the choice of screening modality, i.e. who should perform screening, when and how. A literature search revealed 18 citations presenting data relating to screening by optometrists (Section 3).

The only cost-effectiveness study of screening modalities directly relevant to the UK is the Special Medical Development Project (SMDP). Whilst an extensive study, the SMDP has a number of methodological weaknesses which make it inappropriate to conclude that one screening modality is more cost-effective than another (Section 3.2).

Another British study, undertaken in Frenchay health district, provides starkly different evidence on the effectiveness of screening by optometrists (Section 3.4).

The overall conclusion is that there are no ideal data for addressing the effectiveness and cost-effectiveness of optometrists in screening for diabetic retinopathy (Section 3.9).

The selection of screening modalities for diabetic retinopathy needs to take account of the current environment for care. In particular, the manner in which diabetics currently present to the health service would make a single modality of limited use (Section 4).

Key features of the development of screening schemes include the role of training of practitioners, the development of protocols for care and sharing data, reimbursement and audit (Section 4).

One way to resolve controversy would be to undertake a new prospective study of optometrists in screening. However a more pragmatic design, mirroring the current environment of care, may be important. Smaller trials investigating sub-issues, and, surveys of diabetics and potential screeners may produce a valuable backdrop in designing appropriate studies (Section 5).

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1 Introduction

Diabetic retinopathy is a complication of diabetes that affects the blood vessels in the retina. Deterioration of these blood vessels and proliferation of new vessels may, through haemorrhage and leakage, lead to blindness.

There is a good case for screening and treatment of diabetic retinopathy since the various criteria defining the need for, and cost-effectiveness of, screening are largely fulfilled.

However, there are a number of alternative strategies for screening involving optometrists (ophthalmic opticians), GPs, diabetologists, ophthalmologists and other health staff in a variety of settings: these are not mutually exclusive. In addition, various techniques are available for screening including direct and indirect ophthalmoscopy with or without mydriasis (dilatation of the pupil), and mydriatic and non-mydriatic retinal photography. Ophthalmoscopic screening of all diabetic patients by ophthalmologists is a practical impossibility given the relatively small number of ophthalmologists available. The main alternatives for primary screening in Britain are retinal photography or ophthalmoscopy conducted by general practitioners (GPs), optometrists or diabetologists. Non-mydriatic photography can be performed by any trained person in a community or mobile setting.

It is uncertain what role training and experience play in screening performance. Differences in the conduct of ophthalmoscopy by GPs and optometrists are seldom considered in the literature. Optometrists commonly use direct ophthalmoscopy, an increasing number also use a Volk lens with a slit lamp permitting stereoscopic indirect ophthalmoscopy (which permits depth of field visualisation). GPs commonly use only direct ophthalmoscopy which is inferior for detecting background vessels and pre-proliferative stages and which gives a smaller field of view. While optometrists commonly receive around 300 hours training in ocular examination as part of certification, medical school training may provide, at best, 10 hours of retinal observation for GPs

There is some debate about the importance of the use of mydriasis in retinal examination. Prolonged mydriasis is unpopular with patients although shorter acting mydriatics are available. Diabetic patients have, on average, smaller pupils and poorer reaction to darkness (natural mydriasis) than typical at their age. In general, optometrists do not routinely use mydriasis unless necessary although they are fully trained in mydriatic pharmacology. Use of mydriasis provides a better view of the fundus. However, there is a small risk of inducing angle closure glaucoma which makes some GPs cautious of its use. Dark room facilities,

available to all optometrists and ophthalmologists, assist clear retina visualisation and permit natural pupil dilation where possible.

Issues of training and experience also apply to the taking and reading of photographs. Photographic media may be Polaroids for immediate assessment, or transparencies which offer better picture quality and are suited to expert evaluation at a later date.

Seven field stereoscopic fundus photography in a hospital setting is commonly considered the gold standard against which other modalities are assessed, although other standards are used in some studies. Fluorescein fundus photography allows highly detailed examination of the retinal microcirculation. However, patients find this latter technique unpleasant. Orally administered Fluorescein appears to avoid some of the problems associated with intravenous administration (Owens et al, 1991).

The available literature suggests that there is still considerable uncertainty about how best to implement screening. A recent Department of Health sponsored study suggested that screening by optometrists for diabetic retinopathy was inferior to some alternatives. However, closer examination of the study concerned suggests several plausible explanations, unrelated to screening performance, for apparent differences between the various groups of screeners included. The evidence concerning the role of optometrists in screening for diabetic retinopathy is re-examined here and inappropriate conclusions in the literature are challenged.

This report examines the available scientific evidence concerning the use of optometrists to screen for diabetic retinopathy. The scope is then broadened to consider the current environment of care in Great Britain and how, pragmatically, screening for diabetic retinopathy can be developed.

2 Is screening for diabetic retinopathy worthwhile?

Before examining the evidence on the effectiveness and cost-effectiveness of the different screening modalities, it is necessary to establish that screening by any modality is worthwhile. The principles guiding the need for a screening programme are set out by Wilson and Jungner (1968). These are applied to diabetic retinopathy below.

(i) The disease is an important public health problem.

Diabetic retinopathy is the leading cause of blindness in the working age population (Sorsby, 1972; Kahn, 1974; National Advisory Board [US], 1980; Wilson, 1980; Ghafour, 1983). Most diabetics get diabetic retinopathy in some form during their lives (Klein et al, 1984a,b), although in mild forms no treatment is necessary. Concern rests with detecting the proportion of individuals who develop progressive retinopathy which may result in deterioration of visual acuity and blindness. Two recent English population based studies have addressed the prevalence of diabetic retinopathy in Melton Mowbray (McLeod et al, 1988) and Poole (Gatling et al, 1988). Prevalence of all forms of retinopathy found in the Melton Mowbray study was 41% for IDDs. In the Poole study prevalence was 38% for insulin dependent diabetics (IDDS) and 26% for non-insulin dependent diabetics (NIDDS). Sight threatening retinopathy was found to be prevalent in about 9% of the diabetic population in both studies. The SMDP (described further in Section 3), an English multicentre study conducted between 1986 and 1989, found the prevalence of newly detected sight threatening retinopathy to be between 3.3% and 7.3%, and an average incidence of new sight threatening retinopathy after one year of 1.5%.

(ii) There is an effective treatment for detected disease.

Intervention during the progression of disease by laser photocoagulation is effective and acceptable to clinicians and patients. The Diabetic Retinopathy Study (1976, 1981) and British Multicentre Study (1984) demonstrated the effectiveness of photocoagulation treatment for proliferative retinopathy. Similarly the British Multicentre Study (1983) and the Early Treatment Diabetic Retinopathy Study (1985) demonstrated the effectiveness of photocoagulation in preventing visual loss due to

maculopathy. Estimates of reduction in impairment vary from 50-90% depending on the stage at which disease is detected and the type of retinopathy.

(iii) Facilities for diagnosis and treatment are available.

Stereoscopic seven field fundus photography, or retinal examination by a consultant ophthalmologist, can be performed on an outpatient basis. Treatment is, in principle, available at any hospital ophthalmic department in the United Kingdom.

(iv) There is a latent or early symptomatic stage.

Diabetic retinopathy is a well-defined disorder which can be seen to evolve through several stages, beginning with background retinopathy and finishing with proliferative retinopathy, exudative maculopathy or both.

(v) There should be an adequate screening test.

There is considerable variation in the test performance of the various modalities achieved by various investigators (Singer et al, 1992; and see bibliography). This is likely to be due in part to differences in the conduct of the various studies with respect to test implementation, level of training, definition of retinopathy and test sensitivity. It may also be due to the small sample size in many studies, leading to wide confidence intervals. However, the results of some studies indicate that, when properly conducted, screening performance is sufficiently sensitive and specific.

(vi) The process of screening should be acceptable to the population.

Screening by any of the modalities is straightforward, and complications due to mydriasis (when used) are rare.

(vii) The natural history of the disease should be understood.

Prevalence and progression of diabetic retinopathy differ between insulin dependent diabetics (IDDS) and non-insulin dependent diabetics (NIDDS). [Sometimes diabetics are dichotomised as either type I - insulin dependent with 'younger-onset' diabetes diagnosed before 30 years of age, or type II - diabetes diagnosed at or older than 30 years of age. This grouping is, in practice, very similar in composition to classification as IDD or NIDD]. Vision-threatening retinopathy does not normally

appear in IDDs in the first 5 years after onset of diabetes or before puberty (American College of Physicians, 1992).

(viii) A policy exists on which patients to treat.

The DRS and ETDRS clearly indicate the beneficial effect of photocoagulation for proliferative retinopathy and maculopathy. The ETDRS also established that diabetics with mild to moderate nonproliferative retinopathy or less severe maculopathy should be monitored rather than treated.

(ix) The cost of case finding should be considered relative to overall expenditure on medical care from the condition.

Diabetic retinopathy is the most common cause of blindness in the working population. Studies suggest that screening and treatment may be cost saving from the societal viewpoint, although this may not be true for particular budget holders such as health authorities (Javitt et al, 1989, 1990, 1991; Fendrick et al, 1992; Dasbach et al, 1991). However the estimated health benefits, in terms of prevention of deterioration in sight and blindness, are considerable such that screening is considered an appropriate use of health service resources.

(x) Case finding should be an ongoing process, not 'once-for-all'.

Since diabetic retinopathy is a progressive disease, new cases are expected to occur over time. Having established the need to screen, the period between screens needs careful consideration. From an economic viewpoint, the efficient period would balance the incidence of new cases, the rate of disease progression and the relative costs of different screening intervals.

In summary, the potential benefits of screening for diabetic retinopathy are evident. However, a lack of consistency of findings with respect to test sensitivity, specificity and accuracy characterises the literature and makes attempts at the relative cost-effectiveness of alternative screening modalities speculative. This is explored below, with particular emphasis on screening by optometrists.

3 Are optometrists effective and cost-effective screeners?

A MEDLINE search was conducted for the twenty years from 1975 to 1994. The citations found are indicated in Table 1. Examination of the references of these citations, other MEDLINE searches and consultation with the British College of Optometrists and colleagues provided three additional references. Underlying the total of 18 citations found are 5 data sets relating to screening effectiveness: these are discussed in turn. Only 2 data sets are thought to have direct bearing upon screening in the United Kingdom: these arise from the SMDP [1-5] and the second Frenchay study [7]. The data reported in the first Frenchay study [6] are included in the second and therefore cannot be considered to be independent information.

Table 1. MEDLINE search for studies relating to optometrists, 1975 - 1994

{screening}[a] and {diabetic retinopathy}[b]
=1150 citations

{optometrist}[c] and {screening}[a] and {diabetic retinopathy}[b]
=15 citations + 3 references = 18 citations

Screening	
UK: SMDP[d]	[1] Health Economics Research Group. Diabetic retinopathy screening project: special medical development at Exeter, Oxford and Sheffield. Final report from the evaluation team. March 1990. Brunel University
	[2] Health Economics Research Group. Diabetic retinopathy screening project: special medical development at Exeter, Oxford and Sheffield. Final report from the evaluation team. Summary. March 1990. Brunel University
	[3] Buxton MJ. Sculpher MJ. Ferguson BA. Humphreys JE. Altman JF. et al. Screening for treatable diabetic retinopathy: a comparison of different methods. Diabetic Medicine. 1991; 8: 371-7.
	[4] Sculpher MJ. Buxton MJ. Ferguson BA. Humphreys JE. Altman JF. et al. A relative cost-effectiveness analysis of different methods of screening for diabetic retinopathy. Diabetic Medicine. 1991; 8: 644-50.
	[5] Sculpher MJ. Buxton MJ. Ferguson BA. Spiegelhalter DJ. Kirby AJ. Screening for diabetic retinopathy: a relative cost-effectiveness analysis of alternative modalities and strategies. Health Economics. 1992; 1: 39-51.
UK: Frenchay 1	[6] Gilbert CE. Armstrong S. Burns-Cox C. Dean Hart JC. Screening of diabetics by ophthalmic opticians. Trans. Oph. Soc. UK. 1982; 102: 249-52
UK: Frenchay 2	[7] Burns-Cox CJ. Hart JC. Screening of diabetics for retinopathy by ophthalmic opticians. BMJ . 1985; 290: 1052-4.
	[8] Bron A. Screening for treatable diabetic retinopathy. BMJ. 1985; 290: 1025-6
	[9] Bhopal RS. Hedley AJ. Screening of diabetics for retinopathy by ophthalmic opticians [letter]. BMJ. 1985; 290: 1589.
	[10] Rohan TE. Frost CD. Wald NJ. Prevention of blindness by screening for diabetic retinopathy: a quantitative assessment . BMJ. 1989; 299: 1198-201.
UK: Poole	[11] Hill RD. Screening for diabetic retinopathy at primary care level. Diabetologia, 1981; 10:9
Evaluation	
USA: Wisconsin	[12] Moss SE, Klein R, Kessler SD, Richie KA. Comparison between ophthalmoscopy and fundus photography in determining severity of diabetic retinopathy. Ophthalmology. 1985; 92(1): 62-7.
USA: Alabama	[13] Kleinstein RN, Roseman JM, Herman WH, Holcombe J, Louv WC. Detection of diabetic retinopathy by optometrists. Journal of the American Optometric Association. 1987; 58(11): 879-82.
Referral issues	
UK: Bristol	[14] Clark JB. Grey RH. Lim KK. Burns-Cox CJ. Loss of vision before ophthalmic referral in blind and partially sighted diabetics in Bristol BJ Ophthalmology. 1994; 78: 741-4.
UK: Lanarkshire	[15] Sullivan FM. Stearn R. MacCuish AC. The role of general practitioners in diabetic eye care in Lanarkshire. Diabetic Medicine. 1994; 11: 583-5.
UK: London	[16] Harris A, Bonell C, Evans T, Roberson G Commissioning diabetic eye screening by optometrists: a local initiative at the primary-secondary care interface. Journal of Medical Screening 1994; 1: 13-15
UK: Buxton	[17] Harrison RJ. Wild JM. Hobley AJ. Referral patterns to an ophthalmic outpatient clinic by general practitioners and ophthalmic opticians and the role of these professionals in screening for ocular disease. BMJ. 1988; 297: 1162-7.
Review	
	[18] Ederer F. Methodological problems in eye disease epidemiology. Epidemiologic Reviews. 1983; 5: 51-66.

a vision screening (mesh) **or** diagnosis (exploded), eye (non mesh) **or** screen$ (text word).
b diabetic retinopath$ (text word) **or** diabetic retinopathy (mesh).
c optician? (text word) **or** optometrist? (text word) **or** optometry.
d Special Medical Development Project (SMDP).

3.1 The Special Medical Development Project (SMDP)

The most recent British study, conducted by Buxton and colleagues, also incorporated an economic evaluation [1-5]. The original report [1] gives the details of screening for 6 patient groups in 3 English centres: Exeter, Oxford and Sheffield: the five groups addressing primary screening are analysed in subsequent publications [3-5]. Ophthalmoscopy with mydriasis was used by general practitioners at each centre, by hospital physicians for another group of patients in Exeter and by optometrists for another group in Oxford. Additionally most patients in the groups had non-mydriatic 45° fundus Polaroid photographs taken by ophthalmic clinical assistants (OCAs: non-consultant grade hospital-based ophthalmologists), with blinded assessment by a consultant ophthalmologist. Also, most patients were examined by ophthalmoscope using mydriasis by a clinical assistant following retinal photography. The OCAs' opinions form the reference standard for the study against which other findings were assessed.

Screeners using ophthalmoscopy were asked to record any of seven sight threatening manifestations of retinopathy and to assign referral grades of (i) normal, (ii) abnormal not referred, or (iii) referred. Comparative performance of referral by screeners and clinical assistants was used to determine test sensitivities and specificities: these are shown in Table 2. Findings were similarly reported for non-mydriatic photography performed by a visiting clinical assistant [1,3]

Table 2: Test findings reported by Buxton et al [3]

Ophthalmoscopy with mydriasis:	Exeter		Oxford		Sheffield
	Hospital physician	GP	Optometrist	GP	GP
Patients enrolled	656	2161	1095	978	2324
Patients included[a]	427	1207	415	628	641
Patients with complete data[b]	416	1150	395	618	582
Sensitivity[c]	0.67 (20/30)	0.57 (38/67)	0.48 (10/21)	0.41 (15/37)	0.67 (12/18)
95% Confidence interval	0.50-0.84	0.45-0.69	0.26-0.69	0.25-0.56	0.45-0.88
Specificity[d]	0.96 (371/386)	0.94 (1018/1083)	0.94 (352/374)	0.89 (518/581)	0.86 (484/564)
95% Confidence interval	0.94-0.98	0.93-0.95	0.92-0.97	0.87-0.92	0.83-0.89
Positive predictive value	0.57	0.37	0.31	0.19	0.13
Negative predictive value	0.97	0.97	0.97	0.96	0.99

a Patients were excluded because they were blind, were already treated for diabetic retinopathy, had been seen in the last year by an ophthalmologist, or other unrecorded reason.

b Data were complete when matching data on the referral grade given by both the OCA and the screener were available.

c In parenthesis: proportion of all truly positive cases who screened positive.

d In parenthesis: proportion of all truly negative cases who screened negative.

It can be seen that the study did not find any statistically significant differences in performance between the different screeners in terms of test sensitivity, although the Oxford and Sheffield GP groups appear to have a significantly poorer test specificity. In the first journal-published account of the study [3] the authors avoid drawing inappropriate conclusions since the number of cases of referral is small and uncertainty large. They note that the test sensitivity for all methods is lower than expected and that on this evidence single screening methods would miss a large proportion of cases of sight threatening diabetic retinopathy.

In the first of two journal-published economic evaluations, Sculpher et al [4] include estimates of resource costs for the various screening modalities from their original report [1]. Cost-effectiveness is determined as the cost per true positive detected, using the point estimates of test sensitivities and specificities and assuming a prevalence screen with prevalence of referable disease of 5.8%. The probability of detecting a true positive case for each screening modality was the product of the sensitivity of the test and disease prevalence. The cost of screening was estimated for each modality and included patient travel and time, and the cost of hospital assessment of both true and false referrals. The cost-effectiveness ratios for the various groups are shown in Table 3.

Table 3: Cost per true positive case detected, reported by Sculpher et al [1, 4]

Ophthalmoscopy with Mydriasis:	True positive cases identified per screen[e]	Total Cost per Screen[f]	Cost per True Positive (£,1989-90)[g]
General practitioner			
Exeter	0.033	23.13	702
Oxford	0.024	25.59	1079
Sheffield	0.039	24.14	633
Diabetic physician	0.039	40.26	1033
Optometrist	0.028	21.61	784
OCA			
Exeter	0.058	25.73	441
Oxford	0.058	35.09	609
Sheffield	0.058	26.07	452
Photography			
Exeter (a, b)	0.039, 0.034	35.76, 18.28	923*, 545*
Oxford (c, d)	0.027, 0.020	37.67, 35.13	1390*, 1730*
Sheffield	0.039	25.93	670*

a Patient travelling to hospital
b Patient travelling to GP
c Optometrist group photographed by clinical assistant at hospital
d GP group photographed by clinical assistant at hospital
e Prevalence (5.78%) x Test Sensitivity (see Table 2)
f Total cost per screen includes cost to health service of screening, cost to patients in travel and time and cost of confirmatory diagnosis.
g $\text{Cost per True Positive} = \frac{\text{Total cost/screen}}{\text{True positive cases/screen}}$.
* Calculated using actual numbers screened ([1,4] assume a uniform 2000 screens per year for all camera groups).

A sensitivity analysis considered the effect of varying throughput of screened patients having non-mydriatic fundus photography, and also of changing the underlying prevalence of disease. In their discussion the authors consider the impact of costing only the additional time taken to screen by the hospital physicians and GPs assuming that screening is part of annual assessment. The cost-effectiveness ratios are reduced to nearly a third of the ones shown in Table 3 indicating that findings are very sensitive to cost assumptions. The authors avoid referring to superior and inferior modalities, since the results achieved by the GPs varied among the three centres. They note that OCAs appear to perform very well (test sensitivities and specificities of 100% are applied by definition) but constrained supply of staff does not make this a realistic general screening modality and 100% test characteristics are unlikely to be achieved in practice.

In the second economic evaluation, Sculpher et al [5] extend the previous analysis: data collected on the single modality options are used to model the results of combined strategies in an attempt to devise more acceptable screening performance. These new modalities include combined ophthalmoscopy and non-mydriatic photography and selective screening where high risk patients are automatically referred. High risk patients are defined as those with type I diabetes of 10 or more years duration. Thirteen different modalities are considered involving single, combination and selective screening; those options subject to 3-way domination with respect to sensitivity, specificity and cost per true positive are excluded. Three strategies remain when considering two way domination, i.e. eliminating all strategies inferior in both sensitivity and cost-effectiveness (Table 4).

Table 4: Two-way dominant strategies for screening, Sculpher et al [5]

	Option	Sensitivity	Expected cost per true positive case detected, £	Incremental cost per additional true positive, £
A	- Direct referral of high risk cases; - no screening of low risk cases	0.25	168	
B	- Direct referral of high risk cases; - Camera screening of low risk cases at the GP practice by visiting clinical assistant	0.68	443	601
C	- Direct referral of high risk cases; - Camera screening of low risk cases at the GP practice by visiting clinical assistant, and, - GP ophthalmoscopy with mydriasis	0.85	679	1663

Interestingly the cheapest strategy (A), offering the lowest cost per true positive case detected, involves direct referral of high risk patients with low risk patients left unscreened. However

this strategy alone is unacceptable since most cases meriting referral would be missed. None of the dominant strategies involve optometrists. The authors conclude:

...opticians alone or with GP-visiting camera are more expensive and less sensitive. [1,2]
It is clear that, in relative terms the [optician screen] is not a 'competitive option' [5].

3.2 Critique of the SMDP study findings

Since the SMDP is the only economic evaluation of screening for diabetic retinopathy undertaken in the UK, and since its conclusions relate directly to screening by optometrists, it is important to examine the study carefully. There are two areas of concern with the design of the study and subsequent analysis, each in themselves adequate to lead us to question the above conclusions.

Statistical meaning

1 Assuming that the findings for the five groups can be meaningfully compared, then the study did not find any statistically significant differences in test sensitivity between the three types of screeners (optometrists, GPs and physicians). This is despite a range of test sensitivity in GP groups of from 0.67 to 0.41. However, a significant difference was found in the odds ratios across groups (p=0.004), where the odds ratio is defined as:

$$\text{Odds ratio} = \frac{\text{true negatives x true positives}}{\text{false negatives x false positives}} .$$

The largest influence on the statistic is the poor performance of the Oxford GPs. Examining the three GP groups alone there is a statistically significant difference in their odds ratios (p=0.009). Whether such heterogeneity is genuinely due to differing performance by the GP groups or due to differences in other characteristics is unresolved. However, the pooled estimates of GP performance used in the economic analyses [2,3,5] are difficult to apply when they conceal wide variation from centre to centre.

2 In their cost-effectiveness estimates the authors made no attempt to model the uncertainty surrounding point estimates of test performance. Had they done this, it is likely that most or all of the bounds of cost-effectiveness estimates would have overlapped. This would have led to the appropriate conclusion that all strategies were indistinguishable in terms of cost-effectiveness with the available data. The reporting and use of the point estimates of

sensitivity and specificity to construct the cost-effectiveness estimates has created a false impression of precision. Until recently this has been a common problem in published economic studies; new guidelines for exploring uncertainty through sensitivity analysis seek to improve standards (Briggs et al, 1994; Mason et al, 1995). Even when economic analyses have been based directly on randomised controlled trial data, main estimates have often been reported of cost-effectiveness without associated confidence intervals.

Group comparability and representativeness

The SMDP, in common with other demonstration projects undertaken around the same time, was not designed as a controlled evaluation. Therefore, to arrive at the conclusions made, it is necessary to assume that the primary screeners, their patient groups and their evaluation by the reference standard (the clinical assistants) are all comparable (or adequately so). It is also necessary that these are representative if the conclusions are to have any general meaning beyond the locations of the study itself.

There are a number of reasons to suppose that the conditions of comparability and generalizability may not hold. All of these are acknowledged by the authors in the first report [1]. It is noteworthy that the three centres in the study were chosen precisely because they featured very different demographic and health care characteristics, and that the pattern of screening was permitted to differ at each centre to reflect local preferences [1].

1 In Exeter, the hospital clinician group existed prior to the study, creating a selection bias between them and the GP group, reflected in a lower disease prevalence for the GP group. Similarly the Oxford optometrist group was composed of patients whose GPs declined to screen: this group and the Sheffield GP group had higher exclusion rates and lower prevalence of retinopathy than the other groups. Although reduced prevalence does not bias estimates of sensitivity directly, it does lower the likelihood and thus the experience of encountering disease. Unfortunately the study does indicate the average number (or variation in number) of patients seen by professionals in each group. Clearly if the number of diabetics seen with sight-threatening retinopathy, by individual professionals, was low then this might be expected to influence the consistency and quality of findings: there is likely to be a 'learning curve' for those involved in screening. The authors touch on this, suggesting that the hospital physicians in Exeter may have been more experienced in recognising retinopathy. The study does not record the proportions of those who were

invited to screen for each group who actually participated: it is unclear how representative screeners are of their respective professional groups.

Differences also existed variously between patient groups in terms of age, type and duration of diabetes, and diabetics included and excluded. An analysis of variance was conducted including age, patient gender, duration and type of diabetes and smoking to see if these factors explained differences in test sensitivity between centres. This test was not statistically significant and appears to have been interpreted as equivalence [1], although is unclear what the power was of the study to detect such a difference. In addition, a comparison between centres would mask the reported differences between groups at the same centre.

2 Different clinical assistants (OCAs) were used in each of the centres: however, no inter-observer comparison was attempted to demonstrate comparability between the findings at different centres and between assistants. The use of OCAs as the point of reference was explained as a pragmatic solution, since multi-field stereoscopic fundus photography or Fluorescein angiography would have been prohibitively expensive. For the Oxford group a number of referrals made by an OCA were considered incorrect and altered by the Centre Director (the consultant ophthalmologist). Test sensitivity for the Oxford optometrist group increased to 0.56 from 0.48 when the calculation was based on 'correct' OCA referrals (see Table 5). The test sensitivity also rises for the Oxford GP group. These changes were referred to as 'marginal' and are not subsequently mentioned.

Table 5: Test performance of Oxford screening groups using ophthalmoscopy, based on OCA referral [1].

	Oxford Optometrists	Oxford GPs
Screened positive	10	15
True positive	18	32
Sensitivity	0.56	0.47
95% Confidence Interval	0.33 - 0.79	0.30 - 0.64
Screened negative	352	518
True negative	377	586
Specificity	0.93	0.88
95% Confidence Interval	0.91 - 0.96	0.86 - 0.91
Average Cost per Screen	21.61	25.59
Cost per True Positive	667	962

However, the details of the disagreements and the outcome in terms of treatment given to patients are not recorded. Nor is it clear what information was available (and at what time) that caused the consultant to overrule the OCA's findings. Adhering to the original study protocol, the point estimate of test sensitivity for the Oxford Optometrist group becomes equivalent to the Exeter GP group (Tables 2 and 5).

3 From Table 2 it can be seen that 56% of patient data were excluded from the study (overall), and this rose to 64% for the optometrist group at Oxford. While the small exclusions due to blindness, previous treatment or incomplete data are logical, exclusion of large numbers of patients because they have been seen in the previous year by an ophthalmologist is not. Having recently been seen is not the same as being in the care of an ophthalmologist (although these are assumed to be the same as the analysis develops [3]). Inclusion of this latter group would have provided a truer estimate of prevalence of diabetic retinopathy. Additionally, such large proportions excluded for unknown reasons (28% in the optometrist group) mean that the representability of the groups is uncertain. Greater inclusion would have provided a more pragmatic and less ambiguous interpretation and most importantly would have provided narrower confidence intervals on estimates. It would be interesting to know if the findings of the study were unchanged when using broader inclusion criteria in the analysis.

4 The protocol of screening also differed significantly between centres. At Exeter, all measurement for each diabetic occurred in the same session. At Oxford and Sheffield photography and ophthalmic examination by the clinical assistant occurred at a later date. The interval between primary screen and examination by the OCA is unrecorded. If the period was of the order of months then disease may have developed in this time which would have the effect of lowering test sensitivity. It is not recorded whether the levels of, or participation in, the training sessions provided are the same between groups but GPs appear to have received considerable assistance during the study from research staff: no such assistance or contact is recorded for the optometrist group. Although patient case notes were available to GPs when screening, it is unrecorded whether such information was available to optometrists.

The authors explore the possibility of GP screening as a marginal activity (for example as part of annual health checks for diabetics). In addition they consider whether the NHS sight test charge used in the analysis, for the cost of optometrist screening, may be an underestimate of real resources used. However, it is plausible that screening by optometrists may also be

conducted as a marginal activity. Since most diabetics regularly visit a high street, specific patient travel costs are unlikely and many diabetics undergo regular eye examinations by optometrists, who would be expected to examine the fundus routinely. If lower costs assuming screening as a 'marginal' activity are to be considered then these should be applied to all community-based practitioners.

In summary, it is unclear to what extent the economic analysis [2,5] addresses true differences in screening performance between groups as opposed to differences in study protocol, demography and the role of chance. Point estimates have been abstracted and presented in a manner conveying a false sense of accuracy. The overall conclusions that general practice-based strategies are dominant [2,5] and provide considerable cost-savings compared with optometrist-based strategies [5] are therefore questionable.

While the SMDP is the only British study to attempt explicit comparisons between the effectiveness and cost-effectiveness of optometrists and other screeners, there are other data relating to optometrists' screening performance.

3.3 The First Frenchay Study

Over an 18 month period from July 1980, diabetics in the Frenchay health district of Bristol were examined by optometrists. All diabetics in the district were issued with a new diabetic card and were asked to visit an optometrist and be subsequently examined by an ophthalmologist. Only those diabetics blind or currently under the care of an ophthalmologist were excluded. An ophthalmologist and the study co-ordinator spent 4 hours acquainting the optometrists with the purposes of the study. Optometrists were issued with triplicate forms, so that findings were kept by themselves, sent to the GP and to the study co-ordinator. Retinal examination was usually conducted without mydriasis.

During the study period 345 forms were returned; 23 patients already receiving ophthalmological care were excluded (thus the percentage of diabetics excluded by design is much less than in the SMDP). Of the remaining 322 patients, 285 were reported normal and 37 abnormal. All abnormal patients and a random sample of 206 of the normal group were sent for re-examination by one of two ophthalmologists. The results of the study are summarised in Table 6.

Table 6. Findings of the first Frenchay study [6].

322 eye examinations	(23 of 345 already receiving ophthalmological care and excluded)
37 positive screens	(positive = 'any abnormal pathology')
31 attended re-examination by ophthalmologist	(2 died, 4 failed to attend)
11 had background retinopathy	
1 had advanced untreatable maculopathy	
10 had treatable retinopathy	
6 had non-diabetic pathology	
3 had normal fundi	
285 negative screens	
127 attended ophthalmologist examination	(206 invited; 3 died, 76 failed to attend)
120 had normal fundi	
7 had background retinopathy not requiring treatment	

Since the reported results relate to optometrists looking for any pathological abnormalities, obtaining a useful test sensitivity for diabetic retinopathy from the data (in terms of those requiring treatment) is not straightforward. The test specificity, for any abnormality present is 68%, and test sensitivity is 99% (see Table 8 for method of calculation and assumptions).

It might be thought desirable for optometrists to refer all abnormalities when screening for diabetic retinopathy: the proportion classed as positive was 12% of screens. The role of suitable training for optometrists to screen more specifically for sight threatening retinopathy whilst maintaining adequate screening performance is an important research question. The study, in common with the SMDP, omits certain important details: the number of optometrists invited to participate; the number who actually participated; the number, and variation in number of diabetics with retinopathy seen by optometrists; and the delay in time between screening and re-examination.

3.4 The Second Frenchay Study

The second Frenchay study was conducted in a similar manner and included the data from the first study [7]. However in this study data are presented indicating whether optometrists suspected detected retinopathy to be sight threatening or not, and thus whether referral was merited. Intrinsically this is more useful, since it is in the interests of patients and screeners to minimise false positives, preventing an excessive referral caseload from developing. Screening was conducted over a second period of 22 months starting from March 1982. The

reference standard changed from direct and indirect ophthalmoscopy with mydriasis by an ophthalmologist (in the first screening period) to ophthalmologist-viewed photographs (in the second screening period). The influence of this change upon results is unknown since no common reference standard is used in both screening periods. However, the decision of the ophthalmologist to treat (with examination by either method) is the pragmatic gold standard. The overall study findings are shown in Table 7.

The authors suggest that poor re-examination rate of those with mild or no retinopathy may have been due the reassurance of the optometrists' findings (thereby affecting the patient's motivation to be examined further) and the relative inaccessibility and inconvenience of visiting Bristol Eye Hospital.

Table 7. Findings of the second Frenchay study [7].

814 eye examinations	(23 of 837 already under the care of an ophthalmologist, excluded)
72 positive screens	(positive = potential sight threatening retinal change)
52 attended re-examination by ophthalmologist	(5 died, 15 failed to attend)
15 had retinopathy requiring treatment	
3 had retinopathy untreatable or too advanced to treat.	
20 had background changes not requiring treatment (false positive)	
11 had non-diabetic retinal changes (false positive)	
3 had normal fundi (false positive)	
742 negative screens	(negative = normal fundi or mild changes)
197 attended ophthalmologist examination	(358 invited; 8 died, 153 failed to attend)
175 had normal fundi	
21 showed mild background retinopathy	
1 had maculopathy requiring treatment (false negative)	

If it is assumed that non-attendance bias is not a problem, i.e. attenders at confirmatory examinations are representative, the test performance can be calculated [9] (table 8). Such a bias could never be ruled out but there is no obvious reason why, in those screened negative or positive, non-attenders for re-examination should have a higher proportion of sight threatening retinopathy than attenders.

Table 8. Estimated screening performance in the second Frenchay study [7]. (Data: see Table 7; calculations in parenthesis).

	Reference: Ophthalmologist	
	Positive[a]	Negative
Optometrist: Positive	**24.9** $\{\frac{18}{52} \times 72\}$	**47.1** $\{\frac{34}{52} \times 72\}$
Negative	**3.8** $\{\frac{1}{197} \times 742\}$	**738.2** $\{\frac{196}{197} \times 742\}$

$$\text{Test sensitivity}^b = \frac{24.9}{3.8+24.9} = \mathbf{87\%}$$

$$\text{Test specificity}^b = \frac{738.2}{738.2+47.1} = \mathbf{94\%}.$$

a Screens correctly indicating sight threatening retinopathy include treatable cases and cases beyond treatment

b Assuming no attendance bias:

- checked positive and negative screens are representative of all positive and negative screens; and
- no re-attendance in second screening period of those screened in first period

The results suggest that considerably better performance was achieved by the optometrists in this study than by the Oxford optometrists reported in the SMDP [1-5], and it is interesting to speculate why this should be the case. The caveats about inadequate reporting detail, from the first Frenchay study, apply again. It is known, however, that training was minimal. Referral based on optometrists' belief of the existence of sight threatening retinopathy indicates a 9% referral rate.

3.5 The Poole Study

The feasibility of screening for diabetic retinopathy in the routine diabetic clinic of Poole District General Hospital was conducted and compared with data from a pilot screening study featuring optometrists [11]. The study is reported as an abstract and there are insufficient information about the methods and data generated to calculate screening performance. Prevalence of diabetic retinopathy was 22.4% in the pilot study group and 26.5% in the diabetic clinic population. More recently Gatling and colleagues (1995) have reported an audit of screening and follow-up provided at Poole and Dorset.

3.6 The Wisconsin Study

Moss and colleagues [12] report a population based study in Southern Wisconsin, USA, where retinopathy levels were determined by ophthalmoscopy and graded photographs in 1949 diabetics. Direct and indirect ophthalmoscopy using mydriasis was conducted by an ophthalmologist, a specially trained optometrist and an ophthalmic technician. Seven field stereoscopic fundus photography was used as the reference standard, all measurements for each diabetic occurred at one visit to a mobile van sited near the diabetic's place of residence, and grading of photographs was by trained graders. Consultation was permitted between the three examiners and findings were nearly identical for all three. Exact agreement between ophthalmoscopy and graded photographs occurred in 86% of cases, where grading could be proliferative, non-proliferative, or no retinopathy. Disagreement with graded photographs occurred most often with milder retinopathy and early in the study.

Given its conduct (consultation permitted), the study has no direct relevance to the likely performance of screening by optometrists in Britain.

3.7 The Alabama Study

Kleinstein and colleagues [13] conducted a study at the University of Alabama, USA, to assess the ability of optometrists to diagnose diabetic retinopathy. Optometrists examined patients using direct and indirect ophthalmoscopy with mydriasis, without patient medical history or clinical data. Fourteen patients (25 eyes), with a range from no retinopathy through to extensive retinopathy, were examined and optometrists' findings were assessed against ophthalmologist reading of seven-view stereo colour fundus photos. Eleven optometrists from the university medical centre and eight community optometrists from private practices were assessed.

Optometrists correctly diagnosed whether retinopathy was present or not in 77% of the eyes (95% CI: 73%, 82%), and correctly diagnosed the type and degree of diabetic retinopathy in 57% of the eyes (95% CI: 39%, 75%).). The test sensitivity for diagnosis by the optometrists using ophthalmoscopy was 74% (95% CI: 67%, 81%), while specificity was 84% (95% CI: 73%, 96%). However, for the purposes of calculating sensitivity and specificity, true positive cases were eyes exhibiting diabetic retinopathy (contrasting with studies where the presence

of sight-threatening retinopathy defined a true positive) thus limiting comparison with the SMDP or second Frenchay study.

Correct grading of retinopathy was superior in the medical centre optometrists (64% Vs 49%, $p<0.01$), but test sensitivity was similar (75% and 73%). Test specificity was 94% and 70% for faculty and community optometrists respectively (difference, $p\approx0.1$).

The authors are cautious about the generalizability of their findings (small numbers of patients, a younger than average sample of optometrists). Also the study eliminated diagnostic information and risk factors normally available to screeners. As with the Wisconsin study, there is no direct interpretation of this study's findings in the British primary screening setting. Differences between the community and hospital optometrists may be attributable to different levels of training and experience. However, both groups of optometrists had use of the same facilities.

3.8 Other Citations

A number of other papers provide relevant background information though they do not report additional data on screening performance.

Bron [8] contributed an editorial in the issue of the British Medical journal reporting the second Frenchay study [7]. This discusses the findings of the second Frenchay study, as well as the natural role that optometrists have in primary screening. Bron suggests that diabetologists who work in centralised clinics may be less accessible to diabetics then optometrists, and that GPs do not generally regard their ophthalmoscopic skills highly. The setting up of the SMDP is mentioned with its purpose to identify the most effective way of providing a screening service.

Rohan and colleagues [10] adopted a modelling approach to estimate the number of cases of blindness due to diabetic retinopathy that could be prevented each year in England and Wales using optometrists as primary screeners.

An incidence rate for proliferative retinopathy and maculopathy was derived from the literature. Findings from 5 trials of photocoagulation treatment were pooled to estimate the reduction in blindness due to treatment. The test sensitivity [9] derived from the second Frenchay study [7] was used to define the detection rate achieved by optometrist screening.

The authors estimate that screening and early treatment of retinopathy would reduce the risk of blindness due to diabetic retinopathy by 56%.

The authors proceeded to estimate the number of cases of blindness due to diabetic retinopathy which could be prevented yearly by a fully implemented screening programme (assuming 100% compliance with screening, diagnosis and treatment).

Clark and colleagues [14] examined the history of care of patients registering blind from diabetic retinopathy in Avon over a period of 16 months from July 1990. There were 572 BD8 registrations: records of 471 (82%) were retrieved. Forty-eight registrations were for diabetics of which 32 were principally for diabetic retinopathy. Fifty per cent of these patients had received no regular (annual) screening; 25% were regularly screened (three quarters by local optometrists); 22% were newly diagnosed diabetic at the time of referral; and the circumstances of one patient were unclear. 72% of registrations were due to maculopathy. The authors also looked at process of care for those screened but are appropriately cautious about drawing conclusions from registration data.

Sullivan and colleagues [15] report the findings of auditing care for diabetics in Lanarkshire, Scotland in 1989-90: 50 of 92 practices participated in the study. Sixty-two per cent of patients attended a hospital clinic for diabetes care. Of 3550 diabetic patients in the study approximately one-third had a record of visual acuity and one half had a record of fundoscopy, performed in the 12 months audited by the study.

Harris and colleagues [16] report the experience of a London family health services authority (FHSA) in commissioning a screening service for diabetics. Problems identified in the commissioning process were reluctance by patients and providers to implement change, and for providers to see the merits of alternative modes of provision. A screening programme was piloted and is currently being introduced which extends current services to formally include approved optometrists.

Harrison and colleagues [17] examined patterns of referral by general practitioners and optometrists to an ophthalmic outpatient clinic. Over a 14 month period from November 1986, 1437 patients were referred to Burton District Hospital Centre: available case notes for 1113 patients were reviewed. The accuracy of referral was assessed by comparing primary and secondary reasons for referral with final diagnosis. Optometrists were far more likely to refer patients with glaucoma correctly (80%) than were general practitioners (37%). Patients referred by optometrists and consultant physicians were much more likely to need laser

treatment for diabetic retinopathy than those referred by GPs, although the total number of cases involved was small. There was little evidence that GPs screened for glaucoma or diabetic retinopathy, whereas optometrists screened for glaucoma with considerable skill and also initiated referrals of several patients with previously unrecognised diabetic retinopathy.

Ederer [18] presents a review of epidemiological research in the four chronic diseases that are the major causes of blindness in the USA: age-related cataract, age-related macular degeneration, diabetic retinopathy and glaucoma. Although the role of optometrists is discussed, this is not in the context of screening for diabetic retinopathy and the paper presents no applicable data.

3.9 Summary of the evidence

The main conclusion from this examination of the literature is that there are no ideal data for addressing the effectiveness and cost-effectiveness of optometrists in screening for diabetic retinopathy. Data from the two relevant studies addressing referral on the basis of need for treatment [1,7] suggest point estimates of test sensitivities for optometrist screening of 48% and 87% respectively, and test specificities of 94% in both studies.

Although the focus of interest has been the performance of optometrists (and hence of ophthalmoscopy) an examination of the broader literature reveals mixed messages about the performance of other practitioners and other techniques, such as photography (see for example the review by Singer et al, 1992; Williams et al, 1986 and the reply by Barrie and MacCuish, 1986; Jones et al, 1988; Higgs et al, 1991 and Taylor et al, 1990). When examining the evidence it is necessary to differentiate between studies addressing screening in 'field' conditions and those conducted in 'laboratory' settings.

4 What is the role for optometrists in the environment of care?

A number of aspects of the current environment of care for diabetics are commonly asserted in the literature. Although available data are seldom adequate, appreciation of the environment of care is important if a protocol for screening is to be implemented successfully.

* Consultant ophthalmologists, the implicit gold standard for identifying serious retinopathy, can not realistically provide eye screening. There were an estimated 433 whole-time consultant ophthalmologists in England in 1994, approximately one for every 1100 diabetics (OHE, 1995; Williams, 1994).

* Diabetologists can provide screening for eye complications as part of a whole package of care for diabetes. However, 40%-60% of diabetics are discharged from hospital to GP care and so are not seen by diabetologists (Finlay et al, 1991; Gatling et al, 1995; Yudkin et al; 1980). The two main contenders for screening diabetics in the community (because of their numbers) are GPs and optometrists.

* GPs are unlikely to gain sufficient experience to diagnose retinopathy with confidence. It is estimated that about 1% of the population are clinically diagnosed diabetics, meaning that a practice with a list size of 10,000 may see, on average, 2 diabetics a week (MacCuish, 1992; Williams, 1994). About one third of these diabetics will have some form of retinopathy (McLeod et al, 1988; Gatling et al, 1988; Foulds et al, 1983) and about one half will already formally be under the care of a diabetologist.

* Perhaps as a consequence of this low exposure to diabetic retinopathy, frequency and type of eye screening provided by GPs often appears inadequate (Finlay et al, 1991; Sullivan et al, [15]; Harrison et al [17]; Yudkin et al; 1980). Whether this could be improved by formal training and whether GPs wish to participate in such training is unclear (MacCuish, 1992). However, there is evidence that GPs are willing to establish referral to a variety of schemes to provide the necessary care (Finlay et al, 1991).

* Optometrists are technically well suited to the primary screening role and may be a suitable vehicle for identifying the majority of diabetics not undergoing hospital supervision (MacCuish, 1992; Bron [8]). However, a successful screening programme will clearly involve a protocol agreed by all participants involved in the care of diabetics. Although problems do arise, these seem to have been overcome successfully in Dorset and Avon and

a similar scheme is developing in south east London (Gatling et al, 1995; Harris et al, 1994).

* The scientific evidence does not currently demonstrate a dominant screening modality (i.e. one type of screener using one particular method). In addition, the manner in which diabetics currently present to the health service would make a single modality of limited use. A corporate response to serious eye complications of diabetes seems appropriate, or the development of 'shared care' systems with vigilance on the part of all of those providing care. District Health Authorities and Family Health Service Authorities are well placed to develop and commission the integrated care required (Williams, 1994).

* Many diabetics may visit optometrists regularly. In 1985, 242 diabetics attending Leicester or Bristol Royal Infirmaries were interviewed: 73% used spectacles; 52% had visited an optometrist in the previous year and 70% in the previous two years (Burns-Cox, personal communication). Optometrists are obliged by statute to refer patients with eye diseases, and report results of examinations of diabetics, to their general practitioners. There is scope to extend these requirements to formal screening. Integration of optometrists into the primary health care team permits collaboration not just for diabetic retinopathy screening but for other visual abnormalities such as glaucoma (Tuck et al, 1991; Harrison et al [17]).

* A feature of the Avon and Dorset systems is two-tier screening. Optometrist and GP referrals are sent to a diabetologist who then refers on to an ophthalmologist if appropriate, thus keeping the hospital ophthalmic department case-load at manageable proportions. Optometrists record findings in triplicate, sending copies to the GP and diabetologist. A fee is paid to optometrists, in addition to the NHS sight charge, for every complete finding submitted (Gatling et al, 1995). However, the guidelines of Association of Optometrists advocate a separate fee schedule for screening independent of the NHS sight test fee (Association of Optometrists, 1994). Different payment schemes will embody different incentive structures.

* One key feature in the development of shared care schemes appears to be the role of training, or certification, of participating optometrists. This permits optometrists to 'calibrate' their observations concerning the types of retinal change that merit referral while providing quality assurances to those providing secondary care. It may also prevent excessive and unmanageable referral rates. The British College of Optometrists is

currently developing a national accreditation scheme for diabetic eye screening. The accreditation procedure is itself in need of formal evaluation.

* A second key requirement for providing a consistent quality of care and effective management is argued to be a centralised diabetic registration database. This could provide on-line information and on-screen reminders for those involved in diabetic care, including information on non-attendance by diabetics and also provide a vehicle for auditing care received (Association of Optometrists, 1994). A 'low-tech' alternative might be the development of shared care cards carried by some diabetics, which would be accessible to all practitioners. Development of any system should involve both professionals and patients from the outset, providing those involved with a sense of ownership and should include appropriate education about the potential health benefits to participants (Williams, 1994). It is important that the value of the database itself can be demonstrated by including, at the design stage, audit capabilities.

5 Conclusions

The need to screen for diabetic retinopathy is uncontroversial. The SMDP [1-5], designed originally as a feasibility study rather than an explanatory trial, is inconclusive, primarily due to design limitations. The second Frenchay study [7] provides starkly different evidence suggesting that optometrists perform very well when screening for diabetic retinopathy.

A number of commentators have pointed to some natural advantages that optometrists have as primary screeners for diabetic retinopathy. Optometrists are highly trained in retinal examination without pupillary dilation, and in mydriatic pharmacology when dilation is required. In addition to greater training, optometrists have better ophthalmoscopic facilities than GPs, and currently report detected ocular abnormalities (such as retinopathies and glaucoma) to the patient's general practitioner. General practitioners seldom have adequate dark room facilities, making use of mydriatic essential for an adequate view of the retina. However some GPs may remain reluctant to perform mydriatic assisted retinal examination because of the fear of inducing angle closure glaucoma. Optometrists are accessible from the patient's home or workplace and (as with GPs) may be less daunting to visit than a hospital clinic. Optometrists may be willing to visit nursing and residential homes and general practice mini-clinics. However this would be at the expense of their dark room facilities unless special arrangements were made. Since a high proportion of diabetics already attend an optometrist, the additional cost of formal screening may be small (although the budgetary implications would depend on what fee structure and screening protocol eventually emerges).

Levels and types of screening practices for diabetic retinopathy across Britain are currently largely unknown, but almost certainly feature considerable variation in coverage and quality. However a number of new schemes are emerging, with a variety of protocols (Association of Optometrists, 1994). At present, possibly the nearest approach to a screening service is provided by optometrists, who perform a full retinal examination as part of NHS sight tests (Harrison et al [17]).

When correctly interpreted, the published evidence addressing the role of optometrists in screening for diabetic retinopathy does not indicate a worse performance, or poorer value for money, when compared to other primary care practitioners. In the current environment of care for diabetics in England the 'adversarial' approach of who should (or should not) screen is probably unproductive. Given the current patchy coverage and the large potential benefits of

detecting diabetic retinopathy (and other eye diseases) a collaborative approach is most likely to provide the best quality of care for the diabetics themselves.

5.1 Research questions

It is apparent that better data are required on the environment of care if appropriate studies are to be conducted in future. The following questions could be addressed by surveys:

* What are the current levels of facilities and techniques used for eye examination by optometrists and general practitioners?

* What are the current levels of (and opportunities for) care? What proportion of diabetics currently attend for eye examinations by optometrists, and how regular are these attendences? What proportion of diabetics in GP care have full annual assessments, and what eye examination is involved? What proportion of diabetics slip through the 'care net' altogether?

* How do diabetics view different screening modalities, and what role might education and experience play in their perceptions?

* How amenable are optometrists and general practitioners to formal screening programmes involving themselves, or to participate formally in 'shared care' systems such as those found in Dorset and Avon?

The following questions may be addressed by prospective studies:

* How do formal training and support programmes affect screening performance in the short and long term?

* What effect does frequency of encountering sight-threatening diabetic retinopathy have on a primary screeners' performance?

* What is the influence of mydriasis on screening performance? Alternatives might be uniform usage as opposed to mydriasis used at the discretion of the screener.

A number of other issues include the appropriate funding structure for screening, the relative benefits of formal screening above natural case detection, particular problems for rural

communities, the role of photographic techniques and the need for an integral approach to include screening for other eye diseases such as glaucoma.

It may be that the only way to resolve current controversies would be to undertake a new prospective screening study involving optometrists and other practitioners. The logic of this argument, if followed, would be to conduct an explanatory study, i.e. a more methodologically rigorous comparison of primary screeners, avoiding some of the design limitations of the SMDP. Possibilities are a randomised controlled trial or, more practically, a blinded calibration study (a representative group of diabetics seen by all of GPs, diabetologists, practice nurses, trained photographers and optometrists and then by a gold standard, i.e. consultant ophthalmologists). However, this would be an efficacy study: it would be difficult to emulate the natural environment of screening.

Given the diverse standards of follow-up and care of diabetics in Great Britain, a more pragmatic design mirroring the current environment of care is worth consideration. Under this scheme a population of diabetics would be followed over a number of years in a shared care scheme and compared to a 'matched' population where no formal scheme has been introduced. Outcomes would be proportions of the populations going blind due to indicated eye diseases, referral and treatment rates, and the overall health service and broader social costs of the two systems. Much of the data for such a comparison could be obtained from existing medical records. It is information at this level that will determine if the five year target of reducing diabetes-associated blindness by one-third, such as set out in the Saint Vincent declaration, is achievable (World Health Organisation, 1990).

6 References

Also, see Table 1, page 9.

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Yudkin JS, Boucher BJ, Schopflin KE, Harris BT el al. The quality of diabetic care in a London Health District. Journal of Epidemiology and Community Health, 1980; 34: 277-80.

7 Bibliography: Studies relating to screening for diabetic retinopathy, 1975-1994

Studies found on MEDLINE, using a number of search schemes, are shown in alphabetical order in Table 9. These schemes are shown below, with a code assigned to each. Citations identified using each scheme can be found in Table 9 by searching down the first column.

Community setting: code C

(vision screening *or* exp diagnosis, eye (non mesh) *or* screen$.tw.) *and*
(diabetic retinopath$.tw. *or* diabetic retinopathy) *and*
(mobile.tw. *or* community.tw.)

Diabetologists: code D

(vision screening *or* exp diagnosis, eye (non mesh) *or* screen$.tw.) *and*
(diabetic retinopath$.tw. *or* diabetic retinopathy) *and*
(diabetologist?.tw. *or* diabetic physician?.tw. *or* diabetes clinic?.tw. *or* diabetes centre?.tw.)

General Practitioners: code G

(vision screening *or* exp diagnosis, eye (non mesh) *or* screen$.tw.) *and*
(diabetic retinopath$.tw. *or* diabetic retinopathy) *and*
(general practice?.tw. *or* general practitioner?.tw. *or* primary care.tw. *or* gp?.tw.)

Optometrists: code O

(vision screening *or* exp diagnosis, eye (non mesh) *or* screen$.tw.) *and*
(diabetic retinopath$.tw. *or* diabetic retinopathy) *and*
(optician?.tw. *or* optometrist?.tw. *or* optometry)

Nurses: code N

(vision screening *or* exp diagnosis, eye (non mesh) *or* screen$.tw.) *and*
(diabetic retinopath$.tw. *or* diabetic retinopathy) *and*
(nurse?.tw. *or* nursing.tw.)

Photography: code P

(vision screening *or* exp diagnosis, eye (non mesh) *or* screen$.tw.) *and*
(diabetic retinopath$.tw. *or* diabetic retinopathy) *and*
(photo?.tw. *or* photography.tw. *or* photography *or* camera?.tw. *or* polaroid?.tw.)

Ophthalmologists: code T

(vision screening *or* exp diagnosis, eye (non mesh) *or* screen$.tw.) *and*
(diabetic retinopath$.tw. *or* diabetic retinopathy) *and*
(ophthalmolog$.tw. *or* ophthalmology *or* eye specialist?.tw.)

Table 9: Bibliography of studies relating to screening for diabetic retinopathy

Code	Author(s)	Title	Source
P	Agardh E. Bauer B. Tallroth G. Agardh CD.	Normal eyes in type 1 diabetics stay normal after one year of treatment with continuous subcutaneous insulin pump.	Acta Ophthalmologica. 64(5):530-2, 1986 Oct.
P	Anonymous.	A protocol for screening for diabetic retinopathy in Europe. Retinopathy Working Party.	Diabetic Medicine. 8(3):263-7, 1991 Apr.
P	Anonymous.	Assessment of non-mydriatic photography in detection of diabetic retinopathy [letter].	British Medical Journal Clinical Research Ed.. 293 (6561):1571-2, 1986 Dec 13.
P	Anonymous.	Classification of diabetic retinopathy from fluorescein angiograms. ETDRS report number 11. Early Treatment Diabetic Retinopathy Study Research Group.	Ophthalmology. 98(5 Suppl):807-22, 1991 May.
P	Anonymous.	Color photography vs fluorescein angiography in the detection of diabetic retinopathy in the diabetes control and complications trial. The Diabetes Control and Complications Trial Research Group.	Archives of Ophthalmology. 105(10):1344-51, 1987 Oct.
P	Anonymous.	Detecting diabetic retinopathy [letter; comment] [see comments].	BMJ. 302(6769):174-6, 1991 Jan 19.
T	Anonymous.	Guidelines for eye care in patients with diabetes mellitus. Results of a symposium. The Kentucky Diabetic Retinopathy Group.	Archives of Internal Medicine. 149(4):769-70, 1989 Apr.
P	Anonymous.	Photocoagulation for diabetic macular edema. Early Treatment Diabetic Retinopathy Study report number 1. Early Treatment Diabetic Retinopathy Study research group.	Archives of Ophthalmology. 103(12):1796-806, 1985 Dec.
T	Anonymous.	Screening guidelines for diabetic retinopathy. American College of Physicians, American Diabetes Association, and American Academy of Ophthalmology [comment].	Annals of Internal Medicine. 116(8):683-5, 1992 Apr 15.
G	Awh CC. Cupples HP. Javitt JC.	Improved detection and referral of patients with diabetic retinopathy by primary care physicians. Effectiveness of education.	Archives of Internal Medicine. 151(7):1405-8, 1991 Jul.
P	Aylward GW.	The scotopic threshold response in diabetic retinopathy.	Eye. 3 (Pt 5):626-37, 1989.
P	Aylward GW. Billson FA.	The scotopic threshold response in diabetic retinopathy--a preliminary report.	Australian & New Zealand Journal of Ophthalmology. 17(4):369-72, 1989 Nov.
P	Backlund L. Algvere P. Rosenqvist U.	[Fundus oculi photography. A good screening method for diabetic retinopathy]. [Swedish]	Lakartidningen. 90(49):4453-7, 1993 Dec 8.
T	Baggen JL.	Diabetic retinopathy: agreement of funduscopic assessment by the family physician and the ophthalmologist (letter). [Dutch]	Nederlands Tijdschrift voor Geneeskunde. 135(51) :2451-2, 1991 Dec 21.
G	Baker SB, Vallbona C, Campbell JV, Hamill MB et al.	Diabetic Eye Disease Detection by Primary-Care Physicians	Diabetes Care August 1990; 13 (8): 908-909
G	Baker SB. Vallbona C. Pavlik V. Fasser et al.	A diabetes control program in a public health care setting.	Public Health Reports - Hyattsville. 108(5):595-605, 1993 Sep-Oct.
P	Barrie T. MacCuish AC.	Assessment of non-mydriatic fundus photography in detection of diabetic retinopathy [letter].	British Medical Journal Clinical Research Ed.. 293 (6557):1304-5, 1986 Nov 15.

↑ Codes: **C**ommunity, **D**iabetologist, **G**eneral Practitioner, **O**ptometrist, **N**urse, **P**hotography, Oph**T**halmolgist

Table 9 continued: Bibliography of studies relating to screening for diabetic retinopathy

Code	Author(s)	Title	Source
P	Bartz-Schmidt KU. Schmitz-Valckenberg P.	[Retinal nerve fiber layer photography and papillometry in juvenile diabetes mellitus]. [German]	Ophthalmologe. 91(3):364-7, 1994 Jun.
D	Beaulieu MD.	Hyperglycemia and the complications of maturity-onset diabetes. [Review] [French]	Canadian Medical Association Journal. 122(8):884-9, 1980 Apr 19.
T	Begg IS.	Screening for diabetic retinopathy: changes in direction? [editorial; comment].	Canadian Journal of Ophthalmology. 28(1):3-6, 1993 Feb.
P	Bek T.	Coexistence of localized scotomata and neovascularizations in proliferative diabetic retinopathy.	Acta Ophthalmologica. 68(4):421-7, 1990 Aug.
P	Bek T.	Localised scotomata and types of vascular occlusion in diabetic retinopathy.	Acta Ophthalmologica. 69(1):11-8, 1991 Feb.
P	Bek T.	Localized retinal morphology and differential light sensitivity in diabetic retinopathy. Methodology and clinical results. [Review]	Acta Ophthalmologica - Supplement. (207):1-36, 1992.
P	Bek T. Lund-Andersen H.	Accurate superimposition of perimetry data onto fundus photographs.	Acta Ophthalmologica. 68(1):11-8, 1990 Feb.
OT	Bhopal RS. Hedley AJ.	Screening of diabetics for retinopathy by ophthalmic opticians [letter].	British Medical Journal Clinical Research Ed.. 290 (6481):1589, 1985 May 25.
T	Bischoff P.	[Ophthalmologic follow-up of diabetic retinopathy]. [German] Ophthalmologische Verlaufskontrollen bei der diabetischen Retinopathie.	Klinische Monatsblatter fur Augenheilkunde. 202(5):443-6, 1993 May.
PT	Bischoff PM. Flower RW.	Ten years experience with choroidal angiography using indocyanine green dye: a new routine examination or an epilogue?.	Documenta Ophthalmologica. 60(3):235-91, 1985 Sep 30.
P	Bixenman WW. Joffe L.	Binocular diplopia associated with retinal wrinkling.	Journal of Pediatric Ophthalmology & Strabismus. 21(6):215-9, 1984 Nov-Dec.
P	Borg MG.	Diabetic retinopathy screening service.	Journal of Audiovisual Media in Medicine. 15(1):33-7, 1992
G	Bresnick GH. Condit RS. Palta M. Korth K. et al.	Association of hue discrimination loss and diabetic retinopathy.	Archives of Ophthalmology. 103(9):1317-24, 1985 Sep.
P	Bresnick GH. Davis MD. Myers FL. de Venecia G.	Clinicopathologic correlations in diabetic retinopathy. II. Clinical and histologic appearances of retinal capillary microaneurysms.	Archives of Ophthalmology. 95(7):1215-20, 1977 Jul.
T	Bron AJ.	Screening for treatable diabetic retinopathy [editorial].	British Medical Journal Clinical Research Ed. 290 (6474):1025-6, 1985 Apr 6.
P	Bron AJ. Cheng H.	Cataract and retinopathy: screening for treatable retinopathy. [Review]	Clinics in Endocrinology & Metabolism. 15(4):971-99, 1986 Nov.
N	Brown MM.	Retinal vascular disorders: nursing and medical implications.	Nursing Clinics of North America. 16(3):415-32, 1981.
OT	Burns-Cox CJ. Hart JC.	Screening of diabetics for retinopathy by ophthalmic opticians.	British Medical Journal Clinical Research Ed.. 290 (6474):1052-4, 1985 Apr 6.

↑ Codes: **C**ommunity, **D**iabetologist, **G**eneral Practitioner, **O**ptometrist, **N**urse, **P**hotography, Oph**T**halmolgist

Table 9 continued: Bibliography of studies relating to screening for diabetic retinopathy

Code	Author(s)	Title	Source
P	Bursell SE. Clermont AC. Shiba T. King GL.	Evaluating retinal circulation using video fluorescein angiography in control and diabetic rats.	Current Eye Research. 11(4):287-95, 1992 Apr.
O G P	Buxton MJ. Sculpher MJ. Ferguson BA. Humphreys JE. et al.	Screening for treatable diabetic retinopathy: a comparison of different methods.	Diabetic Medicine. 8(4):371-7, 1991 May.
G	Carter TL.	Age-related vision changes: a primary care guide. [Review]	Geriatrics. 49(9):37-42, 45; quiz 46-7, 1994 Sep.
P	Cerutti F. Sacchetti C. Vigo A. Dianzani I. et al.	Course of retinopathy in children and adolescents with insulin-dependent diabetes mellitus: a ten-year study.	Ophthalmologica. 198(3):116-23, 1989.
P T	Chantelau E. Zwecker M. Weiss H. Kluxen G. et al.	Fundus polaroid screening for diabetic retinopathy. Is one print per patient enough?.	Diabetes Care. 12(3):223-6, 1989 Mar.
G T	Chew SJ. Hart PM. Ang BC. Lim AS.	Ophthalmic screening for diabetics: the importance of physician-ophthalmologist collaboration in the prevention of blindness.	Singapore Medical Journal. 31(1):26-9, 1990 Feb.
P	Chinone S. Tamura T.	[Diabetic retinopathy: study of vascular alteration by monochromatic fundus photography]. [Japanese]	Acta Societatis Ophthal-mologicae Japonicae. 86(9):1262-8, 1982.
O	Clark JB. Grey RH. Lim KK. Burns-Cox CJ.	Loss of vision before ophthalmic referral in blind and partially sighted diabetics in Bristol [see comments].	British Journal of Ophthalmology. 78(10):741-4, 1994 Oct.
T	Cohen J.	Diseases of the retina: 1975-76 review. [Review]	American Journal of Optom-etry & Physiological Optics. 54(7):485-94, 1977 Jul.
G N T	Collins JW.	Proposed criteria for referring diabetic retinopathy.	Nurse Practitioner. 13(4) :21-2, 25, 28, 1988 Apr.
P	Constable IJ. Welborn TA. Cooper RL. McCann VJ. et al.	Medical correlates and diabetic retinopathy screening.	Transactions of the Ophthalmological Societies of the United Kingdom. 100 (Pt 1):78-82, 1980 Apr.
P	Cunha-Vaz J. Leite E. Sousa JC. de Abreu JR.	Blood-retinal barrier permeability and its relation to progression of retinopathy in patients with type 2 diabetes. A four-year follow-up study.	Graefes Archive for Clinical & Experimental Ophthalmology. 231(3):141-5, 1993 Mar.
P	Cunha-Vaz JG. Mota CC. Leite EC. Abreu JR. et al.	Effect of sorbinil on blood-retinal barrier in early diabetic retinopathy.	Diabetes. 35(5):574-8, 1986 May.
P	Dasbach EJ. Fryback DG. Newcomb PA. Klein R. et al.	Cost-effectiveness of strategies for detecting diabetic retinopathy.	Medical Care. 29(1):20-39, 1991 Jan.
P	Davis MD. Hubbard LD. Trautman J. Klein R.	Conference on insulin pump therapy in diabetes. Multicenter study effect on microvascular disease. Studies of retinopathy. Methodology for assessment and classification with fundus photographs.	Diabetes. 34 Suppl 3:42-9, 1985 Aug.
O	Ederer F.	Methodological problems in eye disease epidemiology. [Review]	Epidemiologic Reviews. 5:51-66, 1983.
T	Edwards AL.	Funduscopic examination of patients with diabetes who are admitted to hospital.	Canadian Medical Association Journal. 134(11):1263-5, 1986 Jun 1.

↑ Codes: **C**ommunity, **D**iabetologist, **G**eneral Practitioner, **O**ptometrist, **N**urse, **P**hotography, Oph**T**halmolgist

Table 9 continued: Bibliography of studies relating to screening for diabetic retinopathy

Code	Author(s)	Title	Source
G P	Eggertsen R. Kalm H. Blohme G.	The value of screening for retinopathy and microalbuminuria in patients with type 2 diabetes in primary health care.	Scandinavian Journal of Primary Health Care. 11(2):135-40, 1993 Jun.
C P	Ellingford A.	Diabetic photographic eye screening using a mobile unit in Tayside, Scotland.	Journal of Audiovisual Media in Medicine. 15(3):104-7, 1992 Jul.
P	Elman KD. Welch RA. Frank RN. Goyert GL. et al.	Diabetic retinopathy in pregnancy: a review. [Review]	Obstetrics & Gynecology. 75(1):119-27, 1990 Jan.
P	Engler C. Krogsaa B. Lund-Andersen H.	Blood-retina barrier permeability and its relation to the progression of diabetic retinopathy in type 1 diabetics. An 8-year follow-up study.	Graefes Archive for Clinical & Experimental Ophthalmology. 229(5):442-6, 1991.
P	Engler CB. Parving HH. Mathiesen ER. Larsen M. et al.	Blood-retina barrier permeability in diabetes during acute ACE-inhibition.	Acta Ophthalmologica. 69(5):581-5, 1991 Oct.
P	Falck A. Laatikainen L.	White spots in the central fundus in diabetic children and adolescents.	Acta Ophthalmologica. 70(2):243-7, 1992 Apr.
D T	Fernando DJ. Siribaddana S. De Silva. Subasinge Z.	Prevalence of retinopathy in a Sri Lankan diabetes clinic.	Ceylon Medical Journal. 38(3):120-3, 1993 Sep.
T	Fonda GE.	Optical treatment of residual vision in diabetic retinopathy.	Ophthalmology. 101(1):84-8, 1994 Jan.
P	Fontana M. Verriest G.	Modification by fluoangiography of color vision in diabetic patients.	Ophthalmologica. 192(4):210-6, 1986.
D N P	Forrest RD. Jackson CA. Yudkin JS.	Screening for diabetic retinopathy--comparison of a nurse and a doctor with retinal photography.	Diabetes Research. 5(1):39-42, 1987 May.
D	Foulds WS, McCuish A, Barrie T, Green F, et al.	The chief scientist reports... Diabetic retinopathy in the West of scotland: its detection and prevalence, and the cost-effectiveness of a proposed screening programme	Health Bulletin 1983; 41: 318-26
P	Frank RN. Hoffman WH. Podgor MJ. Joondeph HC. et al.	Retinopathy in juvenile-onset diabetes of short duration.	Ophthalmology. 87(1):1-9, 1980 Jan.
P	Frank RN. Hoffman WH. Podgor MJ. Joondeph HC. et al.	Retinopathy in juvenile-onset type I diabetes of short duration.	Diabetes. 31(10):874-82, 1982 Oct.
P	Freyler H.	[Peripheral fluorescence angiography in diabetic retinopathy]. [German]	Klinische Monatsblatter fur Augenheilkunde. 186(3):184-6, 1985 Mar.
P	Freyler H. Klemen U.	[Relationship between loss of sight and mortality in diabetics with retinopathy (a retrospective study over the terminal 5 years) (author's transl)]. [German]	Wiener Klinische Wochenschrift. 91(10):344-8, 1979 May 11.
P	Freyler H. Klemen U. Arnfelser H.	[Has photocoagulation improved the prognosis of diabetic retinopathy?]. [German]	Ophthalmologica. 175(3):130-9, 1977.
P	Friberg TR. Lace J. Rosenstock J. Raskin P.	Retinal microaneurysm counts in diabetic retinopathy: colour photography versus fluorescein angiography.	Canadian Journal of Ophthalmology. 22(4):226-9, 1987 Jun.

↑ Codes: **C**ommunity, **D**iabetologist, **G**eneral Practitioner, **O**ptometrist, **N**urse, **P**hotography, Oph**T**halmolgist

Table 9 continued: Bibliography of studies relating to screening for diabetic retinopathy

Code	Author(s)	Title	Source
T	Friedman SM. Rubin ML.	Diabetic retinopathy: newer therapies to prevent blindness [published erratum appears in Geriatrics 1992 Jul;47(7):80]. [Review]	Geriatrics. 47(5):71-2, 75, 81 passim, 1992 May.
T	Frost-Larsen K. Larsen HW. Simonsen SE.	The value of dark-adaptation as a prognostic tool in diabetic retinopathy.	Metabolic & Pediatric Ophthalmology. 5(1):39-44, 1981.
P	Fukuda M. Motokura M. Nishikawa N. Manabe R. et al.	[Color image analysis of ocular fundus photography]. [Japanese]	Acta Societatis Ophthal-mologicae Japonicae. 90(3):516-21, 1986 Mar.
T	Funatsu H. Yamashita H. Shimada H. Suzuki M. et al.	Reliability of evaluating grade of diabetic retinopathy. [Japanese]	Acta Societatis Ophthal-mologicae Japonicae. 97(3):396-402, 1993 Mar.
O	Gilbert CE. Armstrong S. Burns-Cox C. Dean Hart JC.	Screening of diabetics by ophthalmic opticians.	Transactions of the Ophthalmological Societies of the United Kingdom. 102 (pt 2):249-52, 1982 Jul.
P T	Gloor B.	[Lasers in ophthalmology]. [German]	Schweizerische Rundschau fur Medizin Praxis. 78(16):467-70, 1989 Apr 18.
T	Graham K. Kesson CM. Kennedy HB. Ireland JT.	Relevance of colour vision and diabetic reti-nopathy to self-monitoring of blood glucose.	British Medical Journal. 281 (6246):971-3, 1980 Oct 11.
G P T	Griffith SP. Freeman WL. Shaw CJ. Mitchell WH. et al.	Screening for diabetic retinopathy in a clinical setting: a comparison of direct ophthalmoscopy by primary care physicians with fundus photography.	Journal of Family Practice. 37(1):49-56, 1993 Jul.
P	Hampton GR. Nelsen PT. Hay PB.	Viewing through the asteroids.	Ophthalmology. 88(7):669-72, 1981 Jul.
O	Harris A, Bonell C, Evans T, Roberson G.	Commissioning diabetic eye screening by optometrists: a local inititaive at the primary-secondary care interface.	Journal of Medical Screening 1994; 1: 13-15
C G O T	Harrison RJ. Wild JM. Hobley AJ.	Referral patterns to an ophthalmic outpatient clinic by general practitioners and ophthalmic opticians and the role of these professionals in screening for ocular disease.	BMJ. 297(6657):1162-7, 1988 Nov 5.
P	Heaven CJ. Cansfield J. Shaw KM.	The quality of photographs produced by the non-mydriatic fundus camera in a screening programme for diabetic retinopathy: a 1 year prospective study.	Eye. 7 (Pt 6):787-90, 1993.
D	Heller SR. Tattersall RB.	Optic disc swelling in young diabetic patients: a diagnostic dilemma.	Diabetic Medicine. 4(3):260-4, 1987 May-Jun.
P	Hellstedt T. Palsi VP. Immonen I.	A computerized system for localization of diabetic lesions from fundus images.	Acta Ophthalmologica. 72(3):352-6, 1994 Jun.
P T	Hendrikse F.	[Consensus on diagnosis, screening and treatment of diabetic retinopathy]. [Review] [Dutch]	Nederlands Tijdschrift voor Geneeskunde. 136(35): 1706-10, 1992 Aug 29.
C P T	Higgs ER. Harney BA. Kelleher A. Reckless JP.	Detection of diabetic retinopathy in the community using a non-mydriatic camera.	Diabetic Medicine. 8(6):551-5, 1991 Jul.
G T	Huiskes AW. Hardus PL. Weise P.	Diabetic retinopathy: agreement of fundoscopic assessment by the family physician and the ophthalmologist. [Dutch]	Nederlands Tijdschrift voor Geneeskunde. 135(42): 1960-3, 1991 Oct 19.

↑ Codes: **C**ommunity, **D**iabetologist, **G**eneral Practitioner, **O**ptometrist, **N**urse, **P**hotography, Oph**T**halmolgist

Table 9 continued: Bibliography of studies relating to screening for diabetic retinopathy

Code	Author(s)	Title	Source
P	Imai K. Ando N. Ichibe M. Iwata K. et al.	[Intraoperative fluorescein angiography with an ultrasensitive imaging tube]. [Japanese]	Acta Societatis Ophthalmologicae Japonicae. 98(8):792-6, 1994 Aug.
P	Jaanio E. Alanko H. Airaksinen PJ. Nieminen H. Lahde S.	Electronic subtraction method for ophthalmic photography.	Acta Ophthalmologica. 58(1):7-13, 1980.
C	Jackson CA. Yudkin JS. Forrest RD.	A comparison of the relationships of the glucose tolerance test and the glycated haemoglobin assay with diabetic vascular disease in the community. The Islington Diabetes Survey.	Diabetes Research & Clinical Practice. 17(2):111-23, 1992 Aug.
P	Jackson RL. Ide CH. Guthrie RA. James RD.	Retinopathy in adolescents and young adults with onset of insulin-dependent diabetes in childhood.	Ophthalmology. 89(1):7-13, 1982 Jan.
T	Javitt JC. Aiello LP. Bassi LJ. Chiang YP. et al	Detecting and treating retinopathy in patients with type I diabetes mellitus. Savings associated with improved implementation of current guidelines. American Academy of Ophthalmology.	Ophthalmology. 98(10):1565-73; discussion 1574, 1991 Oct.
P	Javitt JC. Canner JK. Frank RG. Steinwachs DM. et al.	Detecting and treating retinopathy in patients with type I diabetes mellitus. A health policy model.	Ophthalmology. 97(4):483-94; discussion 494-5, 1990 Apr.
T	Javitt JC. Canner JK. Sommer A.	Cost effectiveness of current approaches to the control of retinopathy in type I diabetics.	Ophthalmology. 96(2):255-64, 1989 Feb.
P	Jones D. Dolben J. Owens DR. Vora JP. et al.	Non-mydriatic Polaroid photography in screening for diabetic retinopathy: evaluation in a clinical setting.	British Medical Journal Clinical Research Ed.. 296 (6628):1029-30, 1988 Apr 9.
P	Kalm H.	Non-stereo photographic screening in long-term follow-up for detection of proliferative diabetic retinopathy.	Acta Ophthalmologica. 70(2):228-34, 1992 Apr.
P	Kalm H. Egertsen R. Blohme G.	Non-stereo fundus photography as a screening procedure for diabetic retinopathy among patients with type II diabetes. Compared with 60D enhanced slit-lamp examination.	Acta Ophthalmologica. 67(5):546-53, 1989 Oct.
P	Karma A. Gummerus S. Kujansuu E. Pitkajarvi T.	Predicting diabetic retinopathy.	Acta Ophthalmologica - Supplement. 182:136-9, 1987.
P	Kernell A. Ludvigsson J. Finnstrom K.	Vitreous fluorophotometry in juvenile diabetics with and without retinopathy in relation to metabolic control: insulin antibodies and c-peptide levels.	Acta Ophthalmologica. 68(4):415-20, 1990 Aug.
G	Khosla PK. Talwar D. Tewari HK.	Contrast sensitivity changes in background diabetic retinopathy.	Canadian Journal of Ophthalmology. 26(1):7-11, 1991 Feb
P	Kinyoun J. Barton F. Fisher M. Hubbard L. et al.	Detection of diabetic macular edema. Ophthalmoscopy versus photography--Early Treatment Diabetic Retinopathy Study Report Number 5. The ETDRS Research Group.	Ophthalmology. 96(6):746-50; discussion 750-1, 1989 Jun.
P	Kinyoun JL. Martin DC. Fujimoto WY. Leonetti DL.	Ophthalmoscopy versus fundus photographs for detecting and grading diabetic retinopathy.	Investigative Ophthalmology & Visual Science. 33(6):1888-93, 1992 May.
P	Klein M. Hirche H.	[Naftidrofuryl in the treatment of simple diabetic retinopathy. A double-blind study]. [German]	Klinische Monatsblatter fur Augenheilkunde. 187(3):195-201, 1985 Sep.

↑ Codes: **C**ommunity, **D**iabetologist, **G**eneral Practitioner, **O**ptometrist, **N**urse, **P**hotography, Oph**T**halmolgist

Table 9 continued: Bibliography of studies relating to screening for diabetic retinopathy

Code	Author(s)	Title	Source
P	Klein R. Klein BE. Neider MW. Hubbard LD. et al.	Diabetic retinopathy as detected using ophthalmoscopy, a nonmydriatic camera and a standard fundus camera.	Ophthalmology. 92(4):485-91, 1985 Apr.
O	Kleinstein RN. Roseman JM. Herman WH. Holcombe J. et al.	Detection of diabetic retinopathy by optometrists.	Journal of the American Optometric Association. 58(11):879-82, 1987 Nov.
P	Klemen C. Prskavec FH. Stelzer N. Schober E. et al.	[Long-term ophthalmologic follow-up of diabetic children]. [German]	Klinische Monatsblatter fur Augenheilkunde. 191(5):392-4, 1987 Nov.
T	Kluxen G. Wilden E.	Retinal blood vessel test in young-onset diabetic patients.	Ophthalmologica. 194(2-3): 140-4, 1987.
P	Koch F. Kloss KM. Hockwin O. Spitznas M.	[Lens changes following intraocular tamponade in vitrectomy. Linear densitometric image analysis of Scheimpflug photographs 6 months after operation]. [German]	Klinische Monatsblatter fur Augenheilkunde. 199(1): 8-11, 1991 Jun.
P	Kohner EM. Lawson PM. Ghosh G. Testa M.	Conference on insulin pump therapy in diabetes. Multicenter study of effect on microvascular disease. Assessment of fluorescein angiograms.	Diabetes. 34 Suppl 3:56-60, 1985 Aug.
T	Kozousek V. Brown MG. Cottle R. Hicks VA. et al.	Use of ophthalmologic services by diabetic patients in Nova Scotia [see comments].	Canadian Journal of Ophthalmology. 28(1):7-10, 1993 Feb.
P	Kozousek V. Shen Z. Gregson P. Scott RC.	Automated detection and quantification of venous beading using Fourier analysis.	Canadian Journal of Ophthalmology. 27(6):288-94, 1992 Oct.
T	Krasnov ML. Margolis MG.	Achievements of Soviet ophthalmologic endocrinology. [RUSSIAN]	Vestnik Oftalmologii. (5):91-5, 1977 Sep-Oct.
P	Kristinsson JK. Stefansson E. Jonasson F. Gislason I. et al.	Screening for eye disease in type 2 diabetes mellitus.	Acta Ophthalmologica. 72(3):341-6, 1994 Jun.
P	Kristinsson JK. Stefansson E. Jonasson F. Gislason I. et al.	Systematic screening for diabetic eye disease in insulin dependent diabetes.	Acta Ophthalmologica. 72(1):72-8, 1994 Feb.
P	Krogsaa B. Lund-Andersen H. Mehlsen J. et al.	The blood-retinal barrier permeability in diabetic patients.	Acta Ophthalmologica. 59(5):689-94, 1981 Oct.
T	Kuchle M. Schonherr U. Nguyen NX. Steinhauser B. et al.	Quantitative measurement of aqueous flare and aqueous "cells" in eyes with diabetic retinopathy.	German Journal of Ophthalmology. 1(3-4):164-9, 1992.
T	Kutschera E.	[Current dimensions of ophthalmology]. [German]	Wiener Medizinische Wochenschrift. 127(21):652-5, 1977 Nov 15.
G N P T	Lairson DR. Pugh JA. Kapadia AS. Lorimor RJ. et al.	Cost-effectiveness of alternative methods for diabetic retinopathy screening [see comments].	Diabetes Care. 15(10):1369-77, 1992 Oct.
P	Lang GE. Handel A.	[Clinical and fluorescein angiography changes in patients with central retinal vein occlusion. A unicenter study of 125 patients]. [German]	Klinische Monatsblatter fur Augenheilkunde. 201(5):302-8, 1992 Nov.
C G P T	Lawrenson RA. Dunn PJ. Worsley D. Williams S. et al.	Discover diabetes: a community based screening programme for diabetic eye disease [see comments].	New Zealand Medical Journal. 107(977):172-4, 1994 May 11.

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Table 9 continued: Bibliography of studies relating to screening for diabetic retinopathy

Code	Author(s)	Title	Source
P	Lee VS. Kingsley RM. Lee ET. Lu M. et al.	The diagnosis of diabetic retinopathy. Ophthalmoscopy versus fundus photography [see comments].	Ophthalmology. 100(10):1504-12, 1993 Oct.
C P	Leese GP. Ahmed S. Newton RW. Jung RT. et al.	Use of mobile screening unit for diabetic retinopathy in rural and urban areas.	BMJ. 306(6871):187-9, 1993 Jan 16.
C P	Leese GP. Newton RW. Jung RT. Haining W. et al.	Screening for diabetic retinopathy in a widely spaced population using non-mydriatic fundus photography in a mobile unit. Tayside Mobile Eye Screening Unit.	Diabetic Medicine. 9(5):459-62, 1992 Jun.
P T	Lewis JM. Jovanovic-Peterson L. Ahmadizadeh I. Bevier W. et al.	The Santa Barbara County diabetic retinopathy screening feasibility study: significance of diabetes duration and systolic blood pressure.	Journal of Diabetes & its Complications. 8(1):51-4, 1994 Jan-Mar.
T	Lichtenstein MJ.	Hearing and visual impairments. [Review]	Clinics in Geriatric Medicine. 8(1):173-82, 1992 Feb.
T	Lienert RT.	Inter-observer comparisons of ophthalmoscopic assessment of diabetic retinopathy.	Australian & New Zealand Journal of Ophthalmology. 17(4):363-8, 1989 Nov.
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P	Malone JI. Van Cader TC. Edwards WC.	Diabetic vascular changes in children.	Diabetes. 26(7):673-9, 1977 Jul.
P	Manivannan A. Kirkpatrick JN. Sharp PF. Forrester JV.	Clinical investigation of an infrared digital scanning laser ophthalmoscope.	British Journal of Ophthalmology. 78(2):84-90, 1994 Feb.
P	Manivannan A. Sharp PF. Phillips RP. Forrester JV.	Digital fundus imaging using a scanning laser ophthalmoscope.	Physiological Measurement. 14(1):43-56, 1993 Feb.
P	Mansour AM. Schachat A. Bodiford G. Haymond R.	Foveal avascular zone in diabetes mellitus.	Retina. 13(2):125-8, 1993.
G P T	Marks JB.	Nonmydriatic fundus photography in screening for treatable diabetic retinopathy. [Review]	Journal of Diabetes & its Complications. 6(4):247-53, 1992 Oct-Dec.
P	Massin-Korobelnik P. Gaudric A.	[Classification and outcome of diabetic retinopathy]. [Review] [French]	Diabete et Metabolisme. 19(5):405-13, 1993 Sep-Oct.
G	Mayfield JA. Rith-Najarian SJ. Acton KJ. Schraer CD. et al.	Assessment of diabetes care by medical record review. The Indian Health Service model.	Diabetes Care. 17(8):918-23, 1994 Aug.
P	McConnell EA. Newland HS. Manning J. Paech M.	Technology assessment applied: a comparison of ophthalmic diagnostic techniques to detect diabetic retinopathy among Aboriginal people in central Australia.	Contemporary Nurse. 2(1):23-8, 1993 Apr.
G	McGill M. Molyneaux LM. Yue DK. Turtle JR.	A single visit diabetes complication assessment service: a complement to diabetes management at the primary care level.	Diabetic Medicine. 10(4):366-70, 1993 May.

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Table 9 continued: Bibliography of studies relating to screening for diabetic retinopathy

Code	Author(s)	Title	Source
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P	Mitchell P. Moffitt P.	Update and implications from the Newcastle diabetic retinopathy study.	Australian & New Zealand Journal of Ophthalmology. 18(1):13-7, 1990 Feb.
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P	Moloney JB. Drury MI.	The effect of pregnancy on the natural course of diabetic retinopathy.	American Journal of Ophthalmology. 93(6):745-56, 1982 Jun.
O P T	Moss SE. Klein R. Kessler SD. Richie KA.	Comparison between ophthalmoscopy and fundus photography in determining severity of diabetic retinopathy.	Ophthalmology. 92(1):62-7, 1985 Jan.
C N T	Muhlhauser I. Sulzer M. Berger M.	Quality assessment of diabetes care according to the recommendations of the St. Vincent Declaration: a population-based study in a rural area of Austria.	Diabetologia. 35(5):429-35, 1992 May.
D P T	Nathan DM. Fogel HA. Godine JE. Lou PL. et al.	Role of diabetologist in evaluating diabetic retinopathy [see comments].	Diabetes Care. 14(1):26-33, 1991 Jan.
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C N	Newell SW. Walser JJ.	Nursing home glaucoma and visual acuity screening results in western Oklahoma.	Annals of Ophthalmology. 17(3):186-9, 1985 Mar.
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P	Palmberg P. Smith M. Waltman S. Krupin T. et al.	The natural history of retinopathy in insulin-dependent juvenile-onset diabetes.	Ophthalmology. 88(7):613-8, 1981 Jul.
G	Parnes RE. Singerman LJ.	Diabetic retinopathy. Preserving your patients' sight. [Review]	Journal of the Florida Medical Association. 81(4):236-9, 1994 Apr.
P	Paton RC.	Non-mydriatic Polaroid photography in screening for diabetic retinopathy [letter].	British Medical Journal Clinical Research Ed.. 296 (6633):1399, 1988 May 14.
T	Patz A.	Retinal neovascularisation: early contributions of Professor Michaelson and recent observations.	British Journal of Ophthalmology. 68(1):42-6, 1984 Jan.
P	Peckar CO. Thomson MA. Smith MA. Khan SR. et al.	The relationship between diabetic control and retinopathy in a group of diabetic teenagers.	Metabolic, Pediatric & Systemic Ophthalmology. 7(2):101-8, 1983.
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Code	Author(s)	Title	Source
P	Porta M.	Emerging strategies for the prevention and treatment of diabetic eye disease. [Review]	Annali Italiani di Medicina Interna. 6(3):325-38, 1991 Jul-Sep.
P T	Pugh JA. Jacobson JM. Van Heuven WA. Watters JA. et al.	Screening for diabetic retinopathy. The wide-angle retinal camera.	Diabetes Care. 16(6):889-95, 1993 Jun.
G	Rand LI.	Financial implications of implementing standards of care for diabetic eye disease. [Review]	Diabetes Care. 15 Suppl 1:32-5, 1992 Mar.
G T	Reenders K. de Nobel E. van den Hoogen H. van Weel C.	Screening for diabetic retinopathy by general practitioners.	Scandinavian Journal of Primary Health Care. 10(4):306-9, 1992 Dec.
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T	Rencova E.	[Use of ophthalmochromoscopy in ophthalmology]. [Czech]	Ceskoslovenska Oftalmologie. 45(4):288-93, 1989 Jul.
G P	Rogers D. Bitner-Glindzicz M. Harris C. Yudkin JS.	Non-mydriatic retinal photography as a screening service for general practitioners.	Diabetic Medicine. 7(2):165-7, 1990 Feb.
C O	Rohan TE. Frost CD. Wald NJ.	Prevention of blindness by screening for diabetic retinopathy: a quantitative assessment [see comments].	BMJ. 299(6709):1198-201, 1989 Nov 11.
P	Ryder RE. Hardisty CA.	Detecting diabetic retinopathy [letter; comment].	BMJ. 302(6777):659, 1991 Mar 16.
P	Ryder RE. Vora JP. Atiea JA. Owens DR. et al.	Possible new method to improve detection of diabetic retinopathy: Polaroid non-mydriatic retinal photography.	British Medical Journal Clinical Research Ed.. 291 (6504):1256-7, 1985 Nov 2.
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Table 9 continued: Bibliography of studies relating to screening for diabetic retinopathy

Code	Author(s)	Title	Source
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P	Smith RT. Lee CM. Charles HC. Farber M. et al.	Quantification of diabetic macular edema.	Archives of Ophthalmology. 105(2):218-22, 1987 Feb.
T	Spencer M.	Ophthalmology. Screening for diabetic retinopathy.	Nursing Standard. 5(50):52-3, 1991 Sep 4-10.
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G	Stead JW. Dudbridge SB. Hall MS. Pereira Gray DJ.	The Exeter Diabetic Project: an acceptable district-wide education programme for general practitioners.	Diabetic Medicine. 8(9):866-9, 1991 Nov.
C T	Stepien CJ. Bowbeer MA. Hiss RG.	Screening for diabetic retinopathy in communities.	Diabetes Educator. 18(2):115-20, 1992 Mar-Apr.
G	Strahlman E. Ford D. Whelton P. Sommer A.	Vision screening in a primary care setting. A missed opportunity?.	Archives of Internal Medicine. 150(10):2159-64, 1990 Oct.
G O T	Sullivan FM. Stearn R. MacCuish AC.	The role of general practitioners in diabetic eye care in Lanarkshire.	Diabetic Medicine. 11(6):583-5, 1994 Jul.
D T	Sussman EJ. Tsiaras WG. Soper KA.	Diagnosis of diabetic eye disease.	JAMA. 247(23):3231-4, 1982 Jun 18.
T	Syrdalen P.	[Laser in ophthalmology]. [Norwegian]	Tidsskrift for Den Norske Laegeforening. 111(23): 2849-51, 1991 Sep 30.
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Table 9 continued: Bibliography of studies relating to screening for diabetic retinopathy

Code	Author(s)	Title	Source
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G P T	Verhoeven S. van Ballegooie E. Crijns H. Hylkema HA. et al.	Is fundus photography useful in screening for diabetic retinopathy in patients with type II diabetes mellitus?. [Dutch]	Nederlands Tijdschrift voor Geneeskunde. 137(34): 1713-7, 1993 Aug 21.
T	Ward SC. Woods DR. Gilstrap LC. Hauth JC.	Pregnancy and acute optic disc edema of juvenile-onset diabetes.	Obstetrics & Gynecology. 64(6):816-8, 1984 Dec.
P	Wareham N. Greenwood R.	Screening for diabetic retinopathy using non-mydriatic fundus photography [editorial]. [Review]	Diabetic Medicine. 8(7):607-8, 1991 Aug-Sep.
T	Wareham NJ.	Cost-effectiveness of alternative methods for diabetic retinopathy screening [letter; comment].	Diabetes Care. 16(5):844, 1993 May.
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T	Wilkes SR. Davidson JA. Munson S. Freeman J.	The Georgia diabetic retinopathy screening study.	Journal of the Medical Association of Georgia. 78(11):765-7, 1989 Nov.
P T	Williams R. Nussey S. Humphry R. Thompson G.	Assessment of non-mydriatic fundus photography in detection of diabetic retinopathy.	British Medical Journal Clinical Research Ed.. 293 (6555):1140-2, 1986 Nov 1.
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P	Wolfe KA. Sadun AA.	Threshold Amsler grid testing in diabetic retinopathy.	Graefes Archive for Clinical & Experimental Ophthalmology. 229(3):219-23, 1991.
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