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## Research: Care Delivery

# Factors determining uptake of diabetic retinopathy screening in Oxfordshire

R. B. R. Moreton<sup>1</sup> , I. M. Stratton<sup>2,3</sup>, S. J. Chave<sup>2</sup>, H. Lipinski<sup>3</sup> and P. H. Scanlon<sup>2,3</sup>

<sup>1</sup>NHS Lothian, Edinburgh, <sup>2</sup>Gloucestershire Diabetic Retinopathy Research Group, Cheltenham General Hospital, Cheltenham and <sup>3</sup>Oxfordshire Diabetic Eye Screening Programme, John Radcliffe Hospital, Oxford, UK

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## Abstract

**Aims** To investigate variables at the demographic and primary care practice levels that influence the uptake of diabetic retinopathy screening.

**Methods** Data were extracted from the management software of one screening programme for 21 797 people registered with 79 general practices. Uptake was examined by gender, age group, modality of screening (mobile unit at general practice versus high-street optometrist), and by general practice. A telephone survey of high-street optometrists provided information on the availability of screening appointments.

**Results** Uptake was 82.4% during the study period, and was higher for men (83.2%) than for women (81.5%) ( $P = 0.001$ ). Uptake varied by age group ( $P < 0.001$ ), being lowest in those aged 12–39 years (67%). Uptake was higher for people invited to a general practice for screening by a mobile unit (83.5%) than for those invited for screening by a high-street optometrist (82%) ( $P = 0.006$ ). After adjusting for these factors and for socio-economic deprivation score at the location of the general practice, heterogeneity in uptake rate was still observed between some practices. Our survey of optometrists indicated wide variation in the availability of time slots for screening during the week and of screening appointment provision.

**Conclusions** Diabetic retinopathy screening services do not achieve high uptake among the youngest or oldest age groups. Practices in the least deprived areas had the highest uptake. Variation in uptake between general practices after adjustment for individual-level variables and deprivation suggests that practice-level factors may have an important role in determining rates of screening attendance.

Diabet. Med. 00, 000–000 (2017)

## Introduction

Diabetes mellitus is an increasing public health concern that is estimated to affect 4.5 million people in the UK [1]. Diabetic eye disease is an important microvascular complication of both Type 1 and Type 2 diabetes, and may lead to visual loss if untreated [2]. Although its incidence may be reduced through improved blood pressure [3] and glycaemic control [4,5], diabetic retinopathy remains the leading cause of preventable sight loss for people of working age in the UK [6].

Non-attendance at diabetic retinopathy screening is a major risk factor for sight-threatening retinopathy [7,8]. The Diabetic Eye Screening Programme defines 70% as the minimum acceptable level of uptake for the current Quality Assurance Standard, with 80% considered achievable [9]. A recent revision to the Quality Assurance Standard, due to come into effect in April 2017, has increased these rates to 75% and 85%, respectively [10]. Although uptake across England reached 81% in 2011–2012 [11], rates vary between local screening programmes [11] and between primary care practices within the same area [12]. Modifiable and non-modifiable risk factors for non-attendance at diabetic retinopathy screening are incompletely understood and research has focused on the effects of demographic factors at the level of the person with diabetes invited for screening. Uptake has been found to be inversely related to socio-economic deprivation with lower screening attendance rates

Correspondence to: Robert B. R. Moreton.

E-mail: bobby.moreton@gmail.com

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**What is new?**

- Uptake for diabetic retinopathy screening was higher for registered people invited for screening by a mobile unit at a general practice than for those invited for screening by a high-street optometrist in univariate analysis.
- This effect disappeared in a generalized linear mixed models analysis that included indices of socio-economic deprivation at general practice location. These effects have not been demonstrated previously because other programmes do not typically deliver screening through both modalities.
- Heterogeneity in screening uptake exists between general practices using either modality of screening.

and higher prevalence of sight-threatening retinopathy among more deprived groups [12]. Those people least likely to attend screening appointments are at greater risk of sight-threatening retinopathy because they are more likely to have other risk factors, including poor glycaemic and blood pressure control [8]. Poor awareness of the importance of retinopathy screening, psychological factors such as guilt due to poor diabetic control and fear of laser treatment, and practical barriers to attendance have also been identified as factors reducing uptake [13].

Less evidence exists on the effects of factors occurring at the level of general practices and optometrists on screening uptake. A recent qualitative case-based study indicated that general practices with high levels of social deprivation and poorer access to screening location are less likely to achieve higher uptake [14]. Further research into practice-level factors influencing uptake is required to inform improvements in retinopathy screening services.

The Oxfordshire Diabetic Eye Screening Programme is unusual in delivering retinopathy screening through both optometrist practices and mobile screening units. Mobile units with digital retinal cameras provide screening sessions at 22 of the 79 general practices throughout Oxfordshire, and registered people are invited to make appointments for screening at those practices. Those at the remaining general practices are invited to make appointments at any one of 16 local optometrist practices. The allocation of general practices to either modality of screening is influenced by the capacity of individual practices to host a mobile screening unit, and by location, with rural general practices more likely to offer screening through mobile units. The modality of screening is the same for all registered people within each town. Combined service delivery provides an opportunity to compare retinopathy screening services delivered through mobile units and optometrist practices.

In this study, we aim to investigate demographic and primary care practice level variables that influence

retinopathy screening uptake. Variance in uptake between general practices using either modality of screening is analysed to examine for unexplained heterogeneity. Data on retinopathy screening services at optometrist practices is collected to further understand practice-level factors that may account for variance in uptake.

**Participants and methods**

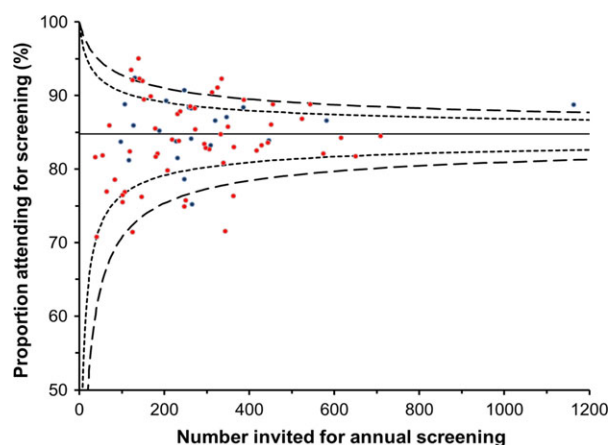
Analyses were performed using data extracted from the Oxfordshire Diabetic Eye Screening Programme management software (OptoMize®, Emis Group PLC). The analysis was restricted to the first date of invitation for each registered person from 1 April 2012 until the end of April 2013, and includes those newly referred to the screening programme and those who had been invited in previous years. This 13-month period was chosen so as to include one invitation for each person because the screening cycle takes just over 12 months. Data on gender, age at first invitation for screening, name and town of registered general practice, date of invitation and date of screening were collected for each person. Decile of Index of Multiple Deprivation (IMD) for the postcode of each general practice address was obtained from the Department for Communities and Local Government [15].

Data were analysed using SAS® 9.4 (SAS Institute Inc., Cary, NC, USA). Individual-level factors contributing to uptake of retinopathy screening were examined with independent chi-squared tests comparing uptake for registered people stratified by gender, age group and modality of screening (mobile unit at general practice versus optometrist practice).

Generalized linear mixed models (GLMM; SAS Proc GLIMMIX) were used to examine the effect of these variables on uptake along with IMD decile for each general practice. General practices were fitted as random effects, and age, gender, modality of screening and IMD group were fitted as fixed effects. Using deciles of IMD was complicated by the numbers of variables and levels in the model and, because Oxfordshire is one of the least deprived areas of England, there were very few practices in deprived areas. Deprivation at general practice address was therefore recorded as follows: IMD Group 1 incorporated deciles 1–5 (most deprived), IMD Group 2 incorporated deciles 6 and 7, IMD Group 3 incorporated decile 8, IMD Group 4 incorporated decile 9, and IMD Group 5 incorporated decile 10 (least deprived).

Screening uptake at each of the 79 general practices was determined. A funnel plot of uptake as a function of the number of people invited for routine annual screening from each general practice was performed to demonstrate heterogeneity between practices (Fig. 1).

Each of the 16 optometrist practices was contacted by telephone during the study period and asked on which days, and when on those days, they offered retinopathy screening appointments, to confirm the next available appointment from the time of the telephone call and how soon they are usually able to offer such appointments.



**FIGURE 1** Funnel plot indicating diabetic retinopathy screening uptake as a function of number of persons invited for screening at general practitioner (GP) practices using both optometrist (red) and mobile unit (blue) screening. Horizontal line indicates mean uptake across all GP practices. Outer dashed lines indicate limits of variance from the mean to 2 SD and 3 SD.

## Results

The Oxfordshire Diabetic Eye Screening Programme invited 21 797 people for screening during the study period and 17 967 (82.4%) attended. Overall uptake rate and uptake rate for groups stratified by gender, age group and modality of screening are shown in Table 1.

The number of people invited for screening at each general practice ranged from 43 to 1236. Funnel plot analysis (Fig. 1) indicated that significant heterogeneity in uptake existed between general practices using either modality of retinopathy screening (minimum, 65%; maximum, 92%).

In univariate analyses using logistic regression, uptake of retinopathy screening was higher for men (83.2%) than for women (81.5%) ( $P = 0.001$ ). Uptake varied between groups stratified by age ( $P < 0.0001$ ), being lowest for the 12–39 years age group (67%), and increasing successively

across age groups up to 79 years (40–59 years, 78%; 60–69 years, 87%; 70–79 years, 88%). Uptake declined in those aged 80 years and above (79%). Uptake was higher for people invited for screening by mobile units (83.5%) than for those invited for screening by high-street optometrists (82%) ( $P = 0.006$ ).

Table 2 describes what are in the three GLMM. Model 3 has the best fit because it has the smallest log likelihood.

The results of the GLMM are shown in Table 3. As in the univariate analysis, uptake varied between groups stratified by age and was lowest in the youngest age group. In Table 3, where IMD Group 1 are the most deprived and IMD Group 5 are the least deprived, the odds ratios show that those people with general practitioners in the most-deprived areas are least likely to attend for screening; IMD Group 1 (0.75, 95% confidence interval (CI), 0.58 to 0.96) compared with IMD Group 2 (0.66, 95% CI, 0.53 to 0.96).

In contrast to the univariate analyses, gender and modality of screening were found to have no significant effect on uptake in the GLMM after age group and deprivation score of general practice were included. The results of the GLMM indicate significant heterogeneity in uptake between general practices using either modality of screening, even after accounting for differences in gender, age, modality of screening and deprivation score. In the GLMM, the intra-class correlation coefficient was 0.03, indicating that 3% of the variability in the screening rate was accounted for by general practices and 97% was accounted for by individual-level or other factors. After fitting the individual-level factors and the practice-level factors, 14 of the general practices had a significant effect at the  $P = 0.05$  level, and four at the  $P = 0.01$  level.

Our telephone survey of 16 optometrist practices indicated heterogeneity in the availability and flexibility of appointments (Appendix 1). The time available for people wishing to book appointments for retinopathy screening with no eye examination varied between practices (median = 23 h/week; minimum = 4 h, maximum = 47 h). Next-day appointments

**Table 1** Uptake of screening (stratified by gender, modality of screening and age group)

		No. invited	No. screened	Percentage screened	<i>P</i> -value*
Total		21 789	17 963	82.4	
By gender	Male	12 384	10 303	83.2	0.0011
	Female	9 369	7 633	81.5	
	Not known	36	27	75.0	
By modality of screening		6 530	5 454	83.5	0.0061
		15 259	12 509	82.0	
By age group	12–39	1 411	940	66.6	< 0.0001
	40–59	6 039	4 727	78.3	
	60–69	5 455	4 763	87.3	
	70–79	5 352	4 727	88.3	
	80 and over	3 531	2 805	79.4	
	Not known	1	1	100.0	

\*Chi-squared test.

**Table 2** Estimates for 2 level generalized dichotomous models of screening uptake

	Model 1	Model 2	Model 3
Fixed effects			
Intercept	1.55 (0.04)	1.40 (0.07)	1.63 (0.09)
Age group		Yes	Yes
Gender		Yes	Yes
Modality of screening		Yes	Yes
Index of Multiple Deprivation group of general practice			Yes
Error variance			
Level 2 intercept	0.114 (0.026)	0.099 (0.023)	0.080 (0.021)
Model fit			
Model fit – twice the log likelihood	2024.6	1468.6	1462.5

**Table 3** Results of the generalized mixed models analysis

		Odds ratio	95% CI	P-value
Age group	12–39	0.52	0.45 to 0.60	< 0.0001
	40–59	0.95	0.85 to 1.05	0.29
	60–69	1.76	1.56 to 1.98	< 0.0001
	70–79	1.96	1.74 to 2.21	< 0.0001
Gender	Female	0.91	0.85 to 0.98	0.014
	Male	Reference		
Modality of screening	Mobile unit	0.99	0.83 to 1.18	0.88
	Optometrist	Reference		
General practice Index of Multiple Deprivation score	Group 1	0.75	0.58 to 0.96	0.02
	Group 2	0.66	0.53 to 0.96	< 0.0001
	Group 3	0.80	0.63 to 1.02	0.070
	Group 4	0.82	0.66 to 1.01	0.063
	Group 5	Reference		

for retinopathy screening were offered by four optometrist practices, and two practices stated that they were usually able to offer appointments within 48 h. Most optometrist practices ( $n = 10$ ) were able to offer appointments within 1 week. One optometrist practice (practice A) could only offer appointments in 4 weeks' time. Weekend appointments were offered by 10 optometrist practices and one practice stated that they would consider offering a screening appointment outside normal opening hours.

## Discussion

Oxfordshire Diabetic Eye Screening Programme achieved an overall screening uptake of 82.4% during the study period. Although this rate is above that defined as achievable by the current Quality Assurance Standard and is just below the achievable rate in the new Quality Standard, it indicates that a significant minority of those invited did not attend screening. These non-attenders are likely to be young people, in whom a longer time interval between diabetic registration and attendance for screening results in greater risk of referable retinopathy being present at the time of first screening [8].

Consistent with previous studies [16–19], rates of attendance were lowest in the youngest age group. Lower uptake

in this group represents a lost opportunity to limit the progression of disease because younger people are at highest risk of developing future retinopathy [18]. As well as increased risk of visual loss, the progression of sight-threatening retinopathy in young people engenders huge socio-economic cost to society. Despite the trend of higher uptake with increasing age, the reduction in attendance rates in those aged over 80 years may relate to reduced mobility or comorbidity limiting access to diabetic retinopathy screening services.

Our analysis of the effect of individual-level factors on uptake benefits from being based on a dataset of all registered people invited for retinopathy screening over 1 year. Data on ethnicity and measurements of blood pressure and glycaemic control for people in our study group were not available to the screening programme and we were thus unable to analyse the effect of these factors.

Uptake was higher for those invited for screening by mobile units than for those invited for screening by a high-street optometrist. However, this effect disappeared in the GLMM that included indices of socio-economic deprivation at the general practice location, reflecting the fact that registered people in more deprived locations are more likely to be offered screening by a high-street optometrist than by a mobile unit. These effects have not been demonstrated

previously because other screening programmes do not typically deliver screening through both modalities. Although the difference in overall uptake between the two screening modalities is small in both univariate analysis and the GLMM, the clinical relevance of this finding relates to optometrists having argued that they offer a wider range of services in terms of possible timings of screening appointments than a mobile screening service. However, the range of services offered by individual optometrist practices within Oxfordshire is highly variable and, given this variation, no increase in uptake within optometrist practices has been demonstrated in this study.

The results of our telephone questionnaire suggest that some of the variance in uptake between those invited for optometrist screening may be due to variation in the availability and flexibility of screening appointments offered by optometrists in different locations. As noted in the case of 'practice A', limited availability of time slots for screening during the week correlated with long waiting times for appointments. Such data are valuable in evaluating screening service provision in different locations.

Consistent with previous studies [12], we found that uptake rates for screening remain lower at practices located in areas of higher socio-economic deprivation. Oxfordshire Diabetic Eye Screening Programme needs to encourage uptake among socio-economically deprived groups because these people are at the highest risk of sight-threatening diabetic retinopathy. IMD score includes the Education, Skills and Training Deprivation Domain which measures the lack of attainment and skills in the local population. Further work should include efforts to determine how one may engage more effectively with those who have a lower educational level, particularly those with poor literacy, health literacy and numeracy.

It is our opinion that general practice likely has a greater effect on screening attendance of registered persons than does the modality of screening they attend. Heterogeneity in screening uptake exists between general practices using either modality of retinopathy screening (see Fig. 1), and this remains true even after adjusting for socio-economic deprivation at the location of the general practice. Although previous studies note greater variance in uptake between general practices than would be expected based on their respective local populations [12], we are unaware of any that have demonstrated such variance quantitatively at a practice level. Variance likely relates to complex interactions between modifiable and non-modifiable risk factors for non-attendance [14].

When looking at four practices individually, three with lower uptake and one with higher uptake, factors that appeared to influence practice uptake apart from socio-economic factors were: the convenience of the screening location, with ease of parking near the location; minority language barriers; and general interest taken by the practice in diabetes care. Within the group who were socio-

economically disadvantaged, it was notable that poor areas of Oxford are served by optometrists, but optometrist practices are not generally located in the poorer parts of the city.

Identifying general practices achieving low levels of uptake provides a basis for further work to assess modifiable risk factors for non-attendance and implement interventions where required. This further work could include examining whether screening uptake varies with practice-level factors such as uptake of patient education resources, the provision of diabetes specialist nurses, whether there is a general practitioner responsible for people with diabetes at the practice, and who registered persons routinely see at the practice for diabetes care.

In conclusion, this study has indicated that existing diabetic retinopathy screening service provision by Oxfordshire Diabetic Eye Screening Programme may not be effective at achieving high uptake among the youngest or oldest age groups. Uptake rates for screening are lower at practices located in areas of higher socio-economic deprivation. Uptake rates have not been found to be higher for those accessing screening services via high-street optometrists, despite this modality of screening being thought to offer increased appointment flexibility above that of mobile units. Significant unexplained heterogeneity in uptake between general practices using either modality of retinopathy screening suggests that practice-level factors may have an important role in determining rates of attendance. Further work should be aimed at determining the extent to which this variance can be accounted for by modifiable practice-level factors that may be amenable to intervention.

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#### Competing interests

None declared.

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#### Author contributions

RBRM wrote the report and designed and conducted the optometrist telephone survey. IMS conducted the statistical analyses. PHS, IMS, SJC and HL all provided input on study design and commented on drafts of the paper. Professor Peter Scanlon is the guarantor of this work and takes responsibility



for the integrity of the data and the accuracy of the data analysis.

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## Appendix 1 Optometrist survey data

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Q1	8	15	46.5	42.5	30	32.5	25.5	34	8	14	3.75	22.75	22.5	16	36.5	15
Q2	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Yes
Q3	35	5	4	1	11	10	3	2	5	3	1	3	1	10	1	7
Q4	> 1 month (4-6 weeks typically)	< 1 week	< 1 week	< 48 h	> 1 week	< 1 week	> 1 week	< 48 h	> 1 week (7-8 days typically)	< 1 week	< 1 week	> 1 week	< 1 week	> 1 week	< 1 week	< 1 week
Q5	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	No	No	Yes
Q6	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes
Overall score	2	6	11	11	7	9	9	9	5	6	4	7	7	4	9	7

A to P, Optometrist practices that responded to the telephone survey (anonymized).

Q1: Estimate the total shop hours per week available to book diabetic retinopathy screening appointments. Q2: Are screening appointments ever available at weekends? Q3: When is the first appointment that you could offer me for diabetic retinopathy screening (number of practice days)? Q4: How quickly are you typically able to offer people an appointment when they contact you? Q5: Would you consider flexible appointments outside the normal shop hours that you currently offer for diabetic retinopathy screening? Q6: Would you consider flexible appointments outside normal shop opening hours for diabetic retinopathy screening?

Overall score – sum of days available: +1 (if screening available at weekend); +3 (if screening available within 1 week); +2 (if screening available in 2 weeks); +1 (if screening possible outside normal diabetic retinopathy screening hours).