Screening Uptake in a Well-Established Diabetic Retinopathy Screening Program

The role of geographical access and deprivation

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OBJECTIVE — To identify criteria that affect uptake of diabetes retinal screening in a community screening program using mobile retinal digital photography units.

RESEARCH DESIGN AND METHODS — Data from the regional diabetes population-based retinal screening program and regional ophthalmology laser database were linked to patient postal code (zip code) data. We used distance from retinal screening event, social deprivation scores, and demographic information to identify risk factors for nonattendance at a diabetes retinal screening event. Patients were subdivided into urban (>125,000 population), other urban (3,000–125,000 population), or rural (<3,000 population) depending on where they lived. Data were collected from 2004 to 2006 inclusive and included 15,150 patients and 32,621 eye screening records.

RESULTS — The mean ± SD age of patients was 63 ± 15 years, and 54% were male. Mean travel time to retinal screening event varied from 7.1 to 17.0 min. For 12% of missed appointments, patients were more likely to be younger, to have longer diabetes duration, to have poor A1C and blood pressure control, to be smokers, and to live in deprived areas. Poor attendance was not associated with sex or distance to retinal screening event.

CONCLUSIONS — Social deprivation is strongly associated with poor attendance at retinal screening events. Time traveled to screening event was not associated with attendance in this study of a mobile retinal screening service, which visited general practitioner surgeries. This data can help inform population-based diabetes retinal screening programs about improving patient uptake.

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Blindness is one of the most feared complications of diabetes (1). Across the U.K., annual digital retinal photography has been introduced as a screening program because it has been shown to be a cost-effective way of reducing visual impairment (2–5). The clinical effectiveness of the program depends on the sensitivity and specificity of the tools being used and upon the population coverage. Digital retinal photography has consistently been shown to be 80% sensitive and 90% specific at detecting sight-threatening lesions (6–8). Population coverage is at least as important but receives less research attention. In screening programs using ophthalmoscopy and retinal photography (9) or optometry (10), blindness due to diabetes was found mainly in patients who did not attend screening or ophthalmology clinics. Improving screening sensitivity beyond 80% will result in small benefits in terms of lowering visual impairment. This is in contrast to improving population coverage. The last members of the diabetes population to be reached by screening are likely to be those who will benefit most, and reaching such individuals is expected to have a major impact on visual impairment and be cost-effective (11).

Screening for diabetic retinopathy is unlike most screening programs. Screening for cervical, breast, or colorectal cancer involves screening a healthy population within a defined age category. Screening for diabetic retinopathy involves screening in a population with a predefined illness who will thus have many other health demands placed on them. Also, once started, screening for diabetic retinopathy will continue for life. For these reasons, the uptake of screening may well be different for diabetic retinopathy compared with other programs. Little is known about the population characteristics that determine uptake of screening in diabetic retinopathy, although it has been suggested that screening uptake may be less in rural than urban areas (12), and it is possible that poor uptake in rural areas may reflect issues of accessibility to the eye screening centers.

We aimed to examine the population characteristics that determine screening uptake in a well-established diabetic retinopathy screening program (13) that uses both mobile camera units and static camera units manned by trained retinal screeners. Controlling for individual factors expected to influence screening uptake, we aimed to test whether 1) those living in deprived areas were less likely to respond positively to the invitation to attend eye screening, 2) those living further from the site of their designated visit were less likely to respond positively to the invitation to attend eye screening, and 3) there were significant practice-level variations in screening uptake.

RESEARCH DESIGN AND METHODS — All patients with diabetes in Tayside, Scotland (n = 16,258, representing 4.2% of the total population of 387,095) undergo annual digital retinal photography as part of a national screening program. The screening program uses two mobile retinal cameras that travel around each general practitioner location in rotation and one static camera in a central location.
Retinopathy and geographical access

Table 1—Summary statistics for explanatory variables

| Variable                      | All patients | Patients invited to eye vans |
|-------------------------------|--------------|------------------------------|
|                               | Mean | Minimum | Maximum | Mean | Minimum | Maximum |
| Sex                           |      |         |         |      |         |         |
| Male                          | 0.54 | 0       | 1       | 0.56 | 0       | 1       |
| Female                        | 0.46 | 0       | 1       | 0.44 | 0       | 1       |
| Age (years)                   | 62.77 | 12      | 102     | 63.42 | 12      | 101     |
| A1C                           |      |         |         |      |         |         |
| Excellent <7%                 | 0.38 | 0       | 1       | 0.40 | 0       | 1       |
| Good 7–8%                     | 0.29 | 0       | 1       | 0.29 | 0       | 1       |
| Unsatisfactory 8–9%           | 0.17 | 0       | 1       | 0.16 | 0       | 1       |
| Poor >9%                      | 0.16 | 0       | 1       | 0.15 | 0       | 1       |
| Duration of diabetes (years)  | 7.34 | 0       | 74      | 7.21 | 0       | 74      |
| Blood pressure (mean arterial pressure) | 97.32 | 56 | 154.67 | 97.73 | 56.66 | 153.33 |
| Smoking status                |      |         |         |      |         |         |
| Nonsmoker                     | 0.40 | 0       | 1       | 0.40 | 0       | 1       |
| Ex-smoker                     | 0.40 | 0       | 1       | 0.42 | 0       | 1       |
| Smoker                        | 0.20 | 0       | 1       | 0.18 | 0       | 1       |
| Accessibility to service (min)| 11.71 | 0       | 87.16   | 5.24 | 0       | 87.16   |
| Carstairs deprivation         |      |         |         |      |         |         |
| 1 Least deprived              | 0.17 | 0       | 1       | 0.18 | 0       | 1       |
| 2                             | 0.16 | 0       | 1       | 0.21 | 0       | 1       |
| 3                             | 0.19 | 0       | 1       | 0.22 | 0       | 1       |
| 4                             | 0.23 | 0       | 1       | 0.24 | 0       | 1       |
| 5 Most deprived               | 0.25 | 0       | 1       | 0.15 | 0       | 1       |
| Screening location            |      |         |         |      |         |         |
| Ninewells Hospital            | 0.47 | 0       | 1       |      |         |         |
| Eye van                       | 0.52 | 0       | 1       |      |         |         |
| Urban rural classification    |      |         |         |      |         |         |
| Dundee                        | 0.41 | 0       | 1       | 0.65 | 0       | 1       |
| Other urban                   | 0.37 | 0       | 1       |      |         |         |
| Rural                         | 0.22 | 0       | 1       | 0.35 | 0       | 1       |

Data were collected from the regional eye screening database (Eyestore), the regional diabetes electronic record (SCI-DC [Scottish Care Information–Diabetes Collaboration]), patient cohort data from the community health index register, and the regional ophthalmology laser database (Table 1). The eye screening data include date of eye screening, camera location, attendance status, and screening results. SCI-DC provides data on date of diagnosis of diabetes, year of birth, and clinical tests such as A1C, blood pressure, and smoking status. The patient cohort data include records on sex, date of address change, year of birth, practice registered, and date of leaving Tayside. The ophthalmology laser data provides date of laser treatment for patients with diabetic retinopathy. All databases contain a pseudo-patient identifier so they can be linked together anonymously. The study was approved by the Tayside Caldicott Guardian, as recommended by the Tayside Committee on Medical Research Ethics. Patients were assigned anonymously to census-based geographical areas based on their residential postal code. To control for disclosure risks, geographical data were attached to the postal codes using a third party (the Health Informatics Centre, Dundee) and the postal codes were removed from the final research dataset. The geographical data include accessibility measures derived using geographical information systems indicating the distance from each person’s residential postal code to their allocated site for screening. This was calculated as the shortest estimated travel time along road networks in minutes. Different road types in urban and rural areas were allocated different average speeds in this calculation. Carstairs (14) deprivation scores were also attached to the residential postal codes; this score is a widely recognized geographical measure of material deprivation that was specially created for the Scottish context. The index is a composite score based on four variables: the percentage of unemployed male residents over age 16 years, the percentage of individuals in households with one or more people per room, the percentage of residents in households with no car, and the percentage of residents in households with an economically active head of household in social class IV or V. Social class is categorized according to occupation as follows: class I, professionals; class II, managerial/technical workers; class III, skilled workers; class IV, partially skilled; and class V, unskilled. These variables are then standardized and summed for each output area. For descriptive purposes, an urban/rural identifier was also attached to the residential postal codes, distinguishing Dundee and other urban (settlements with a population between 3,000 and 125,000) and rural areas in Tayside, based on the Scottish Household Survey sixfold urban/rural classification for Scotland (15).

Nonattending diabetic patients were those invited for screening but who failed to attend. Patients who cancelled their eye screening appointment for a variety of possible reasons were excluded from the analysis. We also confined the analysis to patients invited to the static unit at Ninewells Hospital, Dundee, and the two mobile eye vans. Therefore, patients who attended the eye clinic, research clinic, and “other” clinics, such as antenatal clinics, were removed from the database. The period of data collection for the hospital and the first eye van was January 2004 to December 2006. For the second eye van, which was introduced later, the period covered May 2004 to December 2006. The eye screening data includes 15,150 patients, some of whom were invited more than once during the period, giving a total of 32,621 records.

Statistical analysis
We have panel data with repeated observations for the same patient, and our outcome measure is a binary variable distinguishing those who did or did not attend. Random-effects logit models were used to model the propensity of missing the eye screening. These longitudinal models account for both within- and between-individual variation. We also
tested whether there was significant practice variation using a multilevel model.

**RESULTS** — The mean ± SD age of patients was 63 ± 15 years, and there were more male than female subjects in the dataset (54 vs. 46%). Between 2004 and 2006, 36% of patients were invited once and 64% twice or more. Overall, 12% of the invitations to attend eye screening were missed, with the highest proportion of nonattendees being in urban areas other than Dundee (Table 2), even though patients in these areas had the shortest travel times to the invited screening location.

Model 1 examines the propensity of failing to attend eye screening for all patients, regardless of whether their screening location was static (Ninewells Hospital) or one of the two mobile eye vans (Table 3). Age is significant, with young people having a higher propensity to miss the eye screening, while sex makes no difference. Patients with a longer history of diabetes had a higher risk of missing the screening, as did those who recorded poor A1C before the screening, who were more likely to have stopped smoking, and those who smoked or were ex-smokers.

The average distance traveled by patients to their retinal screening event was 3.3 miles. Geographical accessibility appears to have no effect on attendance, but patients who resided in the most deprived and the second most deprived areas were 2.32 (95% CI 1.92–2.81) and 1.5 (1.24–1.82) times as likely as those in the least deprived areas to miss the screening. Patients who were invited to eye vans for screening were nearly three times (odds ratio 2.92 [95% CI 2.48–3.44]) as likely to miss the screening as patients invited to the static unit at Ninewells Hospital. Model 2, therefore, examines only those invited to the eye van for screening (Table 3).

Overall, the results appear to be similar to the modeling results for all patients who were invited to both the Ninewells Hospital and eye vans (Model 1). The deprivation effect remained strong, though; patients in the most deprived areas were 1.98 (95% CI 1.57–2.5) times less likely to attend than those in the least deprived areas. To identify whether there are practice variations in patient uptake, a multilevel model was used. Controlling for demographic and social factors and medical conditions, as in models 1 and 2, no significant practice-level effects were found (model not shown). Only 45% of cases of laser incidents were carried out between 2004 and 2006 in the screened population. A logit model showed that those patients who missed eye screening at least once during the period were 3.13 (1.58–6.18) times as likely to receive subsequent laser treatment.

**CONCLUSIONS** — Our study identified a number of patient features that are associated with poor attendance at a diabetes retinal screening program. These included young age, poor glycemic and blood pressure control, smoking, and long duration of diabetes. This is unfortunate, as poor glycemic control, poor blood pressure control, and long duration of diabetes are probably the three strongest risk factors for the development of diabetic retinal disease (16,17). Thus, those patients who are least likely to attend screening are also those at greatest risk of sight-threatening eye disease. Our study included a wide range of ages and, in particular, a significant number of people aged <50 years, who may be more confident about their health, even though in this context such confidence may be misplaced.

While ease of access to screening units is associated with uptake in other studies (18,19), it was notable that the travel distance between the patients’ residences and the site of screening did not affect the likelihood of attendance in our analysis. This suggests that, overall, the mobile retinal cameras provide sufficient accessibility to patients, and further attempts to improve access by including more stopping points may not be useful. The policy of a mobile unit attending

### Table 2—Mean travel time and proportion of patients missing invitation by urban/rural types

| Urban rural classification | Mean travel time | Proportion not attending |
|---------------------------|-----------------|-------------------------|
| Dundee                    | 17.0            | 10.7                    |
| Other urban               | 7.1             | 14.7                    |
| Rural                     | 9.5             | 12.6                    |

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mainly general practitioner practice pre-
mises across Tayside appears to be suffi-
cient to reach most patients. Indeed, 
based on a cost-effectiveness analysis, it 
may even be possible to reduce the num-
ber of peripheral sites visited by the mo-
bile retinal screening unit.

On the other hand, social deprivation 
had a strong inverse association with 
screening uptake, with those in more de-
prived areas being considerably less likely 
to attend. This suggests that a targeted ap-
proach of increasing the number of 
screening opportunities in areas of high 
social deprivation could be helpful. We 
found no evidence of practice-level varia-
tions in uptake, even though enthusiasm 
from the general practitioner is clearly as-
associated with patient attendance at 
screening in other screening programs 
(20). Of course, improving uptake in 
more socially deprived areas would re-
quire engagement with a general practice.

Other screening programs have at-
tempts to improve participant uptake 
using a number of different means. Per-
sonalized invitations (18) with an expla-
atory brochure have been shown to be 
helpful (21), especially if endorsed by the 
general practitioner (22). Reminder let-
ters and telephone calls also help (18,19).

Visiting a patient’s home can encourage 
attendance (23) but is labor intensive and 
may not be cost-effective. It has been sug-
gested that any intervention, whatever its 
nature, may be useful (24), and several 
interventions may be no better than just 
one. Drug addiction programs have used 
financial incentives, such as food vouch-
ers and rent payments (25), but these 
would be more controversial in a diabetes 
retinal screening program.

Many of the examples illustrated 
above come from experience in breast 
and cervical screening programs, which in-
volves otherwise “healthy” patients. Dia-
betic retinopathy screening programs 
engage with patients who have a chronic 
condition (i.e., diabetes). Such patients 
have regular contact with health care ser-
ices, and their attitude toward efforts to 
 improve uptake may be significantly dif-
ferent from those of otherwise healthy pa-
tients. We thus need to be careful about 
extrapolating the data from breast and 
cervical screening to diabetic retinal 
screening.

One intriguing finding was that up-
take was considerably better among pa-
tients in Dundee who use the static facility 
at Ninewells Hospital than among those 
elsewhere in Tayside who rely on the mo-
obile eye vans. This is despite the fact that 
travel times were higher in Dundee and 
social deprivation is certainly worse than 
elsewhere in Tayside. One simple expla-
nation for this is that patients’ appoint-
ments for eye screening were linked to 
hospital attendance for other diabetes-
related clinics. Unlike patients attending 
the mobile eye vans, many of the patients 
attending Ninewells may not have needed 
to make a special trip. Hence, we modeled 
the attendance for all patients and those 
attending the mobile clinics separately 
(Table 3).

Finally, we also found that patients 
with diabetes who were less likely to at-
tend for retinal screening were more 
likely to attend for laser photoacoagu-
ation. Patients who were already attending 
the ophthalmology clinic were excluded 
from this analysis, and so it only included 
those patients who were deemed suitable 
for screening and did not have previously 
known sight-threatening retinopathy. 
This again suggests that those patients 
who are not being reached by screening 
are those in greatest need of ophthalmo-
logical intervention. Of course, since 
many patients not attending screening 
ended up receiving laser treatment, it is 
possible that such patients bypassed the 
screening process and still received ap-
propriate care. However, it is more likely 
that such patients attended the ophthal-
almology services when they were symp-
tomatic and did not receive laser 
treatment at the most appropriate time, 
with likely poorer outcomes of laser pho-
toacoagulation. It is also likely that some 
patients presented so late that laser pho-
toacoagulation was no longer possible, 
resulting in a poor outlook for visual acuity.

As Tayside, Scotland, is reasonably repre-
sentative of Scotland as a whole, it is likely 
that the results are generalizable within 
Scotland, where there is a national retinal 
photography screening program. The re-
results may be less applicable to other areas 
where health care delivery and social fac-
tors may be different. In addition, al-
though we highlight a problem, further 
research is required to identify what the 
best solutions may be, although we sug-
gested some possibilities earlier.

In summary, we have identified that 
social deprivation is strongly related to 
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