



Screening for diabetic retinopathy using the mobile retinal camera: the Waikato experience

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Abstract

Aim To report the results of the Waikato Regional Mobile Diabetic Retinopathy Photoscreening Programme.

Methods We audited the results of a diabetic retinal photoscreening programme using the mobile retinal camera in the Waikato region for the period August 1993 to December 2001.

Results A total of 8172 patients were screened one or more times, with a total of 15 555 photoscreens, representing approximately 79% of the expected number of patients with diabetes for the region. Seventy eight per cent showed no diabetic retinopathy (NDR), 9.3% had evidence of non-vision-threatening retinopathy (NVR), and 3.1% had evidence of vision-threatening retinopathy (VTR). A further 2281 (14.7%) led to a referral to an eye clinic for specialist review. The percentage of all screening episodes resulting in VTR fell from 11.5% in 1993 to 1.5% in 2002. The overall failure-to-attend rate for photoscreening was high (18.7%), especially in the Maori population (32.3%).

Conclusion Mobile retinal photoscreening is practical in a large rural area, and its implementation has been associated with a reduction in presentations with vision-threatening retinopathy within the total community. The rate of subsequent development of VTR in the group with normal eyes on initial photoscreening was low and supports a two-yearly repeat photoscreening schedule for this group. Despite significant efforts to improve physical access to photoscreening, the failure-to-attend rates in all ethnic groups other than Europeans are disappointingly high.

In 1993 we reported the introduction of a mobile retinal photoscreening programme for the detection of diabetic retinopathy.¹ In this report we document our experience with the programme from August 1993 to December 2001.

Diabetic retinopathy is the leading cause of blindness and visual impairment in adults in developed societies.^{2,3} Laser photocoagulation therapy has been demonstrated to be effective in the treatment of proliferative retinopathy and diabetic maculopathy,^{4,5,6} and if implemented in time is able to reduce visual impairment and blindness.⁷ However, significant retinopathy is commonly asymptomatic in its early stages,^{4,8} and therefore regular, scheduled eye screening is recommended.⁶ Retinal photoscreening has been accepted as a cost-effective and adequate methodology for this purpose.^{9,10}

The population of the Waikato District Health Board (DHB) (312 918 in the 1996 Census, at the approximate midpoint of the programme period) constitutes nearly 9% of the total New Zealand population. By 2010, the total population is projected to increase to 338 150. One fifth of the Waikato DHB population (62 584 people)

identify themselves as Maori. Forty four per cent reside in rural areas, compared with the New Zealand average of 23%. The absolute number of subjects with diabetes in the Waikato DHB region is not known, but applying age- and ethnicity-specific diabetes prevalence figures¹¹ gives an estimate of 10 326 for the 1996 Census. Prevalence is highest among the Maori, estimated to be 12% of the total Maori population, compared with 10% of the Pacific Islands population and only 6% of all other ethnic groups. Access to ophthalmologists is difficult due to distance and the large number of diabetic subjects in comparison with the restricted number of ophthalmologists. These factors dictated the need for a mobile retinal photoscreening programme for the area.

The prevalence of diabetic retinopathy has been reported in a number of populations,^{9,12} but published data on the prevalence of diabetic eye disease in New Zealand is sparse.^{1,13,14} All diabetic individuals are prone to develop eye complications, with particular subgroups at higher risk. The prevalence of diabetic retinopathy is strongly related to the duration of diabetes. After 20 years, nearly all patients with Type 1 diabetes and over 60 % of patients with Type 2 diabetes have some degree of retinopathy.¹⁵ Up to 21% of Type 2 diabetics are reported to have a degree of retinopathy at the time of diagnosis. Regular screening for the detection of retinopathy is recommended in all diabetic subjects. Patients over 10 years of age with Type 1 diabetes should have an initial eye examination by an ophthalmologist or optometrist within five years of the onset of diabetes. Patients with Type 2 diabetes should have an initial dilated eye examination by an ophthalmologist shortly after the diagnosis of the diabetes is made. Subsequent examinations for both Type 1 and Type 2 diabetic patients should be repeated annually. Examinations will be required more frequently if the retinopathy is progressing.¹⁶

Methods

The methodology for this study has been reported previously.¹ All patients with diabetes mellitus, excluding those with significant eye disease and under the continuing care of an ophthalmologist, were invited to join the programme. Referrals were mostly obtained from general practitioners, members of the Waikato Regional Diabetes Team, the Waikato Hospital ophthalmology clinic, and ophthalmologists. A standard retinal camera was used in conjunction with mydriasis throughout the programme, initially a Kowa FX 50 R, currently a Topcon TRC 50X. All photographs were taken by a qualified specialist medical photographer. The camera was transported to the screening location in the back of a station wagon by the diabetes service's specialist medical photographer. The cameras used were not designed for transport and a pneumatically cushioned transport frame was specially designed by local engineers to enable the cameras to be transported safely in a light motor vehicle. Screening took place at 28 venues throughout the Waikato, including community centres, marae, medical centres, hospital outpatient clinics and a local prison. Specialist diabetes educators within the service arranged screening days for their local area in collaboration with the local general practices. Twenty to sixty patients were booked per screening day.

All patients were registered on a database maintained within the Waikato Regional Diabetes Service centre. The database was used to schedule appointments, record the results of the photoscreens, and report the results and actions recommended by the reviewing ophthalmologist to the patients and their general practitioners.

At photoscreening, the patient's pupils were dilated with 1% tropicamide and 2.5% phenylephrine eye drops administered by the specialist diabetes educator. Two 50° arc colour retinal photographs were taken of each eye, one centred on the macula with the optic nerve head at the periphery of the view, and one centred nasally to the optic nerve head again with the optic nerve head at the periphery of the view. A third photograph, focused at the lens plane, was taken if there was evidence of cataract. Patients were provided with written instructions at the time of making their appointment to bring a

driver to the appointment, not to drive on the day of pupillary dilatation, and to contact their general practitioner in the event of any concerns following the procedure. All slides were identified with the patient's name and the date of photoscreening. Developed films with work sheets were presented to the ophthalmologist for grading. Each image was assigned one of five categories: NDR = no significant diabetic retinopathy; NVR = non-vision-threatening diabetic retinopathy; VTR = vision-threatening retinopathy; OP = other pathology; FNA = films not assessable. In addition, the ophthalmologist could add a free-text comment. The ophthalmologist selected one of four action categories: re-screen in one year; re-screen in two years; re-screen in three years; or refer to the Waikato Eye Clinic. Patients who did not attend were recorded in the database from September 1999 onwards. These patients were then re-booked or the general practitioner requested to re-refer. Prior to September 1999 patients were commonly rescheduled by the local diabetes nurse specialist but there was no formal process for doing so.

Results

From 5 August 1993 to 7 December 2001, 8172 patients were screened for retinopathy one or more times. A total of 15 555 screening episodes were recorded, and 15 334 films were assessable. Of these, 9.8% of patients were rescheduled for screening at one year, 74.9% at two years, and 0.4% at three years. A further 14.7% were referred on to the eye clinic for specialist assessment. Failure-to-attend rates were high throughout the study: European 13.1%, Maori 32.2%, Asian 23.9%, Indian 26.9%, Pacific Islands 34%, with an overall rate of 18.7% of 7188 scheduled appointments.

Numbers of first and subsequent photoscreens per calendar year are shown in Table 1. Currently, approximately 1000 new patients are being enrolled every year.

Table 1. Photoscreens per calendar year of programme

| Year | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|-------------------|------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| First screen | 681 | 786 | 869 | 931 | 997 | 843 | 975 | 1041 | 1049 |
| Subsequent screen | 0 | 62 | 400 | 585 | 816 | 979 | 1386 | 1557 | 1597 |
| Total | 681 | 848 | 1269 | 1516 | 1813 | 1822 | 2361 | 2598 | 2646 |

Table 2. Numbers of subjects, gender and mean age per ethnic group

| Ethnicity | Female | Male | Total no | Mean age | SD age | % of total |
|-----------------|-------------|-------------|-------------|----------|--------|------------|
| Asian | 32 | 29 | 61 | 59.30 | 16.6 | 0.74 |
| European | 2465 | 2567 | 5032 | 65.70 | 16.5 | 61.60 |
| Indian | 64 | 84 | 148 | 57.30 | 12.3 | 1.80 |
| Maori | 880 | 851 | 1731 | 57.70 | 13.4 | 21.20 |
| Not known | 367 | 437 | 804 | 65.10 | 15.0 | 9.80 |
| Other | 87 | 130 | 217 | 62.00 | 15.4 | 2.60 |
| Pacific Islands | 90 | 89 | 179 | 58.64 | 12.7 | 2.20 |
| Total | 3985 | 4187 | 8172 | | | 100 |

The demographic characteristics and ethnicity of the group are listed in Table 2. Males and females are equally represented. Europeans and Maori are the largest subgroups numerically, and the Europeans are older. The group is further categorised according to ethnicity and number of photoscreens per patient in Table 3. Patients were screened up to seven times in the course of the programme.

Table 3. Distribution of number of screens per patient in each ethnic group

| Ethnicity | Number of screens | | | | | | | Total |
|-----------------|-------------------|------|-----|-----|-----|----|---|-------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Asian | 32 | 17 | 9 | 3 | | | | 61 |
| European | 2181 | 1365 | 862 | 461 | 141 | 17 | 5 | 5032 |
| Indian | 76 | 41 | 25 | 5 | | 1 | | 148 |
| Maori | 878 | 471 | 228 | 118 | 31 | 5 | | 1731 |
| Not known | 476 | 242 | 72 | 13 | 1 | | | 804 |
| Other | 163 | 42 | 8 | 4 | | | | 217 |
| Pacific Islands | 94 | 46 | 23 | 11 | 3 | 1 | 1 | 179 |

As seen in Table 4 the overall prevalence of NVR and VTR are 9.3% (n = 1448) and 3.1% (n = 474) respectively. Maori patients have a higher prevalence of VTR (4.3%) than Europeans (2.5%). The prevalence figures for each retinopathy category per calendar year of the programme are shown in Table 5. The highest prevalence of VTR was recorded in the first two years, with a marked fall over the course of the programme.

Table 4. Distribution of retinopathy findings based on ethnicity

| Ethnicity | FNA n (%) | NDR n (%) | NVR n (%) | OP n (%) | VTR n (%) | Total n |
|-----------------|------------------|----------------------|-------------------|------------------|------------------|---------------|
| Asian | 13 (12.4) | 72 (68.6) | 13 (12.3) | 6 (5.7) | 1 (0.9) | 105 |
| European | 601 (5.9) | 8096 (79.5) | 883 (8.7) | 345 (3.4) | 258 (2.5) | 10 183 |
| Indian | 20 (7.7) | 204 (78.8) | 17 (6.6) | 6 (2.3) | 12 (4.6) | 259 |
| Maori | 200 (6.3) | 2344 (74.2) | 381 (12.1) | 100 (3.2) | 136 (4.3) | 3161 |
| Not known | 61 (4.9) | 959 (77.8) | 99 (8.0) | 66 (5.4) | 48 (3.9) | 1233 |
| Other | 31 (10.8) | 221 (77.0) | 24 (8.4) | 8 (2.8) | 3 (1.0) | 287 |
| Pacific Islands | 31 (9.4) | 236 (72.2) | 31 (9.4) | 13 (4.0) | 16 (4.9) | 327 |
| Total | 957 (6.2) | 12 132 (78.0) | 1448 (9.3) | 544 (3.5) | 474 (3.1) | 15 555 |

FNA = films not assessable; NDR = no significant diabetic retinopathy; NVR = non-vision-threatening diabetic retinopathy; OP = other pathology; VTR = vision-threatening retinopathy

Table 5. Percentage distribution of findings per calendar year of programme

| Year | FNA (%) | NDR (%) | NVR (%) | OP (%) | VTR (%) | Total (n) |
|------|---------|---------|---------|--------|---------|--------------|
| 1993 | 1.0 | 79.2 | 4.1 | 4.1 | 11.5 | 681 |
| 1994 | 3.9 | 75.6 | 11.4 | 3.9 | 5.2 | 848 |
| 1995 | 5.5 | 79.0 | 9.0 | 2.5 | 4.0 | 1269 |
| 1996 | 9.4 | 74.2 | 9.6 | 3.0 | 3.8 | 1516 |
| 1997 | 8.2 | 76.1 | 9.8 | 2.4 | 3.4 | 1813 |
| 1999 | 2.0 | 81.0 | 6.0 | 9.0 | 2.0 | 1822 |
| 2000 | 0.6 | 87.8 | 7.3 | 3.3 | 1.1 | 2361 |
| 2001 | 6.8 | 76.6 | 11.3 | 2.3 | 3.1 | 2598 |
| 2002 | 12.4 | 72.3 | 11.6 | 2.2 | 1.5 | 2646 |

FNA = films not assessable; NDR = no significant diabetic retinopathy; NVR = non-vision-threatening diabetic retinopathy; OP = other pathology; VTR = vision-threatening retinopathy

To provide an estimate of the incidence of VTR during the period of the study, patients were split into those with NVR on first photoscreening (643) (Table 6), and those with NDR on first photoscreening (6376) (Table 7). There were 13 618 patient years of follow up in the initial NVR group, and 888 patient years of follow up in the initial NDR group. The incidence of VTR in the initial NDR group equalled 76 unique patient events in 13618 patient years (5.58 events per 1000 patient yrs). The incidence of VTR in initial NVR group equalled 49 unique patient events in 888 patient years (55 events per 1000 patient yrs).

Table 6. Photoscreen results on patients with non-vision-threatening retinopathy (NVR) at initial review

| | Years from first screen | | | | | | | | | | |
|-----|-------------------------|----------|----|----|----|----|----|----|----|---|-------|
| | 0 | 3 months | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
| FNA | | | 13 | 3 | 4 | 4 | 3 | 2 | 0 | 1 | 30 |
| NDR | | | 61 | 49 | 35 | 29 | 17 | 14 | 1 | 2 | 208 |
| NVR | 643 | | 67 | 35 | 23 | 23 | 13 | 8 | 11 | 1 | 824 |
| OP | | | 12 | 1 | | 3 | 2 | | 1 | | 19 |
| VTR | | | 21 | 9 | 1 | 7 | 6 | 6 | 1 | | 51 |

FNA = films not assessable; NDR = no significant diabetic retinopathy; NVR = non-vision-threatening diabetic retinopathy; OP = other pathology; VTR = vision-threatening retinopathy

Table 7. Photoscreen results on patients with no significant diabetic retinopathy (NDR) at initial review

| | Years from first screen | | | | | | | | | | |
|-----|-------------------------|----------|-----|------|-----|------|-----|-----|-----|----|-------|
| | 0 | 3 months | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
| FNA | | | 27 | 146 | 33 | 44 | 23 | 30 | 25 | 14 | 342 |
| NDR | 6376 | 11 | 204 | 2465 | 436 | 1154 | 330 | 469 | 156 | 85 | 5310 |
| NVR | | 2 | 32 | 173 | 61 | 93 | 58 | 83 | 42 | 27 | 571 |
| OP | | | 18 | 57 | 23 | 34 | 26 | 10 | 6 | 3 | 177 |
| VTR | | | 4 | 26 | 11 | 13 | 7 | 5 | 10 | 2 | 78 |

FNA = films not assessable; NDR = no significant diabetic retinopathy; NVR = non-vision-threatening diabetic retinopathy; OP = other pathology; VTR = vision-threatening retinopathy

Discussion

It has been estimated that the total number of people with diabetes in New Zealand will increase from 147 300 in the year 2000 to 180 400 by the year 2010.¹⁷ The explosive growth of the diabetic population demands greater efficiencies in the management of our patients with potential or actual vision-threatening conditions. A screening programme should aim to detect patients at risk when they can still be effectively treated, and this can be achieved by regularly checking the patients' eyes. The 1988 service planning guidelines for diabetes recommended regular eye review for all patients with diabetes. This was not occurring due to the fact that New Zealand doesn't have enough ophthalmologists to meet the extra demand that comprehensive systematic review would put on the service. Our mobile retinal photoscreening programme reduced the burden of normal eye screening on our ophthalmology

service and allowed community-based capture of retinal images, ensuring coverage of those subjects who do not regularly attend hospital clinics. Images were then assessed centrally by specialist ophthalmologists.

Various methods of screening have been shown to be sufficiently sensitive and specific for the detection of sight-threatening eye disease (STED)^{12,18} at justifiable costs.^{10,19} However, the sensitivity and specificity of a screening programme are not the only important considerations. The extent of the population coverage and the screening intervals are vital to the success of a screening programme. The mobile service makes the screening more accessible to a larger number of patients. Our mobile retinal photoscreening programme has achieved good ascertainment of the estimated diabetic population for at least one photo screen. Approximately 79% of the estimated 1996 diabetic population in the Waikato region were screened one or more times.

The percentage of the non-assessable images was 6.2%. The British Diabetic Association recommends a maximum failure rate of 5% for any screening programme to be acceptable.²⁰ It is important to differentiate between technical reasons for poor photography and physical causes such as cataract. The photograph should be repeated if possible if the reason is technical. If there is any other eye disease the patient should be referred to an ophthalmologist. Overall, the number of non-assessable images has been acceptable.

We found that 12 132 eyes (78.0%) didn't show any retinal lesion and, therefore, these patients were rescheduled for repeat photoscreening in two years, thus reducing the waiting list for a specialist ophthalmologist examination. The percentage referred for specialist review was 14.7%.

The true prevalence of sight-threatening diabetic retinopathy (STDR) is unknown, but current evidence suggests that 40–45% of the diabetic population have some diabetic retinopathy (DR) with 10–14% having STDR.¹² Other investigators recently found a baseline prevalence of any retinopathy, proliferative diabetic retinopathy (PDR), and sight-threatening eye disease (STED) of 45.7%, 3.7% and 16.4% respectively, in Type 1 diabetes.²¹ In Type 2 diabetes, the baseline prevalence of any retinopathy, PDR and STED was 25.3%, 0.5% and 6.0% respectively. A large study of DR has been conducted from 1977 in Newcastle. Over 11 years, 5519 diabetic subjects were assessed. Thirty five per cent had some evidence of retinopathy and in 11.4% VTR was found.²²

Our data provide an estimate of the baseline prevalence of grades of diabetic retinopathy and VTR in the Waikato diabetic population, at the point of acquisition into a community-based retinopathy screening programme. The prevalence of any DR was 9.3% (1448 of 15 555) and of VTR was 3.1% (474 of 15 555). Maori patients showed a higher prevalence of VTR (4.3%). The prevalence of VTR has fallen since inception of the programme, as incipient problems were detected in the initial cycles of screening. The reduction in prevalence of retinopathy in our programme indicates that the prevalence of undetected and untreated significant retinopathy in the community is falling.

Our results also suggest that the risk of subsequent VTR is tenfold higher in the NVR than the NDR group. This is in agreement with the previous epidemiological studies describing the onset and progression of diabetic retinopathy. The WESDR (Wisconsin

Epidemiologic Study of Diabetic Retinopathy) established that progression of retinopathy was a function of baseline retinopathy.^{23,24} The more severe the baseline retinopathy, the greater the frequency of progression to vision-threatening retinopathy. Conversely, among Type 2 diabetic patients whose baseline photographs showed no retinopathy, there was less PDR or progression to severe macular oedema over four years. Furthermore, although some guidelines suggest annual screening is required,^{16,23,24} screening every two years has proved clinically satisfactory for monitoring NDR patients in our series.

It should be noted that, in the Waikato management programme, patients with significant retinopathy are followed in specialist ophthalmology clinics and do not appear on the photoscreening register once they have been referred. We do not know precisely how many patients are in the specialist clinic programme at the moment, but expect this to be a significant number. We intend to identify these patients to enable us to assess the percentage of expected diabetic patients in the region receiving either specialist review or photoscreening review.

Several cross-sectional studies show a higher prevalence of microalbuminuria, proteinuria and end-stage renal failure in Maori and Pacific Island patients with Type 2 diabetes compared with Europeans.²⁵ The reasons for these ethnic differences in diabetic nephropathy have not been defined. Similar issues can be raised in relation to diabetic retinopathy. Our results demonstrated a higher prevalence of VTR in Maori (4.3%) than Europeans (2.5%). This is in agreement with a household survey of known diabetics in South Auckland, which indicated that diabetic eye disease had resulted in blindness in at least one eye in 7% of Maori, 8% of Pacific Island patients, but only 2% of Europeans.¹⁴ Among patients with Type 2 diabetes attending the Wellington Diabetes Clinic, Pacific Islands people were more likely to have any retinopathy by direct ophthalmoscopy (40%) than Europeans (23%) or Maori (16%).¹³ It remains to be determined how much of this apparent increase in susceptibility is due to modifiable metabolic factors, which may in turn be related to socioeconomic status and lack of access to culturally appropriate medical care, and how much is due to genetic factors.

In the future, the use of digital imaging systems and development of automated assessment systems should improve the efficiency and effectiveness of the management of patients with diabetic retinopathy²⁶ and reduce the frequency of results that cannot be assessed.

In conclusion, the Waikato Regional Mobile Diabetic Retinopathy Photoscreening Programme has shown that mobile retinal photography is a practical and effective method of screening for diabetic eye disease in rural areas.

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Acknowledgements: We thank the Waikato Regional Diabetes Service staff for their enthusiastic contribution to the programme.

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