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A small number of older type 2 diabetic patients end up visually impaired despite regular photographic screening and laser treatment for diabetic retinopathy

Catharina Hansson-Lundblad1, Kristina Holm2, Carl-David A gardh3 and Elisabet A gardh1

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2Department of Ophthalmology, Lund University Hospital, Lund, Sweden
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ABSTRACT

Purpose: The present study describes the prevalence of visual impairment and blindness in a geographically defined population 8 years after the introduction of a screening programme in 1987 for early detection of sight-threatening diabetic retinopathy.

Methods: Of 374 patients with diabetes, comprising 2.6% of the population in the study community, 72% were examined with fundus photography or biomicroscopy during 1994–95. These patients form the basis of this study. The screening programme was fulfilled by 93% of subjects, all of whom underwent ophthalmic examinations at least every other year. A total of 79 eyes in 52 patients received photocoagulation for macular oedema alone or in combination with severe non-proliferative or proliferative retinopathy.

Results: Eight years after the implementation of the programme, only three patients, all with type 2 diabetes (diabetes diagnosed at or after 30 years of age), had visual acuity \( \leq 0.1 \). The total number of eyes with visual acuity \( \leq 0.5 \) was higher in insulin-treated type 2 diabetic patients \( (n = 20) \) than in those on oral treatment \( (n = 5) \) or diet treatment only \( (n = 1) \) \( (p = 0.006 \) in both cases). The only independent risk factor for visual impairment in eyes with sight-threatening retinopathy was age.

Conclusion: A small number of older type 2 diabetic patients end up with visual impairment due to unsuccessful photocoagulation of macular oedema.

Key words: population - diabetic retinopathy - blindness - screening - laser coagulation

Diabetic retinopathy is the principal cause of blindness before the age of 60 years in industrialized countries (Williams 1994). Intensified metabolic control and blood pressure treatment reduces the risk of sight-threatening diabetic retinopathy (Diabetes Control and Complications Trial Research Group 1993; UK Prospective Diabetes Study Group 1998a,b). However, prevention of visual impairment once sight-threatening retinopathy (proliferative retinopathy and/or macular oedema) has developed requires laser treatment (Diabetic Retinopathy Study Research Group 1981; Early Treatment Diabetic Retinopathy Study Research Group 1991). Since photocoagulation can preserve but seldom restore visual function, the best treatment affects are obtained before visual acuity (VA) has been affected. Screening for early detection of treatable diabetic retinopathy is one of the most important tools in the prevention of diabetic blindness (Stefansson et al. 2000). Such screening procedures are cost-effective and there are several modes of organization and methods that can be used depending on geographical areas and technical facilities available (Stefansson et al. 2000).

We have previously described low frequencies of visual impairment in both type 1 and type 2 diabetes after the introduction of a screening programme for early detection of sight-threatening retinopathy in combination with laser treatment when appropriate (Agardh et al. 1993). That study was representative of a type 1 but not of a type 2 diabetic population in Sweden, as the screening programme at the time included all type 1 diabetic patients but excluded those with type 2 diabetes in receipt of primary care. The present study was conducted in order to describe the prevalence of visual impairment in a population-based survey of diabetic patients in one Swedish community.

Diabetic patients under routine care in general practice or at the nearest depart-
ment of medicine were offered regular fundus examinations in a screening pro-
gramme. This study was conducted 8 years after the introduction of the pro-
gramme. One of the study’s principal aims was to establish to what extent pa-
tients had undergone fundus examinations. A second aim was to register the
examination intervals. A third aim was to describe the prevalence of blindness and
visual impairment and to relate the num-
ber of visually impaired eyes to treatment
diabetes, degree of metabolic control,
hypertension, renal variables, and body
mass index (BMI).

Patients and Methods

Patients

The total population of the Burlöv Com-
munity in southern Sweden numbered 14
500 inhabitants in 1995. All patients in
the community with diabetes mellitus (374) in receipt of primary health care
(n = 257) or in the care of the nearby medical department (n = 117) during two
calendar years 1994–95 were identified. The
diabetes diagnosis relied on WHO
criteria from 1985 (World Health Organ-
isation 1985). Type 1 diabetes was defined as
diabetes diagnosed before 30 years of age, and type 2 diabetes as diabetes diag-
nosed at or after 30 years of age. Out of
374 patients, 268 (72%) had undergone
an eye examination during those 2 years.
These patients form the basis of this
study.

Demographic data for the community
in 1995 are compared with equivalent
data for the country of Sweden in Table
1. A ge distribution and rate of unemploy-
ment were similar but mean annual in-
come was slightly lower, at SEK 148,000
compared with a national mean of
SEK 151,000. The increase in mean an-
nual income over the period extending
from 3 years before to 3 years after the
period of study (1994–95) was also lower
than in national terms. Higher education
was slightly less frequent than the na-
tional average. The population in the
community increased more during the
period than it did in Sweden as a whole
and the proportion of non-Swedish citi-
zens was higher, at 17% versus 6%.

Programme for ophthalmologic
examinations and treatment

A screening programme for early detec-
tion of sight-threatening diabetic retino-

Table 1. Demographic data 1995. (From Statistics, Sweden, http://www.scb.se.)

<table>
<thead>
<tr>
<th></th>
<th>Sweden</th>
<th>Burlöv Community</th>
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<tbody>
<tr>
<td>Age distribution (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–15 years</td>
<td>22</td>
<td>21</td>
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<tr>
<td>16–64 years</td>
<td>61</td>
<td>65</td>
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<tr>
<td>65+ years</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>Population change1000</td>
<td>+2.3</td>
<td>+8.7</td>
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<tr>
<td>Non-Swedish citizenship (%)</td>
<td>6</td>
<td>17</td>
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<tr>
<td>Mean income (SEK)</td>
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<tr>
<td>(16–64 year of age)</td>
<td>151,000</td>
<td>148,000</td>
</tr>
<tr>
<td>Increase in mean income (%)</td>
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<td>(1992–98)</td>
<td>31.9</td>
<td>25.9</td>
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<tr>
<td>Unemployment (%)</td>
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<tr>
<td>(16–64 year of age)</td>
<td>6.7</td>
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<tr>
<td>Education (%) (25–64 years of age)</td>
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<tr>
<td>Elementary school</td>
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<td>Junior high school</td>
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<td>High school 2 years</td>
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<td>University &lt; 3 years</td>
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<tr>
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</table>

pathy was introduced in the community
in 1987. This offered diabetic patients
regular ophthalmologic examinations by
fundus photography (Nikon NF C 50).
Afer dilation of the pupils, three 45°
fields per eye were photographed. These
comprised one nasal field, one temporal
field and one central field that included
stereo photos of the macula. Patients
with no or mild retinopathy continued in
the screening programme and were
photographed at 1–2 year intervals after
re-referral by the general practitioner. Pa-
tients with moderate to severe retinopa-
thy (Early Treatment Diabetic Retinopa-
thy Study Research Group 1991) were
examined by biomicroscopy more fre-
quently outside the screening programme
by experienced ophthalmologists and,
when appropriate, treated with photo-
coagulation.

Laser treatment

Laser coagulation was offered within 3
months of diagnosis. Patients with clin-
cically significant macular oedema received
focal and/or grid treatment and patients
with severe non-proliferative retinopathy
or proliferative retinopathy received pan-
retinal photoocoagulation according to
guidelines from the Early Treatment Dia-
abetic Retinopathy Study Research Group 1991. Treatment of the macular region
preceded that of the periphery.

Visual acuity

Visual acuity was tested using fixed-dis-
tance charts. Three levels were identified
according to VA in the better eye, as
V A = 0.1, 0.2–0.4, and = 0.5. Blindness was
defined as VA ≤ 0.1 and visual impair-
ment as VA 0.2–0.4.

Medical variables

Medical variables registered were HbA 1c,
and blood pressure levels, antihyperten-
sive medication, urinary albumin and
serum creatinine levels and BMI.

Analytical techniques

Glycosylated haemoglobin levels were
analysed by ion exchange chromatogra-
phy using microcolumns (Bio-RAD,
Richmond, California, USA) (reference
range: 4.0–5.6%). Urinary albumin con-
centration was measured with an electro-
imunoassay using human albumin
(Kabi Vitrum, Stockholm, Sweden) (de-
tection limit 12.5 mg/l) or by turbidim-
etry with an automated analyser (CO-
BASE Mira, Roche, Switzerland), anti-
bodies (rabbit antihuman albumin) and
techniques as described by Dakopatts
(Copenhagen, Denmark) (detection limit
5 mg/l). Creatinine levels were measured
with an enzymatic method (creatinine-
hydrolase; Ektachem-analyzer, Instru-
ment K kodak, New York, USA).

Statistics

Student’s unpaired two-tailed t-test was
used for equal and Mann–Whitney’s test
for unequal standard deviations. Pear-
son’s and Spearman’s correlation tests

Statistical data for the community
in 1995 are compared with equivalent
data for the country of Sweden in Table
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</table>
were performed for identification of independent risk factors (SPSS 10.0 for Windows). Fisher’s exact test was used for testing differences of proportions between groups.

**Results**

Patient characteristics for those included in the present study are presented in Table 2. Data on age, age at onset and duration of diabetes were available for all patients. For other variables, data were available for 39–90% of patients (Table 2). A total of 102 patients were excluded from the study due to lack of data on fundus examinations during the 2-year period of the study period.

**Fundus examinations and screening intervals**

Of 266 patients, 32 had been diagnosed with diabetes within a 2-year period prior to fundus examination and thus did not need more than one examination according to our programme protocol. Of the remaining 234 patients with either type 1 (n = 39) or type 2 (n = 195) diabetes, 93% (218/234) fulfilled the screening programme, with at least two examinations within a 5-year period of the programme. A II type 1 diabetic patients (39/39) were examined according to the programme, as were 179 of 195 type 2 diabetic patients, 84/88 of whom were on insulin, 74/80 of whom were on oral treatment, 19/25 of whom were on diet treatment only, and 2/2 whose treatment was unspecified. Only 7% of subjects (16/234) had been examined less often than at the anticipated 2–2.5-year intervals.

**Laser treatment and vitrectomy**

A total of 79 eyes in 50 patients had received laser treatment, focal and/or grid alone (n = 35), panretinal photocoagulation in combination with focal/grid treatment when appropriate (n = 44). Vitrectomy had been performed in an additional four eyes.

**Visual acuity**

The numbers of eyes and patients found to be either blind or visually impaired due to diabetic retinopathy in relation to type of diabetes are given in Table 3. None of the type 1 diabetic patients and only three of the type 2 diabetic patients, two on insulin and one on oral treatment, were blind (VA ≤ 0.1) due to diabetic retinopathy. The proportion of visually impaired eyes was higher among patients with insulin-treated type 2 diabetes than among those on oral treatment and those on diet alone (p = 0.006 in both cases). In one eye in one type 1 diabetic patient, visual impairment was related to cataract rather than to diabetic retinopathy. In type 2 diabetic patients, other causes of visual impairment, including cataract and macular degeneration among others, were present in 51 eyes with no retinopathy or with mild to moderate diabetic retinopathy without macular oedema. The proportions varied between 0 and 5% in the different treatment groups.

Type 2 diabetic patients with sight-threatening diabetic retinopathy in at least one eye were older (p = 0.042), tended to have been younger at diabetes diagnosis (p = 0.015) and therefore to lived with diabetes for a longer time since diagnosis (p < 0.001). They also tended to have higher HbA1c levels (p = 0.029), and higher s-creatinine levels (p = 0.032)
than those without sight-threatening diabetic retinopathy in at least one eye (Table 4). Age at onset, duration of diabetes, and Hba1c were independently related to sight-threatening retinopathy. All type 2 diabetic patients with sight-threatening retinopathy and at least one eye with visual impairment (VA < 0.5) due to diabetic retinopathy had fulfilled the requirements of the screening programme. They were older (p < 0.001) at the time of the study and had been younger at diabetes diagnosis (p = 0.037) than those with VA ≥ 0.5 in both eyes (Table 5). Only age was independently related to visual impairment. It is noteworthy that 22/37 patients in the screening programme with sight-threatening retinopathy ended up with impaired VA in at least one eye.

**Visual impairment and treatment of diabetic retinopathy in type 2 diabetes**

Out of 15 eyes with visual impairment (VA 0.2–0.4), six had been treated for macular oedema alone and nine for a combination of macular oedema and severe non-proliferative or proliferative retinopathy. Corresponding figures for 11 blind eyes (VA 0–0.1) were four and three, respectively. In addition, vitrectomy had been performed in two blind eyes. Among those eyes with sight-threatening retinopathy and VA ≥ 0.5, 17 had been treated for macular oedema alone, one was on a waiting list for treatment, and 16 had undergone panretinal photocoagulation in combination with focal/grid treatment for macular oedema.

**Discussion**

The present study on the evaluation of a screening programme for early detection of treatable diabetic retinopathy in a geographically defined population identified 374 diabetic patients, comprising 2.6% of the population in one Swedish community. This figure is slightly lower than the estimated prevalence of 3% in the region (Bitzen & Schersten 1986) and we cannot exclude the possibility that some otherwise eligible subjects may have attended private general practitioners or may not have seen any doctor at all. The study was confined to one community, which was comparable to the entire country in terms of age distribution and employment levels. However, its mean income was slightly lower, its population net increase was higher, and the number of inhabitants with non-Swedish citizenship was considerably higher than for Sweden as a whole, even exceeding the mean for the three big city areas of Stockholm, Gothenburg and Malmö (9%). Furthermore, there was a trend towards lower levels of education. Thus, the implementation of the screening programme may have been hindered by cultural differences and low socio-economic status. It has been shown that low levels of education and low income are associated with cataract, cataract surgery and impaired vision (Klein et al. 1994), and patients with diabetes without college education seem to develop proliferative retinopathy more often those with tertiary education (Chaturvedi et al. 1996). Based on education levels and socio-economic status, the population of the present study may have been less willing to attend regular examinations and more prone to visual impairment than other more homogenous populations with higher levels of education.

Of the 374 patients identified as having

**Table 4. Patient characteristics in 226/227 type 2 diabetic patients: a comparison between those with and without sight-threatening diabetic retinopathy in at least one eye.**

<table>
<thead>
<tr>
<th></th>
<th>Sight-threatening retinopathy (n = 37)</th>
<th>No sight-threatening retinopathy (n = 189)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>69 ± 11a</td>
<td>64 ± 12</td>
</tr>
<tr>
<td>Age at onset (years)</td>
<td>51 ± 12a</td>
<td>56 ± 13</td>
</tr>
<tr>
<td>Duration (years)</td>
<td>18 ± 9f</td>
<td>8 ± 7</td>
</tr>
<tr>
<td>Hba1c (%)</td>
<td>8.2 ± 1.5a</td>
<td>7.4 ± 1.9</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>157 ± 23p</td>
<td>149 ± 20</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>80 ± 11</td>
<td>82 ± 11</td>
</tr>
<tr>
<td>Antihypertensive medication (n)</td>
<td>21/33</td>
<td>91/162</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>28 ± 7</td>
<td>29 ± 5</td>
</tr>
<tr>
<td>UA-Albumin (mg/L)</td>
<td>3 (0–4050)</td>
<td>0 (0–347)</td>
</tr>
<tr>
<td>S-Creatinine (µmol/L)</td>
<td>91 (59–601)</td>
<td>71 (44–200)</td>
</tr>
<tr>
<td>Oral treatment (n)</td>
<td>28</td>
<td>67</td>
</tr>
<tr>
<td>Diet only (n)</td>
<td>8</td>
<td>77</td>
</tr>
<tr>
<td>Diet only (n)</td>
<td>1</td>
<td>43</td>
</tr>
</tbody>
</table>

Data on visual acuity was missing in 1/227 patients. Values represent mean ± SD, or median (range) for u-albumin and s-creatinine.

<table>
<thead>
<tr>
<th>Value</th>
<th>p-value</th>
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<td>U</td>
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</table>

SBP = systolic blood pressure; DBP = diastolic blood pressure; BMI = body mass index.

**Table 5. Patient characteristics for type 2 diabetic patients with sight-threatening retinopathy: a comparison of patients with VA < 0.5 in at least one eye and patients with VA ≥ 0.5 in both eyes.**

<table>
<thead>
<tr>
<th></th>
<th>Visual acuity</th>
<th>Visual acuity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥ 0.5 in at</td>
<td>≥ 0.5 in both</td>
</tr>
<tr>
<td></td>
<td>least one eye</td>
<td>eyes</td>
</tr>
<tr>
<td></td>
<td>(n = 22)</td>
<td>(n = 15)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>74 ± 10a</td>
<td>61 ± 10</td>
</tr>
<tr>
<td>Age at onset (years)</td>
<td>54 ± 11b</td>
<td>46 ± 11</td>
</tr>
<tr>
<td>Duration (years)</td>
<td>20 ± 9</td>
<td>15 ± 7</td>
</tr>
<tr>
<td>Hba1c (%)</td>
<td>8.4 ± 1.7</td>
<td>8.0 ± 1.1</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>158 ± 25</td>
<td>157 ± 21</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>80 ± 11</td>
<td>81 ± 11</td>
</tr>
<tr>
<td>Antihypertensive medication (n)</td>
<td>14/21</td>
<td>7/12</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>28 ± 8</td>
<td>28 ± 5</td>
</tr>
<tr>
<td>UA-Albumin (mg/L)</td>
<td>3 (0–4050)</td>
<td>3 (0–125)</td>
</tr>
<tr>
<td>S-Creatinine (µmol/L)</td>
<td>99 (60–601)</td>
<td>76 (39–228)</td>
</tr>
<tr>
<td>Insulin treatment (n)</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>Oral treatment (n)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Diet only (n)</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Values represent mean ± SD, or median (range) for u-albumin and s-creatinine.

<table>
<thead>
<tr>
<th>p-value</th>
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SBP = systolic blood pressure; DBP = diastolic blood pressure; BMI = body mass index.
been diagnosed with diabetes, 72% participated in the screening programme. While this rate of participation is lower than in comparable studies, it should be noted that 93% of these subjects fulfilled the programme’s requirements, representing a higher proportion of study subjects to do so than in previous studies of homogeneous Nordic populations (A gardh et al. 1993; H enricsson et al. 1996; K ristinsson et al. 1997). Lack of ophthalmological examinations was evident only among patients with type 2 diabetes. We cannot exclude the possibility that the proportion of patients with sight-threatening retinopathy and visual impairment may have been different (i.e. higher) in those who did not have any ophthalmological examination. However, in a country like Sweden, with a state health care system, it seems unlikely that diabetic patients suffering from severe visual impairment would not see a doctor. Thus, we speculate that the frequency figures given in the present study are unlikely to be too low.

Eight years after the institution of the screening programme, the prevalence of blindness for type 1 diabetic patients was 0%, and for type 2 diabetic patients only 1%. Although the numbers of patients in this study are limited, particularly those with type 1 diabetes, the results of this study on a geographically defined population show that patients offered regular fundus screening examinations, followed by laser treatment when appropriate, rarely develop blindness due to diabetic retinopathy. The results are in accordance with those of other Nordic studies on small homogeneous populations (A gardh et al. 1993; K ristinsson et al. 1994a,b; H enricsson et al. 1996). Compared to figures for the prevalence of blindness and visual impairment reported during the 1980s (N ielsen 1982; J ernéld & A lgvere 1987; S jöjölie & G reen 1987), the results of the present study and others during the 1990s are encouraging. On a larger scale, B äcklund et al. (1997) found that the number of newly blind patients referred to low vision rehabilitation centres in Stockholm County, Sweden, decreased by one-third during a 15-year period after a mass mailing to people with diabetes urging them to have retinal examination. In contrast, Porta et al. (1995) were unable to demonstrate decreased registration of blindness in northwest Italy between 1967 and 1991, despite the introduction of screening programmes for diabetic retinopathy. Recently, however, Porta et al. (2001) reported a decreased incidence of blindness in type 1 diabetic patients, although blindness in type 2 diabetes, particularly among elderly patients, remained constant.

Despite screening and laser treatment, blindness and visual impairment could not be avoided, particularly in type 2 diabetic patients with macular oedema. Impaired VA in this patient group was found to be associated with older age, but not with other risk factors such as longer duration of diabetes, degree of metabolic control and blood pressure levels. Thus, despite early diagnosis and treatment, impaired VA in type 2 diabetes is most likely due to unsuccessful laser treatment in older type 2 diabetic patients with macular oedema. This accords with the results obtained by Porta et al. (2001). Sight-threatening retinopathy per se, regardless of VA, was associated with some well-known risk factors, such as age at onset and duration of diabetes, as well as with degree of metabolic control (A iello at el. 2001). Systolic blood pressure was not an independent risk factor.

In summary, the present study on a geographically defined population suggests there are beneficial effects in screening for and laser treatment of diabetic retinopathy in both type 1 and type 2 diabetes. It also identifies a subgroup of older type 2 diabetic patients in whom VA cannot be preserved, probably due to unsuccessful photocoagulation of diabetic macular oedema.

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