Diabetes & Metabolism 35 (2009) 431–438

Review

Epidemiology of diabetic retinopathy: Expected vs reported prevalence of cases in the French population

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Received 21 January 2009; received in revised form 27 May 2009; accepted 2 June 2009
Available online 5 November 2009

Abstract

Aim and methods. – Impaired eyesight and vision loss due to retinopathy are among the most feared complications in diabetic patients. As the number of diabetic patients is predicted to increase, a corresponding increase in the number of patients with diabetic retinopathy (DR) is also to be expected. This review is an update of the published literature pertaining to the epidemiology of DR.

Results. – Over the past 20 years, eight population-based studies have been conducted in Western countries using photographic evidence of DR. Their results have consistently suggested that the prevalence of DR is close to 28.7%, whereas proliferative DR and macular oedema account for 9% and 17%, respectively, of all diagnosed cases. Various longitudinal studies indicate an annual incidence of DR of 2–6%. However, in France, the epidemiology of DR has mostly been investigated by observational studies. The recorded prevalence of DR, based on physicians’ reports, is estimated to be 10%, suggesting that DR is underdiagnosed in the French diabetic population. The discrepancy between the expected and reported prevalences of DR could be explained by the number of patients whose retinal status is unknown. DR screening with non-mydriatic fundus photography is effective for identifying early and advanced DR. Screening programmes carried out over the past 5 years in different regions of France indicate that 10–20% of diabetic patients with previously unknown retinal status have retinopathy.

Conclusion. – Further implementation of screening programmes is the key to improving DR diagnosis and preventing vision loss in the French diabetic population.

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Keywords: Diabetic retinopathy; Epidemiology; Prevalence; Incidence; Screening; Review

Résumé

Épidémiologie de la rétinopathie diabétique : différence entre la prévalence attendue et la fréquence des cas déclarés en France.

Objectif. – La rétinopathie est l’une des complications du diabète les plus redoutées, en raison du risque d’altération de la vision et de cécité. Dans les années à venir, le nombre de cas de rétinopathie diabétique (RD) devrait augmenter par suite d’une augmentation du nombre de patients diabétiques.

Méthodes. – L’objectif de cette revue a été de mettre à jour les données épidémiologiques sur la RD.

Résultats. – La recherche bibliographique a trouvé huit études de prévalence de la RD menées dans des pays occidentaux au cours des 20 dernières années ; il s’agissait d’études de population et le diagnostic de RD était établi à partir de photographies rétiniennes. Les résultats sont superposables et montrent une prévalence de la RD d’environ 28,7% ; la RD proliférante et l’œdème maculaire rendent compte de 9 et 17% des cas de RD diagnostiqués. Différentes études de suivi indiquent que l’incidence annuelle de la RD est d’environ 2 à 6%. En France, les données épidémiologiques reposent surtout sur les résultats d’études observationnelles. La prévalence de la RD déclarée par les médecins est estimée à 10%. La différence entre la prévalence attendue et la prévalence déclarée de la RD laisse supposer que pour un grand nombre de sujets diabétiques, l’examen de la rétine n’a pas été effectué et le statut rétinien n’est pas connu. Le dépistage de la RD par photographies du fond d’œil permet d’identifier la RD à un stade précoce ou avancé. Plusieurs campagnes de dépistage ont été menées en France depuis cinq ans. Une RD a été trouvée chez 10 à 20% des patients dépistés qui n’avaient pas bénéficié d’une exploration rétinienne préalable.

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doi:10.1016/j.diabet.2009.06.002

2. Literature search methods

For the past 25 years, the epidemiology of DR has been dominated by the findings of the Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR) [9]. However, data from the WESDR are now outdated and reflect diabetes management in the past. Other longitudinal population studies — such as the UKPDS, DCCT and EDTRS — have also investigated the prevalence and incidence of diabetes complications [10–12]. The overall prevalence of the disease was 3.95%, confirming its constant progression over time [2].

Diabetes has many manifestations in the eye, of which diabetic retinopathy (DR) and cataract are the most frequent causes of visual impairment. In Western countries, diabetic eye disease represents one of the leading causes of blindness, after macular degeneration, glaucoma and cataract [3]. DR is broadly divided into two clinical stages: nonproliferative (NPDR) and proliferative diabetic retinopathy (PDR). DR progressively affects the integrity of the retinal microvessels, resulting in abnormal permeability and non-perfusion of capillaries, leading to microaneurysms. PDR is observed when the occlusion of retinal capillaries leads to retinal ischaemia, thereby promoting the development of neovascularization of the surface of the retina. Macular oedema (MO) develops when abnormal permeability results in the collection of fluid around the macula. Laser photocoagulation therapy has proved effective for reducing DR progression, and vitrectomy can prevent severe vision loss in patients with advanced DR. Because DR is a detectable and treatable condition, local and international guidelines have recommended an annual fundus examination for diabetic patients [4–8].

The prevalence of DR is thought to be strongly related to the prevalence of diabetes. As the prevalence of diabetes is expected to rise in the future, a concomitant increase in the number of patients affected with DR should also be expected. Several factors have been identified as risk factors in the development of DR, including the duration of diabetes, diabetes type, and poor glycaemic and blood pressure control [9–11].

For the past 25 years, the epidemiology of DR has been dominated by the findings of the Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR) [9]. However, data from the WESDR are now outdated and reflect diabetes management in the past. Other longitudinal population studies — such as the UKPDS, DCCT and EDTRS — have also investigated the prevalence and incidence of diabetes complications [10–12]. The objective of the present review is to provide an update of the published literature pertaining to the epidemiology of DR, with a particular focus on data relevant to DR diagnosis in France.

2. Literature search methods

The MEDLINE database was searched from 1980 to 2008, using a strategy based on the terms ‘diabetic retinopathy’, ‘epidemiology’, ‘prevalence’ and ‘incidence’, and limited to ‘human’ and ‘English language’. Relevant articles were original reports of population-based studies restricted to selected Western countries (Europe, USA, Canada, Australia), and designed to specifically describe the prevalence and/or incidence of DR. The MEDLINE search generated 2460 citations, of which 58 were considered relevant.

As there are inconsistencies among epidemiological studies, and differences in study methods can contribute to conflicting reports of prevalence and incidence [13], the search was restricted to studies using the reference method for DR diagnosis — specifically, multifield stereoscopic fundus photography, graded by an ophthalmologist using the Early Treatment Diabetic Retinopathy Study (ETDRS) classification system [14]. In addition, we discarded the WESDR for the present review, although a number of related articles were retrieved. The reasons for doing this were:

- the WESDR study was initiated in the early 1980s, and the included patients were grouped according to their age at diagnosis and treatment received, and not according to the type of diabetes, as is currently done;
- significantly higher prevalence rates of DR were reported (up to 70% in patients treated with insulin) in contrast to more recent studies, as it is likely that advances in the management of diabetes (such as improved glycaemic and blood pressure control) have led to a progressive decline in retinopathy frequency.

3. Epidemiology of diabetic retinopathy in Western countries

3.1. Prevalence of diabetic retinopathy

A total of eight studies provided prevalence data for DR, including PDR and MO. These included the Beaver Dam Eye Study, Exeter Diabetic Retinopathy Screening Programme (EDRS), Blue Mountains Eye Study, Visual Impairment Project (VIP), Arhus County Study, Casteldaccia Eye Study, Australian Diabetes, Obesity and Lifestyle Study (AusDiab) and Multi-Ethnic Study of Atherosclerosis (MESA) [15–22] (Table 1). All were population-based and conducted from 1988 to 2002 in the USA, Australia and Europe (United Kingdom, Denmark, Italy), and all used reference examination for DR diagnosis. Patients included had known type 1 or type 2 diabetes (a few patients had newly diagnosed diabetes in [15,17]). Their mean age ranged from 64 to 72 years and their mean duration of diabetes from 7 to 14.6 years.

Despite heterogeneity in patient-selection criteria, country and selection period, the percentage of patients found with DR...
Table 1
Prevalence of diabetic retinopathy (DR) in Western countries in population-based studies using the reference method for DR diagnosis.

| Study (reference) | Setting, country, time period | Diabetic patients (n) & diabetes type | Mean age (years; min–max or ± S.D.) | Mean duration of diabetes (years; min–max or ± S.D.) | Prevalence of DR
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Any DR (%)  PDR (%)  MO (%)</td>
</tr>
<tr>
<td>Beaver Dam Eye Study [15]</td>
<td>Population-based, USA, 1988–1990</td>
<td>445 (435 with gradable photographs), type 2 (known, 395; newly diagnosed, 50)</td>
<td>NK (≥ 43)</td>
<td>NK</td>
<td>36.8 1.8 3.0</td>
</tr>
<tr>
<td>Exeter Diabetic Retinopathy Screening (EDRS) Programme [16]</td>
<td>Population, Exeter, UK, 1992</td>
<td>775, types 1 &amp; 2</td>
<td>72.1 (15–100)</td>
<td>13.0 (1–79)</td>
<td>24.2 2.8 6.1</td>
</tr>
<tr>
<td>Blue Mountains Eye Study [17]</td>
<td>Older residents (aged ≥ 49 years), Sydney, Australia, 1992–1994</td>
<td>256 (253 with gradable photographs), types 1 &amp; 2 (known, 214; newly diagnosed, 39)</td>
<td>NK (≥ 49)</td>
<td>Newly diagnosed: 15.4% 1–9: 54.9% 10–19: 20.9% ≥ 20: 8.7%</td>
<td>32.4 1.6 4.3</td>
</tr>
<tr>
<td>Visual Impairment Project (VIP) [18]</td>
<td>Residents (aged ≥ 40 years), Victoria, Australia, 1992–1996</td>
<td>234, types 1 &amp; 2</td>
<td>64.2 (45–91)</td>
<td>14.6 (0–44)</td>
<td>29.1 4.2 5.6</td>
</tr>
<tr>
<td>Arhus County study [19]</td>
<td>Representative sample of diabetic patients, Arhus County, Denmark, 2000</td>
<td>378, type 2</td>
<td>65 ± 12</td>
<td>9 ± 8</td>
<td>31.5 2.9 5.3</td>
</tr>
<tr>
<td>Casteldaccia Eye study [20]</td>
<td>Population-based (aged ≥ 40 years), Italy (Sicily)</td>
<td>132, types 1 &amp; 2</td>
<td>40–49: 7.6% 50–59: 18.2% 60–69: 46.2% ≥ 70: 28.0%</td>
<td>1–9: 29.5% 10–19: 40.9% ≥ 20: 29.5%</td>
<td>34.1 4.5 7.6</td>
</tr>
<tr>
<td>Australian Diabetes, Obesity and Lifestyle study (AusDiab) [21]</td>
<td>Population-based (aged ≥ 25 years), Australia, 2002</td>
<td>333, known type 2</td>
<td>65 ± 11b</td>
<td>7b (0–15)</td>
<td>21.9 2.1 3.3</td>
</tr>
<tr>
<td>Multi-Ethnic Study of Atherosclerosis (MESA) [22]</td>
<td>Subjects free of cardiovascular disease, prospective cohort, USA, 2002–2006</td>
<td>153c, types 1 &amp; 2</td>
<td>64.3 ± 9.5</td>
<td>8.5 ± 8</td>
<td>24.8 2.6 2.7</td>
</tr>
</tbody>
</table>

Total 2693 Weighted meand 28.7 2.6 4.8

PDR: proliferative diabetic retinopathy; MO: macular oedema; NK: not known (not indicated in the article).

a Diagnosed with DR only.
b Diagnosed with DR only.
c Caucasian patients only.
d Number of subjects included in each study as weights.
was relatively similar, ranging from 21.9 to 36.8% (weighted mean, using the number of subjects included in each study as weights: 28.7%). PDR accounted for about 9% of all cases of diagnosed DR (range: 1.6–4.5%; weighted mean: 2.6%), and MO accounted for around 17% of all diagnosed DR cases (range: 2.7–7.6%; weighted mean: 4.8%). In summary, the prevalence rates of DR were consistent across these selected studies, suggesting that the prevalence of DR is close to 28.7% in the Western world (countries promoting the same strategies to manage diabetes and to control glycaemia/blood pressure levels in their populations) [23].

In Table 1, the data presented are for Caucasian populations only, although the prevalences and risk factors of DR have been described among multiethnic populations in US studies. In MESA [22], African-American and Hispanic populations had significantly higher prevalences of any DR than white/Caucasian and Chinese populations. However, ethnicity was not an independent predictor of retinopathy, suggesting that other risk factors (diabetes duration, glycaemic levels) may be involved in the higher rates of retinopathy seen in African-Americans and Hispanics. Ethnic differences in DR diagnosis were also reported in the Veterans Affairs Diabetes Trial (VADT) [24]. In this cohort, severe retinopathy was more frequent in African-Americans and Hispanics than in non-Hispanic whites/Caucasians but, unlike MESA, the differences could not be explained by standard risk factors. To our knowledge, the prevalence of DR according to ethnicity has not been investigated in EU countries.

3.2. Incidence of diabetic retinopathy

Only three population-based studies assessed DR longitudinally using the reference method for DR diagnosis (VIP, Blue Mountains Eye Study and AusDiab [25–27]) (Table 2). In all three studies, which were limited to a small number of patients, the cumulative incidences of DR were 11% (95% CI: 3.8–18.1%), 22.2% (95% CI: 14.1–32.2%) and 13.9%, respectively, after five years of follow-up [25–27].

Data from larger screening cohorts suggest that the incidence of DR is high, as is also the incidence of severe vision-threatening DR. Primary-care patients in the Liverpool Diabetic Eye Study were initially screened between 1991 and 1999, and those who had no baseline DR were prospectively studied (501 type 1 and 3743 type 2 patients) [28,29]. Over a period of five years, the cumulative incidence of DR was 36.8 and 30.5% in type 1 and type 2 patients, respectively, while sight-threatening DR was present in 3.9% in both patient groups. Gender was not related to the incidence of DR, but longer duration of disease was associated with greater risk of DR in both types of diabetes.

The results of long-term follow-up studies suggest that the cumulative incidence of DR has decreased over the past 35 years, at least in type 1 diabetics. In the Danish Steno cohort, patients diagnosed between 1965 and 1984 were studied for up to 20 years [30]. In the most recently diagnosed patients — those referred between 1979 and 1984 — decreases in the incidences of DR and MO were demonstrated, suggesting that modern strategies to control glucose levels and to lower blood pressure have contributed to reducing the incidence of these diabetes complications.

DR incidence has also been evaluated in clinical trials. The event rates in such populations should theoretically be lower than those in observational cohorts, in part due to the inclusion of more compliant patients. However, in the randomized comparative DIRECT-Prevent 1 study, retinopathy was seen in 25% of type 1 diabetic patients treated with candesartan vs 31% in the placebo-treated group over a median period of 4.7 years [31]. The authors suggested that the DR incident rate in the placebo group probably reflected the optimal rate achieved with the current practice.

In summary, data from various longitudinal studies suggest that the annual incidence of DR is approximately 2–6%. This means that the incidence rates are only about five to 10 times lower than the prevalence rates, suggesting a high turnover of patients with retinopathy. This is probably related to their shorter life expectancy due to advanced age and longstanding diabetes.

3.3. Prevalence of diabetic retinopathy in France

Our search could find no population-based studies conducted in France using a reference method to diagnose DR. In the CODIAB study [32–34], the sample was mainly hospital-based, and limited to a small number of patients with type 2 diabetes who regularly attended hospital for endocrinology consultation. In this study, DR was explored using a reference method for diagnosis (direct ophthalmoscopy, slit-lamp examination, fluorescein angiography). The prevalences of any DR, PDR and MO were 33, 3.3 and 5.6%, respectively. Advanced retinopathy (PDR, MO) increased with increased duration of diabetes, and was strongly linked to the other diabetes complications studied — namely, peripheral neuropathy and nephropathy. Interestingly, DR prevalence rates were similar to those reported in population-based studies in other Western countries, although the CODIAB patients were not necessarily representative of the diabetic population, as they were potentially more severely affected than patients seen in private practice.

3.4. Prevalence of declared diabetic retinopathy

Several observational studies have evaluated the prevalence of known DR in France on the basis of physicians’ reports (Table 3). Retinopathy was identified in 12% of patients with type 2 diabetes by Grimaldi et al. [35], with DR frequency being significantly increased with increasing patients’ age and longer disease duration. In the cohort with longstanding diabetes (mean duration: 10–15 years) described by LeFloch et al. [36], DR was found more frequently in patients with type 1 rather than type 2 diabetes, and whether treated or not with insulin (31.1, 12.9 and 8.6%, respectively).

ECODIA was a cross-sectional survey of a representative sample of general practitioners and diabetologists/endocrinologists who had collected data from 4119 ambulatory patients with type 2 diabetes [37]. The patients’ mean duration of diabetes was 8.9 years, and more than a third had complications.
### Table 2

Incidence of diabetic retinopathy (DR) in Western countries.

<table>
<thead>
<tr>
<th>Study (reference)</th>
<th>Setting, country, time period</th>
<th>Patients (n) &amp; diabetes type</th>
<th>Incidence of DR (95% confidence interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Impairment Project [25]</td>
<td>Population-based, Australia, 1992–1994 (follow-up data collected 5 years later)</td>
<td>121, types 1 &amp; 2</td>
<td>Cumulative 5-year incidence: Any DR: 11% (3.8–18.1%); PDR: 2.9% (0–6.4%); MO: 8% (2.7–13.3%)</td>
</tr>
<tr>
<td>Blue Mountains Eye Study [26]</td>
<td>Population-based (older residents), Australia, 1992–1994</td>
<td>150, types 1 &amp; 2</td>
<td>Cumulative 5-year incidence: Any DR: 22.2% (14.1–32.2%)</td>
</tr>
<tr>
<td>Australian Diabetes, Obesity and Lifestyle study (AusDiab) [27]</td>
<td>Population-based (aged ≥ 25 years), Australia, 2002</td>
<td>144, known diabetes</td>
<td>Cumulative 5-year incidence: Any DR: 13.9%; PDR: 0.7%; MO: 3.0%; PDR: 0.0%</td>
</tr>
<tr>
<td>Steno Diabetes Center study [30]</td>
<td>Clinic-based cohort, Denmark, patients managed until year 2000</td>
<td>600, type 1 (four groups of patients based on year of diabetes onset)</td>
<td>Cumulative incidence of DR (patients followed ≥ 20 years): Groups A, B, C*: 31.2% (22.2–39.8%), 30.3% (22.2–38.4%), 19.3% (11.2–27.4%), respectively; Group D*: 12.5% (5.2–19.8%)</td>
</tr>
<tr>
<td>Liverpool Diabetic Eye study [28]</td>
<td>Screening population in primary care, Scotland, UK, 1991–1999</td>
<td>501, type 1</td>
<td>Cumulative 5-year incidence: Any DR: 36.8% (20.6–44.1%); sight-threatening DR: 3.9% (1.4–5.4%); sight-threatening maculopathy: 3.2% (1.0–5.4%)</td>
</tr>
<tr>
<td>Liverpool Diabetic Eye study [29]</td>
<td>3743, type 2</td>
<td></td>
<td>Cumulative 5-year incidence: Any DR: 30.5% (28.2–32.8%); sight-threatening DR: 3.9% (2.8–5.0%); sight-threatening maculopathy: 3.2% (2.2–4.2%)</td>
</tr>
<tr>
<td>DIRECT-Prevent 1 [31]</td>
<td>Randomized, placebo-controlled trial of candesartan, international, multicentre, 2001–2008</td>
<td>1421 (placebo, 710), type 1, normotensive patients, treated with insulin</td>
<td>Cumulative 4.7-year incidence in placebo group: 31%</td>
</tr>
</tbody>
</table>

PDR: proliferative diabetic retinopathy; MO: macular oedema.


### Table 3

Prevalence of known diabetic retinopathy (DR) in France according to physicians’ reports.

<table>
<thead>
<tr>
<th>Setting, study time period</th>
<th>Patients (n) &amp; diabetes type</th>
<th>Prevalence of known DR [95% confidence interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grimaldi et al. [35]</td>
<td>1203 GPs, 1996–1997</td>
<td>5548, type 2, patients intended to be treated with acarbose 12%</td>
</tr>
<tr>
<td>LeFloch et al. [36]</td>
<td>3084 GPs, 1996–1997</td>
<td>7391, type 1, 8.9%; type 2, with insulin, 18.7%; type 2, without insulin: 72.4% 31.1% (type 1), 12.9% (type 2, receiving insulin), 8.6% (type 2, not receiving insulin); 62.9%, 51.5, 49.4% respectively, consulted an ophthalmologist within the past year 10.6% [9.5–11.6%]</td>
</tr>
<tr>
<td>ECODIA [37]</td>
<td>Representative sample: 311 GPs, 51 diabetologists/endocrinologists, 1998–1999</td>
<td>4119, type 2 9.9% (43% consulted an ophthalmologist within the past year, based on reimbursement data)</td>
</tr>
<tr>
<td>ENTRED [38]</td>
<td>Representative sample: patients reimbursed for OADs or insulin, 1718 physicians, 2001</td>
<td>3648, types 1 &amp; 2 41% (43% consulted an ophthalmologist within the past year, based on reimbursement data)</td>
</tr>
<tr>
<td>Rubino et al. [39]</td>
<td>France, Italy, Spain, UK: total 162 physicians (France, 49 GPs), 2005</td>
<td>Recorded diagnosis of DR Total: 752 patients (type 2, 72%) France: 130 patients (type 2, 59.2%) 11.4% [8.8–13.9%]</td>
</tr>
</tbody>
</table>

GPs: general practitioners; OADs: oral antidiabetic drugs.

* Patients with recorded diagnosis of DR.
related to diabetes. In this case, the prevalence of declared DR was 10.6% (95% CI: 9.5–11.6%).

In the ENTRED survey, ophthalmological and neuropathic complications of diabetes were assessed in a representative sample through questionnaires and patient reimbursement data from social security services [38]. Data were analyzed from 3648 subjects reimbursed for an oral antidiabetic drug and/or insulin during the fourth trimester of 2001, and from their 1718 physicians. According to the patients’ questionnaires, 14.5% had already received previous laser treatment and 42.6% had undergone fundus examination during 2001. According to the physicians’ questionnaires, 9.9% of patients had DR, 4.5% had already received laser treatment and 65.3% had previously undergone ophthalmological examination. In contrast, reimbursement files showed that only 43% of patients had consulted an ophthalmologist during the past year. These results suggest that the physicians’ declarations were biased (underestimated), as demonstrated by the lower reporting of laser treatment compared with the patients’ declarations. In addition, measures were also possibly underevaluated, as a smaller proportion of patients than had been declared had undergone fundus examination during the past year.

The rates of recorded diagnoses of DR was recently assessed and compared in diabetic patients living in different European countries [39]. DR was reported in 11.4% of French patients (95% CI: 8.8–13.9%) vs 10.3%, 19.6% and 19.7% of patients living in Spain, UK and Italy, respectively. These data suggest that the severity of DR is related to longer duration of diabetes and to the frequency of other comorbidities — particularly nephropathy and coronary heart disease. PDR accounted for 20.8% of reported DR in French patients, which may reflect the fact that patients were more likely to be diagnosed with DR only at later stages of diabetic disease or when DR is at a more advanced stage.

However, the value of such observational studies is limited, as the patient’s DR status relies exclusively on the physician’s diagnosis. Yet, taking all the selected studies together, the frequency of “known” or “recorded” DR in French diabetic patients was around 10% — well below the 28.7% average estimated prevalence of DR from epidemiological studies. This suggests that DR is either underdiagnosed in patients with diabetes or that the prevalence of DR is much lower in France than in other Western countries perhaps because of, for instance, different strategies in the screening and treatment of diabetes.

### 3.5. Prevalence of diabetic retinopathy in screening programmes

In 1998, a statistical analysis of the French healthcare database (French National Health Insurance, or Caisse nationale d’assurance maladie des travailleurs salariés [CNAMTS]) indicated that less than 40% of diabetic patients living in metropolitan France had undergone an eye examination during the past year [40]. One contributing factor to the low number of eye examinations was the growing number of diabetic patients and decreasing number of ophthalmologists able to perform funduscopic examinations [41]. These observations led to the development of more convenient methods for diagnosing and monitoring DR that had, at the very least, the same sensitivity and specificity as examination by an ophthalmologist. Fundus photography using a non-mydriatic camera is becoming more widely used [42] while, in parallel, ambulatory techniques have been promoted to enhance patient access to such care [43]. Over the past five years in France, different screening programmes have been conducted using these alternative methods [44–49].

In Dépistage ophtalmologique du diabète (DODIA), initiated in 2002 in the northern parts of Paris, 882 primary-care patients were screened using either dilated eye examination, performed by an ophthalmologist, or non-mydriatic eye fundus photography, performed by an orthoptist and analyzed by an expert site. DR was detected in 10.4% of patients by eye examination compared with 17.3% by fundus photography [45]. Following this conclusive outcome, several screening programmes were implemented using non-mydriatic photography. In Artois (PREVART network), 7% of 1322 ambulatory screened patients were diagnosed with DR (NPDR = 2.8%; PDR = 4.8%; MO = 0.5%) between 2002 and 2003 [47]. Over the 2004–2005 period, 676 patients living in rural areas of Burgundy were screened using an itinerant non-mydriatic camera [48]. Of these patients, 8.6% were found to have DR. Patients screened had satisfactory control of their diabetes (mean HbA1c = 7.2%), but 6.8% had never consulted an ophthalmologist and 55% had not had an eye examination within the past two years. Not surprisingly, prevalence rates were lower than in DODIA, probably

### Table 4

Prevalence of diabetic retinopathy (DR) in France according to screening programmes.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Characteristics, study time period</th>
<th>Patients (n) &amp; diabetes type</th>
<th>Prevalence of DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>DODIA [45]</td>
<td>Non-mydriatic photography vs dilated eye examination; primary-care patients, Paris (northern parts), 2002</td>
<td>882, types 1 &amp; 2</td>
<td>17.3% (non-mydriatic camera) vs 10.4% (dilated eye exam)</td>
</tr>
<tr>
<td>Lesven et al. [46]</td>
<td>Non-mydriatic photography, inpatients, Brest Hospital</td>
<td>767</td>
<td>10%</td>
</tr>
<tr>
<td>Soulié-Strougar et al. [48]</td>
<td>Ambulatory screening, non-mydriatic photography, Burgundy, 2004–2005</td>
<td>676, types 1 &amp; 2</td>
<td>8.6% (n = 58, including two patients with known, inactivated DR)</td>
</tr>
<tr>
<td>OPHDIAT [49]</td>
<td>Non-mydriatic photography, 16 screening centres, Île-de-France, Sept 2004–Dec 2006</td>
<td>13,777, types 1 &amp; 2</td>
<td>23.4%, 5.6% with severe DR requiring urgent referral</td>
</tr>
</tbody>
</table>
due to selection bias. As patients voluntarily participate in such screening campaigns, those who attend are usually highly motivated and treatment-compliant. This also means that, in such individuals, the rate of diabetes complications is likely to be less marked.

Finally, the most large-scale experience of DR screening is the Ophthalmology–Diabetes–Telemedicine (OPHDIAT), a telemedicine network covering the Île-de-France area [49]. Over a 28-month period, 13,777 diabetic patients of unknown retinal status were screened for DR using non-mydriatic cameras. Photographs were taken by technicians (16 screening sites located in hospitals, healthcare centres and prisons), while the images were graded by trained ophthalmologists at a reading centre. DR was detected in 23.4% of patients. Of the patients diagnosed with DR, 0.5% had PDR and 3.4% had MO. In addition, 5.6% of patients (n = 777) had undiagnosed severe DR requiring urgent referral to an ophthalmologist for laser treatment.

In summary, evaluation of screening programmes using non-mydriatic fundus photography supports the view that they are effective for the identification of both early and advanced DR [43]. More important, the results of recent screening programmes (Table 4) indicate that 10–20% of French diabetic patients of previously unknown retinal status have retinopathy.

4. Conclusion

On the basis of robust epidemiological studies conducted in Western countries over the past 20 years, it is suggested that the expected prevalence of DR is close to 28.7% in the diabetic population, while PDR and MO may be present in 2.6 and 4.8%, respectively, of patients. Results from different longitudinal studies suggest that the yearly incidence of DR is approximately 2–6%. According to observational studies based on physicians’ reports, the recorded prevalence of DR in the French diabetic population is approximately 10%. The discrepancy between the expected and recorded prevalences may be due to the large proportion of patients whose retinal status is unknown. Although clinical guidelines recommend examination of diabetic patients for ophthalmological complications at the time of diagnosis and on repeated annual surveillance [5, 6, 8], the evidence suggests that patients do not fully comply with screening and that the prevalence of DR in non-compliant patients could be as high as 10–20%.

Alternative methods of DR screening using nonmydriatic fundus photography have been validated, and show the same sensitivity and specificity in DR diagnosis as does ophthalmoscopy. In addition, DR screening programmes using ambulatory screening and/or a telemedicine network have been successfully conducted on a local community basis and have proved to facilitate access to regular, annual evaluations of patients with diabetes. Indeed, implementing DR screening programmes that cover the entire French territory are, without doubt, a key target for improving DR diagnosis and shortening treatment delays in patients with referable retinopathy.

5. Conflicts of interest

Dr Delcourt has been a consultant for Chauvin–Bausch & Lomb, Alcon, Novartis, Pfizer and Lilly, and received funds from Théa Laboratories. Dr Massin has been a consultant for Lilly, Takeda, Novartis, Pfizer and Solvay. Dr Rosilio is an employee of Eli Lilly and Company.

Acknowledgements

The authors thank Dr C. Soubrouillard (Eltium) for her assistance in the preparation of this manuscript.

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