Prevalence of diabetic retinopathy in Peruvian patients with type 2 diabetes: results of a hospital-based retinal telescreening program

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Suggested citation Villena JE, Yoshiyama CA, Sánchez JE, Hilario NL, Merin LM. Prevalence of diabetic retinopathy in Peruvian patients with type 2 diabetes: results of a hospital-based retinal telescreening program. Rev Panam Salud Publica. 2011;30(5):408–14.

ABSTRACT

Objective. *To estimate the prevalence of diabetic retinopathy (DR) in patients with type 2 diabetes and to determine any association with clinical factors.*

Methods. *This hospital-based screening project was designed to prospectively detect the presence of DR in patients with type 2 diabetes by grading images acquired with a digital retinal camera.*

Results. *Of 1 311 patients screened, appropriate retinal images were obtained in 1 222 subjects (93.2%). DR was detected in 282 patients (23.1%) [95% confidence interval (CI): 20.71–25.44]; 249 patients (20.4%) (95% CI: 18.1–22.6) had nonproliferative DR and 33 (2.7%) (95% CI: 1.8–3.6) had proliferative DR. In 32 patients (11.3%), DR was unilateral. The frequency of DR was the same in both sexes. Prevalence of blindness was twice as frequent in patients with DR as in those without it (9.4% and 4.6%, respectively)* (P = *0.001). The frequency of DR at diagnosis was 3.5% and it increased with the duration of diabetes. DR was more frequent in patients with arterial hypertension, macrovascular or microvascular complications, and hemoglobin A1c (HbA1c)* ≥ *7.0% and in those treated with insulin or sulfonylureas. It was less prevalent in those with HbA1c* < *7.0%, with greater body mass index, and who had been treated with metformin.*

Conclusions. *The prevalence of DR in these patients with type 2 diabetes was 23.1%. Nonproliferative retinopathy accounted for 77.0% of cases. Although less prevalent than in a previous report, it doubled the frequency of blindness in the people affected. A national screening DR program should be considered in order to detect this prevalent condition early and treat it in a timely fashion.*

Key words Diabetic retinopathy; diabetes mellitus; telemedicine; Peru.

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Diabetes mellitus is increasing dramatically throughout the world. It is estimated that, for 2010, diabetes mellitus affects 285 million adult people globally, including 17.9 million in the Central and South America region (1).

Diabetic retinopathy (DR), a specific vascular complication of diabetes, is the leading cause of blindness in working-age individuals in developed countries (2). The World Health Organization esti-

mates that DR is responsible for 4.8% of the 37 million cases of blindness throughout the world (3). The prevalence of DR increases with the duration of diabetes; nearly all persons with type 1 diabetes and more than 60% of those with type 2 diabetes have some retinopathy after 20 years (4).

Randomized clinical trials have clearly demonstrated that intensive glucose control reduces the risk of occurrence of DR (5–9) and the risk of developing severe visual loss from proliferative DR, and macular edema can be significantly reduced through the use of timely laser photocoagulation (10, 11). Therefore, screening for early detection of DR to prevent blindness and impaired visual conditions is mandatory and cost-effective (12, 13).

To investigate the prevalence of DR in Peruvian patients with type 2 diabetes, a screening project was established using retinal telescreening. The results are presented here.

MATERIALS AND METHODS

This is a prospective observational and intervention study. In 2007, the Center for the Americas at Vanderbilt University in the United States of America convened a work group to begin a collaborative project to increase access to preventive eye care in Latin America. Its multidisciplinary team wished to investigate whether a telescreening model used in Tennessee (14) could be adopted for use in Peru. This project led to a memorandum of understanding between Vanderbilt University and the Universidad Peruana Cayetano Heredia for establishing a pilot screening program for DR in Lima, Peru, at the Hospital Nacional Cayetano Heredia, a 300-bed public hospital affiliated with the Universidad Peruana Cayetano Heredia. The hospital provides health care to 2 million low-income people living in the communities of San Martín de Porres, Los Olivos, Independencia, Comas, San Juan de Luringancho, and Rimac in the northern belt of the city of Lima.

The work group provided seed funding for training and salary support for a nurse, an endocrinologist, and an ophthalmologist. It also acquired a retinal camera, associated software, computer equipment for image grading, and long-distance telecommunications equipment, which were placed at the Endocrine Unit of the Hospital Nacional Cayetano Heredia.

Population study

From 18 September 2007 to 9 September 2010, 1 347 diabetic patients were referred to the project by their treating endocrinologist for a cost-free evaluation of DR as part of the patient's diabetes care.

According to criteria of the American Diabetes Association, 1 311 had type 2 diabetes mellitus (15), 774 (59.0%) were women, and 537 (41.0%) were men; those 1 311 are the basis of this report.

The project protocol was approved by the ethics committees of the Universidad Peruana Cayetano Heredia and the Hospital Nacional Cayetano Heredia. Each patient signed an informed consent document.

Patients at risk of sight loss and those diagnosed with severe nonproliferative retinopathy and proliferative retinopathy or clinically significant macular edema received free laser treatment at the Asociación Oftálmica Paracas, a nonprofit institution and partner of the project.

Fundus photography

A Canon nonmydriatic retinal camera CR-DGI and a Canon digital camera EOS 30D (Canon, Tokyo, Japan) were used to take two 45° digital images per eye (four images per patient) through a physiologically dilated pupil. Participants were seated in a dark room to allow their pupils to dilate naturally in preparation for the retinal imaging capture performed by the nurse. If the pupil was not sufficiently dilated for retinal vessels to be clearly recorded on the optic nerve and within one disc diameter of the fovea, pharmacologic dilation was achieved by instilling a 1.0% tropicamide solution (16). One image was centered on the fovea and the other image was centered on the optic nerve. The digital images were temporarily stored in a laptop computer attached to the camera. They were later transmitted to a workstation established at the Universidad Peruana Cayetano Heredia for grading.

A trained ophthalmologist at Vanderbilt University graded all the images. Severity of DR was categorized by using the proposed international clinical DR and diabetic macular edema disease severity scales (17). For the first year of the project, images and grading were also reviewed by the Vanderbilt Ophthalmic Imaging Center as part of a quality assurance initiative. Matching for grading between the centers was 86.0%.

The project nurse used a Snellen chart to test distance visual acuity. Spectacle correction was used when available. The visual acuity component of the World Health Organization criteria was used to define blindness (visual acuity < 6/120) and low vision (visual acuity from 6/120 to < 6/18) both in the better seeing eye. The nurse asked participants about their age, sex, race, ethnicity, educational attainment (illiterate, less than high school, high school education, or higher), family income, and employment status. History of microvascular (retinopathy, nephropathy, and neuropathy, both peripheral and autonomic) and macrovascular (coronary heart disease, cardiac failure, cerebrovascular disease, and peripheral vascular disease) complications, history of arterial hypertension, and risk factors for DR—such as hemoglobin A1c (HbA1c), lipids, duration of diabetes, systolic and diastolic blood pressure, body mass index (BMI), waist circumference, current smoking status, and diabetic treatment—were ascertained by the treating endocrinologist from the clinical chart and were registered on a special form. BMI was categorized according to the World Health Organization (18), and cutoff values for metabolic syndrome for waist circumference were > 87 cm for women and > 97 cm for men (19).

Statistical methods

Statistical analyses were conducted using Stata TM 10.1. Characteristics of the study population were described by using medians and interquartile ranges for continuous variables and percentages for categorical variables. A chi-squared test was used for categorical variables. Associations were considered to be significant at $P < 0.05$.

RESULTS

The median age of patients was 59 years (interquartile range, 52.0–67.0 years) with a median duration of diabetes of 5 years (interquartile range, 1.0–11.0 years); 764 patients (58.3%) had not had a previous ophthalmological evaluation. Appropriate retinal images

were obtained in 1 222 patients (93.2%) of the 1 311 patients screened. In 89 patients (6.8%), no retinal images were obtained because of opacities of the ocular media in both eyes; 221 patients (16.9%) had opacities in just one eye.

DR was detected in 282 patients (23.1%); 20.3% of patients had nonproliferative DR and 2.8% had proliferative DR (Table 1). The frequency of DR was the same for men and women.

The grade of DR was concordant in both eyes in 186 patients (66.0%). Eyes were unevenly affected in 38 patients (13.5%). In 32 patients (11.3%), DR was unilateral, and in 26 patients (9.2%) grading was possible in only one eye because of media opacities in the contralateral eye.

Clinically significant macular edema was found in 28 patients (2.3%), with no difference between women and men. It was unilateral in half of them, and 19 had nonproliferative DR.

Blindness occurred twice as frequently in patients with DR as in those without it (9.4% and 4.6%, respectively; $P = 0.001$). Similarly, low vision was more prevalent in those with DR than in those without it (30.8% and 21.7%, respectively; $P = 0.001$).

DR had a peak frequency in the sixth and seventh decades of age (Figure 1). There was no difference in prevalence between those < 65 years old and those ≥ 65 years old (24.0% and 21.0%, respectively; $P = 0.265$).

Of patients with DR, 3.6% were illiterate, 32.1% went to primary school only, 48.4% went to high school, and 15.9% went to university ($P = 0.007$).

With regard to income, 72.0% of patients earned minimum wage or less, and 27.8% had a better income, with no difference in the frequency of DR between the groups (26.3% and 21.2%, respectively; $P = 0.145$); 58.3% of patients were unemployed, 39.6% were economically active, and 2.2% were retired. There was no difference in DR frequency among those groups.

DR prevalence increased with the duration of diabetes ($P = 0.0001$) (Figure 2). In those with a diagnosis of ≤ 3 months, the frequency of DR was 3.5%. DR was more prevalent in patients with arterial hypertension and in those with any macrovascular, neuropathic, or renal complication (Figure 3). The frequency of DR was the same in patients with and without the antecedent of any lipid disorder (23.3% and 23.0%, respectively; $P = 0.904$).

DR was present in 31.2% of patients with a BMI < 25 kg/m^2, compared with 21.6% in those with a BMI ≥ 25 kg/m^2 ($P = 0.004$). DR prevalence was the same in patients with abdominal waist circumference above and below cutoff values for metabolic syndrome (24.4% and 26.0%, respectively; $P = 0.633$).

Patients with HbA1c < 7% had a lower frequency of DR than those with HbA1c ≥ 7% (16.9% and 24.8%, respectively; $P = 0.008$).

TABLE 1. Frequency of diabetic retinopathy grades in 1 222 patients with type 2 diabetes, Lima, Peru, 2007–2010

Grade	No.	%
No retinopathy	940	76.9
Mild nonproliferative diabetic retinopathy	125	10.2
Moderate nonproliferative diabetic retinopathy	104	8.5
Severe nonproliferative diabetic retinopathy	20	1.6
Proliferative diabetic retinopathy	25	2.1
High-risk proliferative diabetic retinopathy	8	0.7
Total	1 222	100

FIGURE 1. Age distribution of 1 220 type 2 diabetes patients with retinopathy, Lima, Peru, 2007–2010

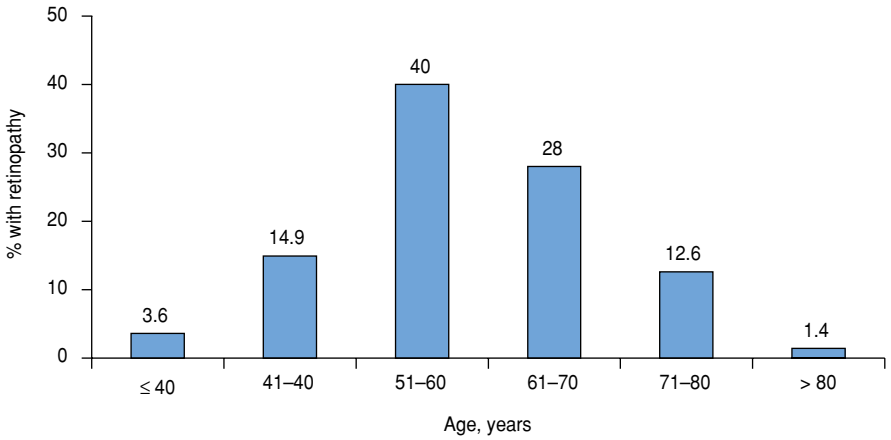


FIGURE 2. Frequency of diabetic retinopathy in 1 197 patients with type 2 diabetes by duration of diabetes, Lima, Peru, 2002–2010

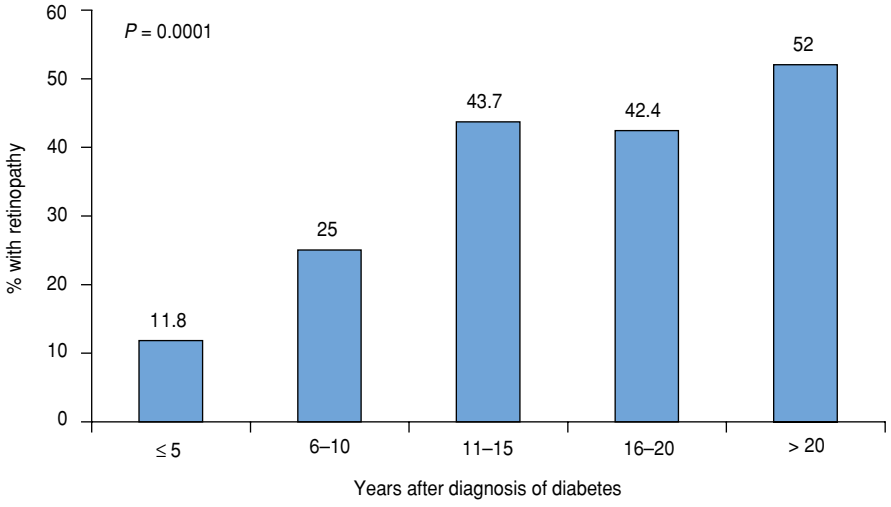
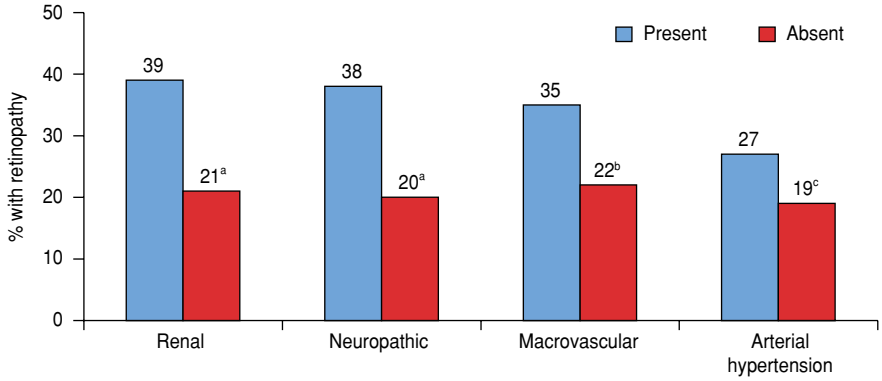


FIGURE 3. Frequency of diabetic retinopathy in patients with type 2 diabetes by presence of diabetic complications and arterial hypertension, Lima, Peru, 2007–2010



[a]$P = 0.0001$.
[b]$P = 0.006$.
[c]$P = 0.002$.

DR was more prevalent in patients who used insulin alone or in combination with oral drugs (37.2%), followed by those on sulfonylureas only (33.6%), sulfonylureas plus metformin (24.0%), and others (21.4%). Patients on metformin only had the lowest frequency of DR (14.4%; $P = 0.0001$).

DISCUSSION

A DR prevalence of 23.1% was found in patients with type 2 diabetes. A previous study from Peru (20) using binocular indirect ophthalmoscopy in 849 patients with type 2 diabetes reported a DR prevalence of 30.0%, 24.0% with nonproliferative retinopathy and 6.0% with the proliferative type. Mean ages of patients and duration of diabetes were almost the same in both series. Although the different technology used in both studies may explain this difference, other factors, such as quality of metabolic control and treatment options, may also be involved. The previously reported prevalence of DR was closer to that found in users of insulin or sulfonylureas in this study.

The reported prevalence of DR in Latin America and Spain varies from 14.5% to 58.8% (21–31) depending on sample size and reporting center, with higher estimates coming from retinal centers (22, 28). In Brazil, retinopathy and neuropathy were the complications that contributed the most to years lived with disability in the population (32).

The prevalence and severity of DR vary according to ethnicity: both are higher in African Americans, Hispanics, and South Asians than in white people and are not fully accounted for by differences in the distribution of retinopathy risk factors (11, 26, 33, 34).

The Los Angeles Latino Eye Study reported a 45.8% prevalence of DR and a 5.6% prevalence of proliferative DR in 1 187 patients with type 2 diabetes. More than 60.0% of eye disease in this population was undiagnosed and undetected, reinforcing the importance of screening programs (35). The prevalence of DR reported from other Hispanic populations in the United States varies from 36% to 48% (36–40), which is almost twice the prevalence found by this study in Peru. This difference may be due to differences in dietary habits, physical activity, overweight prevalence, late diagnosis of diabetes, access to medical care, compliance with diabetes medication, or genetic factors (41, 42).

The same prevalence of DR was found in women and men. In the National Health and Nutrition Examination Survey 2005–2008 (43), male gender was a significant and independent risk factor for DR, and in the United Kingdom Prospective Diabetes Study (44) it was a factor for progression of retinopathy in those with DR present at baseline. However, being male was not a factor in the Los Angeles Latino Eye Study (45) or in a Rochester study (46).

Patients with DR had twice the frequency of blindness and a higher prevalence of low vision than those without DR. The overall prevalence of presenting visual impairment in the National Health and Nutrition Examination Survey 1999–2004 among participants with diabetes was 11.0%, and among those without diabetes it was 5.9% (47). Diabetes was an independent risk factor for poor vision in the Los Angeles Latino Eye Study (45); in the Barbados Eye Study, DR accounted for 8.7% of blindness (48).

No difference in DR was found among those less than and more than 65 years old. In the recent National Health and Nutrition Examination Survey 2005–2008 results, DR was more prevalent in people age 65 years or older (43); in the United Kingdom Prospective Diabetes Study, age is a factor for progression of DR (44).

DR was less prevalent in those with higher education, with no difference in prevalence regarding family income and actual economic activity. There is a known inverse socioeconomic morbidity and mortality gradient in people with diabetes (49), although it is largely due to conventional cardiovascular risk factors. A review of 51 studies (34) found that diabetic patients from ethnic minorities had increased mortality rates and higher risk of diabetes complications. These differences almost disappeared after adjustment for risk factors such as smoking, socioeconomic status, income, years of education, and BMI, with the exception of increased risk of DR for African American and Hispanic diabetics in the United States (4, 34). Family aggregation and genetic factors may explain this persistent increased risk (41, 42).

Duration of diabetes is a major risk factor associated with the development of DR. In this study, more than 40% of people with diabetes for more than 10 years had DR. The prevalence of DR in Hispanic patients with diabetes longer than 15 years varies between 54.0% and 79.6% (40).

DR was present in 3.5% of patients at diagnosis, which is lower than 7.0% to 39.0%, as previously reported (38, 40, 50, 51).

An increased prevalence of DR was found in patients with any macro- or microvascular complication. Hyperglycemia is a key factor for both conditions, producing vascular damage through mitochondrial overproduction of superoxide secondary to an increased flux through the polyol pathway, intracellular production of advance glycosylated end products, protein kinase C activation, and increased hexosamine pathway activity (52).

Arterial hypertension is another factor that is important for DR (10, 11, 45). Intensive management of hypertension has been demonstrated to slow the pro-

gression of retinopathy (53). In addition, controlling blood pressure significantly reduced the clinical complications of diabetic eye diseases—including microaneurysms, retinal exudates, and loss of visual acuity (54).

Adiposity has been associated with increased prevalence of DR (46, 55–57). A lower prevalence of DR was found in the higher BMI categories. This has been described in three studies (30, 57, 58). Low BMI reflects poor metabolic control, decreased pancreatic insulin reserve, and the need for insulin therapy.

DR occurred more frequently in patients treated with insulin alone or in combination and in those taking sulfonylureas. The same findings were reported previously (20, 43, 45).

The severity of hyperglycemia is the key alterable risk factor associated with the development of DR. In this study, the prevalence of DR was greater in those with HbA1c ≥ 7%. Support for this association is found in results of both clinical trials and epidemiologic studies (5–11).

There is general agreement that the duration of diabetes and severity of hyperglycemia are the major risk factors for developing DR. The United Kingdom Prospective Diabetes Study showed that each 1% decrease in HbA1c value was associated with a 37% reduction in the risk of developing retinopathy among patients with type 2 diabetes (59).

The strength of this study is the large number of diabetic patients screened. This is the largest patient series reported from Latin America. A modern and sensitive screening technology and a protocol-driven imaging and grading process were used.

This study has several limitations. Because of the hospital-based location, more patients with advanced disease may have been screened than would be found in the community at large. Although the project was cost-free and widely advertised in the hospital, a selection bias by patients' endocrinologists cannot be rule out. Similarly, assessment of diabetic complications was done mostly by endocrinologists during routine health care activities and might have been underestimated.

In conclusion, this study found a prevalence of DR of 23.1%. Blindness was doubled in the affected patients. DR prevalence increases with duration of diabetes, presence of macro- and microvascular complications, arterial hypertension, lower BMI, and treatment with insulin or sulfonylureas.

Screening patients for DR with retinal telescreening technology is feasible and may reduce the amount of time eye specialists need to provide screening services directly, thus permitting them to deliver more high-level interventions like laser photocoagulation and vitrectomy surgery.

DR is a common condition that often leads to permanent disability. In resource-limited settings, an efficient and practical method of screening patients with known risk factors is a necessary first step in improving access to therapeutic interventions. The use of retinal telescreening to examine medically underserved people with diabetes could be expanded into a national program, identifying diabetics with sight-threatening pathology, linking them to treatment centers, and ultimately reducing the number of newly blind in Peru and throughout the Americas.

Acknowledgment. This project was supported in part by an unrestricted grant from Research to Prevent Blindness to the Vanderbilt University School of Medicine Department of Ophthalmology and Visual Sciences.

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Manuscript received on 25 November 2010. Revised version accepted for publication on 25 July 2011.

Prevalencia de retinopatía diabética en pacientes con diabetes tipo 2 en el Perú: resultados de un programa hospitalario de detección sistemática mediante telemedicina

RESUMEN

Objetivo. Calcular la prevalencia de la retinopatía diabética en pacientes con diabetes tipo 2 y determinar su asociación con factores clínicos.

Métodos. Este proyecto de detección sistemática hospitalaria se diseñó para detectar de manera prospectiva la presencia de retinopatía diabética en pacientes con diabetes tipo 2 mediante la valoración de imágenes obtenidas con una cámara digital para fotografía retiniana.

Resultados. Se evaluó a 1 311 pacientes y se obtuvieron imágenes retinianas apropiadas en 1 222 de ellos (93,2%). Se detectó retinopatía diabética en 282 pacientes (23,1%) (intervalo de confianza [IC] de 95%: 20,71–25,44): 249 pacientes (20,4%) (IC de 95%: 18,1–22,6) tenían retinopatía diabética no proliferativa y 33 (2,7%) (IC 95%: 1,8–3,6) presentaban retinopatía diabética proliferativa. En 32 pacientes (11,3%), la retinopatía diabética era unilateral. La frecuencia de retinopatía diabética fue la misma en ambos sexos. La prevalencia de ceguera fue del doble en los pacientes con retinopatía diabética que en aquellos sin ella (9,4% y 4,6%, respectivamente) (P = 0,001). La frecuencia de retinopatía diabética en el momento del diagnóstico fue de 3,5% y aumentó con la duración de la diabetes. La retinopatía diabética fue más frecuente en los pacientes con hipertensión arterial, complicaciones macrovasculares o microvasculares y hemoglobina A1c (HbA1c) ≥ 7,0%, y en aquellos tratados con insulina o sulfonilureas. Fue menos prevalente en los pacientes con HbA1c < 7,0%, en aquellos con mayor índice de masa corporal y en los tratados con metformina.

Conclusiones. La prevalencia de retinopatía diabética en estos pacientes con diabetes tipo 2 fue de 23,1%. La retinopatía no proliferativa representó 77,0% de los casos. Aunque la prevalencia de la ceguera fue menor que en un informe anterior, su frecuencia en las personas con retinopatía diabética fue del doble que en las no afectadas. Se debe considerar llevar a cabo un programa de detección sistemática nacional de retinopatía diabética para diagnosticar de forma temprana esta afección frecuente y tratarla de manera oportuna.

Palabras clave Retinopatía diabética; diabetes mellitus; telemedicina; Perú.