WORLD VIEW

The prevalence and severity of diabetic retinopathy, associated risk factors and vision loss in patients registered with type 2 diabetes in Luganville, Vanuatu

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Aim: To determine the prevalence and severity of diabetic retinopathy in patients with type 2 diabetes in Luganville, the second largest town in Vanuatu. Additionally, to investigate risk factors for retinopathy and the effect of retinopathy on visual acuity (VA) within this group.

Method: All 83 registered patients with type 2 diabetes in Luganville, a town of 13 121 people, were invited for an interview and anthropometric measurements. A questionnaire including assessment of hypertension and glycaemic control, which are known risk factors for diabetic retinopathy, was administered. This sample accounted for approximately 1.07% of Luganville's adult population. Presenting VA was measured. The retina was photographed with a non-mydriatic fundus camera and images later independently graded for the extent of retinopathy.

Results: 68 (82%) of the 83 patients attended. The mean (SD) age was 54 (11) years and 31 (46%) were male. Diabetic retinopathy was present in 36 (52.9%) of the sample. Sight-threatening retinopathy requiring urgent referral was present in 15 (22.1%) patients. Presenting VA was worse than 6/12 in the better eye in n = 32 (47%) and in up to half of these cases the principal cause was retinopathy. In addition, four people had uniocular blindness resulting from diabetes. The mean body mass index was lower in those patients with diabetes with retinopathy than in those without (p = 0.010), but there were no other significant differences between the two groups and, specifically, no difference in the frequency of retinopathy risk factors. 42 (61.8%) patients had hypertension (⩾135/85 mm Hg) or were taking antihypertensive therapy.

Conclusions: The prevalence of registered patients with diabetes in Luganville's adult population was 1.07%. Diabetic retinopathy was highly prevalent in the sample (in 36, 52.9%), and in 15 (22.1%) there was a significant threat to sight, with up to 25% of the sample possibly already affected by decreased VA or blindness resulting from diabetes-related eye disease. Retinopathy risk factors were also prevalent. A diabetes screening programme with baseline ophthalmic assessment and follow-up are urgently needed to enable timely intervention and treatment.

D iabetic retinopathy now ranks among the leading causes of vision impairment in Pacific Island nations.[1] Although diabetes was uncommon 30 years ago in indigenous Pacific populations maintaining a traditional lifestyle, and especially rare in the Melanesian populations, the prevalence of type 2 diabetes has increased dramatically in urban areas in recent years[2–5] with a probable rise in diabetic retinopathy. This growing problem in the Pacific mirrors an emerging global pandemic of type 2 diabetes and other non-communicable diseases, which are thought to result from lifestyle and dietary changes.[6 7]

Patients with type 2 diabetes, unlike those with type 1, frequently have significant retinopathy at first diagnosis due to a time lag between onset and clinical diagnosis. Although the pathogenesis of retinopathy in diabetes is still not fully understood, a number of risk factors have been identified including hypertension, poor glycaemic control and increasing duration of diabetes.[8–12] Targeting these modifiable risk factors aggressively and regular screening to allow timely intervention with panretinal photocoagulation reduce the progression to proliferative retinopathy and vision loss.[13] Such primary and secondary prevention strategies are believed to be cost-effective.[14]

The prevalence of diabetic retinopathy has been reported for a few Pacific nations, ranging from 8.2% to 52.6%,[15–18] but in the last ophthalmic survey in Vanuatu (1989), of 3520 people aged >6 years, diabetic retinopathy was not identified as a major cause of blindness or low vision.[19] There have been no recent studies on the prevalence of non-communicable diseases or on the prevalence of diabetic retinopathy in Vanuatu.[1 20] This study aimed to establish the prevalence of diabetic retinopathy and associated risk factors and vision loss among patients enrolled on the diabetes register in the town of Luganville, the second largest town in Vanuatu. Luganville possesses the smaller of only two diabetic registers in Vanuatu (the other being in the capital city, Port Vila). For logistical reasons, this smaller register was chosen as the basis for the study. A second objective was to assess patients' understanding and attitude towards diabetes and its complications, lifestyle risk factor modification and treatment, in order to guide future cost-effective healthcare planning for patients with type 2 diabetes in a nation with limited health resources.

METHODS

Subjects and settings

Vanuatu is an independent Melanesian archipelago in the Southwest Pacific with an estimated population of 215 541.[21] The town of Luganville on the island of Espiritu Santo has an estimated population of 13 121 (2004) living in a 10 km × 2 km area and was selected for the study as it is the second largest urban area after the capital city, and hosts the island's

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Abbreviations: BMI, body mass index; CSME, clinically significant macular oedema; VA, visual acuity

only hospital, the Northern District Hospital.[22] [23] All patients on the type 2 diabetes register at this hospital, living within the district of Luganville (n = 83), were invited to attend clinic for a review of their diabetes and medications. All patients were adult ni-Vanuatu (ie, local born people) and were aged ≥14 years. Informed consent from all patients and local ethics committee approval for the study were obtained.

Examination methods

Subjects were asked to fast overnight and arrive at the clinic between 8:00 h and 10:00 h with their invitation letter. On arrival, subjects were registered, allocated a survey number and their name, age, sex, occupation, literacy, educational status, smoking and family history were recorded. A standardised questionnaire was administered in the local language, Bislama. This included questions to ascertain how their diabetes was first diagnosed (screening in the community, spot testing in hospital or presentation with a diabetes-related complaint), their awareness and knowledge of diabetes, risk factors, complications and management of their disease. The hospital notes were consulted to corroborate the current treatment regime, and also to establish duration of diabetes since diagnosis, and coexistent hypertension and its treatment.

Anthropometric measures included height, weight, hip and waist circumferences. Body mass index (BMI, kg/m^2) was calculated as weight (kg) divided by height (m^2). The waist-to-hip ratio was obtained by dividing the waist circumference by the hip circumference. Blood pressure was measured and hypertension defined as systolic blood pressure >135 mm Hg or diastolic blood pressure >85 mm Hg.[24] Fasting capillary glucose was measured with a glucometer.

The presenting visual acuity (VA) was recorded in each eye at 4 m or 1 m on the log of minimum angle of resolution chart, with refraction for distance if the patient wore spectacles for distance, and with pinhole if the VA was <6/6, to assess for refractive error. The log of minimum angle of resolution values for each eye were converted to the Snellen chart equivalents to use the World Health Organisation classification system for presenting VA in the better eye.[25] The most likely cause of vision loss was recorded for subjects with worse than 6/12 VA in the better eye. Cataract was recorded as present if the red reflex was obscured by lens opacity exceeding 1 mm^2 area, measured with a direct ophthalmoscope (≥grade 2A).[26] A pinhole improvement in the VA was taken as evidence of uncorrected refractive error.

Photography

Retinal photography (portable Nidek NM-100 Type-D, Tokyo, Japan) was performed at the end of the examination after pupil dilatation. Three overlapping, non-stereoscopic 30° field photographs of each eye were taken recording a retinal view of approximately 60° vertically and 40° horizontally.[27]

Two experienced graders at Moorfields Eye Hospital Reading Centre, London, UK, masked to subject details graded the photographs independently. Each of the nine determinants of retinopathy was graded by greatest degree in any field, for the macula and retina separately. Overall, retinopathy and maculopathy levels were assigned for each patient, based on the grading score of the worse eye, and according to the following order of precedence; proliferative features or photocoagulation> pre-proliferative changes> maculopathy with clinically significant macular oedema (CSME)> maculopathy without CSME> background features, and patients were categorised using the former UK National Screening Council recommendations.[28] This simple grading scheme was chosen because of the relatively low (0.5 Mpixel) resolution of the NM-100 fundal images compared with gold standard reference images used for grading in the UK.

Sight-threatening eye disease was defined as the presence of any of the following in either eye: CSME, preproliferative or proliferative retinopathy or photocoagulation. Quality assessments were annotated on the grading form as perfect, acceptable, poor, very poor (ungradeable), obscuring lesion (ungradeable) or data missing.

Data analysis

The SPSS software package was used to report descriptive statistics and frequencies in the dataset. Where χ^2, parametric (t test) and non-parametric tests (Mann–Whitney U test) were used, p<0.05 was taken as statistically significant.

RESULTS

In all, 68 of the 83 registered patients were examined (82% response rate). Of the 15 non-responders, three were known to be on another island at the time of the study and at least 4 were unable to attend their appointment on account of a cyclone.

General characteristics

Table 1 summarises the study population. The mean (SD) age of patients was 54 (11) years. There was no significant age or gender difference in participants (table 3; 37 women, 31 men).

Prevalence of diabetes and retinopathy

The estimated prevalence of known type 2 diabetes (all patients on the register, n = 83) in the adult population of Luganville (approximately 7728 people aged ≥14 years[22]) was 1.07%. Diabetic retinopathy was present in 36 (52.9%) subjects of this study population. Background retinopathy was present in 14 (20.6%) people, of whom 1 person had CSME, and 9 had maculopathy. Maculopathy (without retinopathy) was present in 8 (10.3%) people of whom 1 (1.5%) had CSME. Pre-proliferative retinopathy was present in 12 people (17.6%) of whom two (3%) had CSME (one of these had received laser photocoagulation treatment) and six (8.8%) had maculopathy. One person (1.5%) had both proliferative retinopathy and CSME (table 2). Potentially sight-threatening retinopathy was present in 15 (22.1%) people of the known population with diabetes.

Comparison of patients with and without retinopathy

Table 3 illustrates that there were no significant differences between those patients with (n = 35) and those without (n = 33) retinopathy with respect to duration of diabetes, blood pressure, waist-to-hip circumference ratio, median fasting blood sugar, smoking history, the presence of diabetes-related-symptoms or the presence of cataract. The two groups did differ significantly with respect to body mass index, which was significantly lower in the group with retinopathy (mean (SD) 27.9 (4.1) kg/m^2) than in the group without retinopathy (mean (SD) 29.7 (4.3) kg/m^2, p = 0.010). Hypertension was present in 21 (63.6%) patients without retinopathy and 21

Table 1 Comparison of responders and non-responders

	Responders	Non-responders
Male, n (%)	31 (45.6)	9 (60)
Female, n (%)	37 (54.4)	6 (40)
Mean (SD) age (years)	54 (11)	50 (12)
Duration of diabetes, years. Median (IQR)	4 (6)	5 (6)
Total, n	68	15

IQR, interquartile range.
There were no significant differences between responders and non-responders with respect to gender, age or duration of diabetes.

Table 2 Prevalence and severity of retinopathy by grade and presence of maculopathy or photocoagulation in the worse eye

Classification of retinopathy	Frequency of retinopathy n (%)	Frequency of maculopathy CSME+ n, CSME− n	Photocoagulation
None	41 (60.3)	1, 7	0
Background	14 (20.6)	1, 9	0
Pre-proliferative	12 (17.6)	2, 6	1
Proliferative	1 (1.5)	1, –	0
Total	68	27	1

CSME+, clinically significant macular oedema; CSME−, maculopathy but not clinically significant macular oedema.

(60%) with retinopathy. Antihypertensive treatment was used by only 7 (33.3%) of the patients with hypertension without retinopathy and by 15 (71.4%) of those with hypertension and retinopathy.

Questionnaire
In all, 16 (23.5%) people in the sample were diagnosed with diabetes as a result of random screening, whereas 39 (57.4%) presented to hospital with diabetes-related symptoms, and the remaining 13 (19.1%) were tested opportunistically while presenting to hospital for a non-related complaint. Most patients had not heard of diabetes before diagnosis (n = 51, 75%). Altogether, 38 (55.9%) understood that being overweight and inactive is harmful, 59 (86.8%) understood that a diet high in fat and salt is harmful and 61 (89.7%) understood that a diet high in sugar is harmful. Only 30 (44.1%) knew that smoking harms health. Only 40 (58.8%) people were aware that diabetes could cause blindness. A majority reported that they had tried to deal with some or all of these lifestyle risks, (n = 52, 76.5%), and the main reason given by those who had not was that they had not realised that it was important.

Table 3 Comparison of characteristics and risk factors in patients with and without diabetic retinopathy

	No diabetic retinopathy	Diabetic retinopathy	Significance
Gender			
Male, n (%)	15 (45.5)	16 (45.7)	NS
Female, n (%)	18 (54.5)	19 (54.3)	
Mean (SD) age (years)	52.6 (11.6)	55.1 (10.4)	NS
Mean (SD) systolic BP, (mm Hg)	134 (19)	138 (28)	NS
Mean (SD) diastolic BP, (mm Hg)	82 (12)	81 (18)	NS
Persons with hypertension Number (%)	21 (63.6)	21 (60)	NS
On treatment for hypertension Number (%)	7 (21.2)	15 (42.9)	NS
Mean (SD) BMI, (kg/m^2)	29.7 (4.3)	27.9 (4.1)	0.010
Mean (SD) waist to hip ratio	0.98 (0.05)	0.98 (0.05)	NS
Median (IQR) fasting blood sugar	10.2 (7.2)	9.8 (7.5)	NS
Median (IQR) duration of diabetes mellitus, years	2 (7)	5 (8)	NS
Positive smoking history Number (%)	13 (39.4)	12 (34.3)	NS
Current smokers	0	0	
Persons with symptoms, n (%)	18 (54.5)	25 (71.4)	NS
Cataract present in better eye, n (%)	10 (30.3)	7 (20)	NS
Total, n (%)	33 (48.5)	35 (51.5)	NS

BMI, body mass index; BP, blood pressure; IQR, interquartile range; NS, not significant; p⩾0.05.

The mode of treatment in the majority (n = 47, 69.1%) of patients in the sample was oral hypoglycaemic agents (sulphonamides gliclazide, glibenclamide, tolbutamide and/or the biguanide metformin). In total, 17 (25%) people were diet controlled, and 4 (5.9%) were on insulin. The median fasting blood glucose was 9.9 (range 4.9–30.4, IQR 7.2–13.9). The antihypertensive drugs used in the 21 patients treated for hypertension were the beta blocker atenolol and the angiotensin-converting enzyme inhibitor captopril, with the latter being used most frequently (in 20 patients). Most of them had received good follow-up for their diabetes in the preceding 12 months; 20 people (29.4%) had attended clinic 10–12 times, 44 (64.7%) had attended 1–6 times and only 4 (5.9%) had not attended at all.

There was a family history of diabetes in a first-degree relative in 18 (26.5%) patients. Three (4.4%) people reported a family history of ischaemic heart disease but the remainder were unaware of a family history.

Most women were housewives, or retired (31, 83.8%), (4, 10.8%) were white-collar workers and 2 (5.4%) were blue-collar workers. Most men were blue-collar workers (14, 45.2%), 9 (29%) were retired and 8 (25.8%) were white-collar workers. Various levels of formal education (1–18 years) had been received by 56 (82.4%) people and 12 (17.6%) people had never been to school.

VA and causes of reduced vision
The presenting VA in the better eye was 6/12 or better in 36 (52.9%) patients. In the 16 (23.5%) patients with near normal vision, causes of decreased acuity included diabetic retinopathy (8 (50%) patients), and cataract (5 (31.3%) patients). In the 15 (22%) patients with moderate visual impairment causes included diabetic retinopathy (8 (53.3%) patients) and cataract (6 (40%) patients). No patients were severely visually impaired and only one patient was blind due to cataract (table 4). In all, four patients were blind in one eye as a result of diabetic retinopathy (vitreous haemorrhage, branch retinal vein occlusion, CSME and tractional retinal detachment).

Image quality
One patient had images that were very poor (ungradeable) in one eye only, and two patients were missing images for one eye only. Of the remaining 133 eyes graded, 67 eyes had images of ''acceptable'' quality, whereas 66 eyes had images of ''poor'' quality, as compared to the reference images at Moorfields Reading Centre. Cataract was present in 32 of the 66 eyes with ''poor'' quality images, compared to 9 of the 67 eyes with ''acceptable'' quality images.

DISCUSSION
Study demographics
There was a high response rate in this study (82%). General characteristics of the sample from this register were broadly similar to those of type 2 diabetes patient populations in other studies,[9] [29] [30] although the sample size was relatively small.

Prevalence of retinopathy and associated risk factors
Diabetic retinopathy was highly prevalent in patients on the Luganville diabetes register, being found in 36 (52.9%) patients, including a high proportion of sight-threatening retinopathy, in 15 (23.5%) individuals. This may be an underestimate of the true prevalence and severity of retinopathy in this urban sample, as a high frequency of ''poor'' quality images (49.6%) was recorded, probably resulting from the relatively low resolution of the camera (0.5 Mpixels), the moderately high prevalence of cataract, and movement artifact from using a hand-held camera. This suggests a significant rise in the

Table 4 Presenting VA in the better eye (WHO classification)

WHO VA category (presenting VA in the better eye)	Definition (based on Snellen chart VA)	Subjects n (%)	Principal cause of reduced VA in better eye
Normal	x>6/12	36 (53.0)	—
Near normal	6/18≤x<6/12	16 (23.5)	Diabetic retinopathy 50% (n=8) Cataract 31.3% (n=5) Not ascertained 12.5% (n=2) Refractive error 6.3% (n=1)
Moderate visual impairment	6/60≤x<6/18	15 (22.0)	Diabetic retinopathy 53.3% (n=8) Cataract 40% (n=6) Axial pterygium 6.7%(n=1)
Severe visual impairment	3/60≤x<6/60	0	—
Blind	x<3/60	1 (1.5)	Cataract (n=1)
Total		68 (100)	

VA, visual acuity; WHO, World Health Organization

prevalence and severity of diabetic retinopathy in urban areas of Vanuatu since the 1989 eye survey (3520 subjects aged ≥6 years) which recorded a prevalence of 0.4% bilateral blindness (cataract in 85%), but no diabetic retinopathy.[19] However, a limitation of this study was that it was only possible to examine patients already known to have diabetes. The unusually low frequency of diabetes in Luganville reported (1.07%) probably reflects an underestimate of the true prevalence of diabetes in this urban area, with a bias towards individuals with more advanced and symptomatic disease being included on the register.

The prevalence of diabetic retinopathy in the Pacific has increased dramatically over the past 30 years. Earlier studies in Raratonga (1980)[17] and Nauru (1982)[18] reported the prevalence of retinopathy among diabetics as 8.2% and 24%, respectively. More recent studies in Western Samoa (1991)[16] and Fiji (1996)[15] have reported prevalences of 43.2% and 52.6%, respectively.

To compare with populations outside the Pacific, the United Kingdom Prospective study reported retinopathy in 39% (n=675) of men and 35% (n=432) of women [9]; the Cardiff study in 14% (n=38)[29] and the Madras study in 34.1% (n=2319).[30] Although comparison of retinopathy rates across different countries is highly problematic because of differences in the number of patients studied, demographic differences and methods used for screening the patients, the prevalence and severity of retinopathy in the current study was surprisingly high.

Several factors may account for this. First, the prevalence of type 2 diabetes in Luganville estimated by this study of registered patients was unexpectedly low at 1.07%. The true prevalence of diabetes in Luganville remains unknown, and this small register size probably reflects significant underdiagnosis in the population, with a tendency for more advanced and symptomatic disease to present. The World Health Organization estimated that there were 6000 people with diabetes in Vanuatu in 2000 (types 1 and 2, all ages)[31] although this was not based on Vanuatu prevalence studies, but on extrapolation from the diabetes prevalence in adults aged ≥20 years in a 1980 study in Fiji (n=1709).[32] A population of 6000 in the year 2000 (estimated n=192 000)[22] would give a prevalence of 3.1% across all ages, and this is likely to be an underestimate for adults, given that there were no known cases of type 1, or type 2 diabetes under the age of 23 years in Luganville. The questionnaire ascertained that 39 (57.4%) presented to hospital with diabetes-related symptoms prior to their diagnosis of diabetes, whereas 29 (42.6%) of the sample were diagnosed as a result of community screening or opportunistic hospital testing. This bias in the mode of diagnosis probably results from the low availability both of diagnostic kits for diabetes and of health workers in Vanuatu, limiting the opportunity for organised nationwide community screening. Diabetes screening studies in other economically developing countries have revealed marked discrepancies in the prevalence rates of previously diagnosed and study-diagnosed diabetes. In Tonga, another Pacific Island, this difference was 2.1% versus 13%.[33] Even in the UK, 40% people with diabetes are thought to remain undiagnosed, illustrating that the detection of this "silent" chronic disease remains difficult even when healthcare facilities are relatively optimised.[34]

A second reason to account for the high prevalence and severity of diabetic retinopathy in this study was the finding that the well-established risk factors for retinopathy progression, hypertension and poor glycaemic control, were relatively prevalent in this population, suggesting that lifestyle interventions and treatments to target primary prevention of retinopathy have not been optimised. Less than half (47.6%, n=20) of subjects with hypertension were on antihypertensive treatment. Although glycaemic control was not formally measured in the current study, the median fasting capillary glucose was 9.9, with a wide range from 4.9 to 30.4 (IQR 7.2–13.8) indicating that control may be poor in some cases, a problem possibly resulting from poor compliance or financial constraints limiting the use of insulin for those inadequately controlled on oral hypoglycaemic agents in Vanuatu.

A third reason was the absence of routine eye screening to detect retinopathy in patients with diabetes and an incomplete follow-up for those with retinopathy. People diagnosed with diabetes were not routinely referred to the ophthalmic nurses or the ophthalmologist for screening. Thus, opportunities for laser treatment of retinopathy and for patient education about lifestyle to target secondary prevention were missed, despite the presence of a full time ophthalmologist and laser equipment in Luganville. Inadequate patient and public health awareness about diabetes and its visual complications was supported by the finding that only 58.8% (40 patients) of the study sample of registered diabetics were aware that diabetes could cause visual impairment and blindness.

The median duration of known diabetes was longer in the group with retinopathy, at 5 years compared with 2 years. This difference was not significant which may reflect inadequate study power resulting from the small sample size. In comparison, the median duration found in a recent study of patients with type 2 diabetes in the UK was slightly longer at 6 years.[35] In those, both with and without retinopathy, the data were skewed towards "least years" duration. This probably reflects increased awareness and detection of diabetes in recent years, and may also result from many people remaining undiagnosed until much later stages of the disease, until they develop symptoms.

Burden of diabetic retinopathy and impact on vision

In subjects with near normal vision and moderate visual impairment the most likely causes were diabetic retinopathy and cataract. Vision surveys on populations elsewhere in the Pacific region, employing the same World Health Organization classification for presenting VA, have also reported diabetes as one of the most common causes of blindness and low vision.[1]

SUMMARY

This study has shown that type 2 diabetes is probably under-diagnosed in the urban population of Luganville, and that in those who are diagnosed, ophthalmic screening and follow-up are vitally important to identify those with retinopathy. The costs of treating advanced diabetes and its complications are considerably high, yet the per capita annual expenditure on health in Vanuatu is only approximately 110 international dollars.[36] Improved patient and population education about diabetes might result in a reduction in lifestyle risk factors and increased detection of new cases, and early detection of retinopathy would enable limited resources to be targeted to high-risk individuals. The number of people developing vision-threatening retinopathy could be significantly reduced through more aggressive management of modifiable risk factors, hypertension and poor glycaemic control, and by intervening with laser photocoagulation at the optimal time. The prevalence of diabetes in Vanuatu and worldwide is predicted to rise, especially in urban areas. It is vital that an infrastructure for diabetes detection, treatment and follow-up is implemented nationwide, with resources to sustain it, in order to minimise the costly and disabling complications of unchecked diabetes.

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