Ethnic Differences in the Prevalence of Diabetic Retinopathy in Persons With Diabetes When First Presenting at a Diabetes Clinic in South Africa

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OBJECTIVE—To describe the prevalence and associated risk factors for diabetic retinopathy (DR) within a multiethnic population at presentation to a diabetes clinic in South Africa.

RESEARCH DESIGN AND METHODS—Retinal photography was conducted using a nonmydriatic digital camera without mydriasis and graded by one of three senior graders. Logistic regression analyses were used to assess the association between any DR, referable DR, and clinical risk factors.

RESULTS—A total of 1,537 persons with type 1 and 3,978 with type 2 diabetes were included. Prevalence of any DR in type 1 diabetes was 35.2% (background DR 26% and referable DR 9.2%) and in type 2 diabetes was 20.5% (14.1 and 6.4%, respectively). In type 1 diabetes, there was an increased risk of any DR in Asian Indians, whereas the risk of referable DR was increased for indigenous Africans compared with Caucasians. In type 2 diabetes, the risk was increased for all non-Caucasians compared with Caucasians. Longer duration of diabetes and elevated HbA_{1c} were independently associated with any and referable DR in both type 1 and type 2 diabetes, with the addition of hypertension and smoking in type 1 diabetes when adjusted for age at diagnosis of diabetes, sex, and ethnicity.

CONCLUSIONS—The prevalence of DR in this population from South Africa was similar to that reported globally; however, ethnic differences were observed. Increasing duration of diabetes and poor glycemic control were the strongest risk factors associated with any and referable DR in both type 1 and type 2 diabetes.

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South Africa has an estimated population of ~50 million inhabitants, the majority being indigenous Africans (79.5%) with a minority comprising Caucasian (9%), mixed race (9%), and Asian Indians (2.5%) (1). The health care provider system in South Africa consists of a large and under-resourced public sector and a smaller, fast-growing private health care sector. Health care varies from the most basic primary health care, which is provided free by the state to ~80% of the population, to highly specialized services available in the private sector (2). It has been estimated that the prevalence of diabetes in South Africa is 5–10% of the population (3), with only ~11% of those with diabetes having their eyes routinely examined for diabetic retinopathy (DR) (4).

There is some evidence to suggest that the risk of DR and blindness in South Africa can vary with ethnicity (5–8). This in part may be due to increased prevalence and impact of additional putative risk factors for DR or as yet unidentified risk factors for DR. Recently, the global prevalence of DR has been reported to be 55.8% in African Americans, 46.7% in Caucasians, and 20.9% in Asians (9). To date, the reported prevalence of DR in South Africa's public sector has ranged between 14 and 55% in indigenous Africans, 41% in Caucasians, and 22 and 37% in Asian Indians with diabetes (10–12). The aim of this study was to describe the prevalence of DR within a defined population with diabetes attending, for the first time, a private diabetes clinic, the Centre for Diabetes and Endocrinology (CDE) in Johannesburg, South Africa, and to identify the associated risk factors as well as explore any ethnic variations in the prevalence of DR. Prevalence figures are essential in order to estimate current and future burden of disease and benefits that may result from the implementation of a DR-screening service.

RESEARCH DESIGN AND METHODS

Setting

The CDE is a private multispecialist center based in Johannesburg, South Africa, established in 1994. It serves as the principal center in a network of 262 smaller urban and rural centers providing diabetes care services in underdeveloped communities in South Africa. Details of the diabetes management program of the CDE have been described in detail previously (13).

Methods

All persons with diabetes attending the CDE undergo routine digital retinal photography performed at the time of their first visit and annually thereafter. Digital retinal photography was conducted in a darkened room using a nonmydriatic digital camera (Canon CR6–45NM; Canon) capturing one macular centered image per eye without the use of mydriasis by one of two trained technicians, one of whom is a diabetes nurse educator. All retinal images from the patient's first

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screening event obtained from 2001–2010 were independently reviewed and graded by one of three senior retinal graders according to a modified U.K. standard DR-grading protocol used by the DR Screening Service for Wales (14). Levels of DR were classified as no DR (NDR) if no lesions were detected, any DR when at least one microaneurysm and/or a blot hemorrhage were detected, and referable DR (RDR), which included preproliferative and proliferative lesions of DR as well as exudative maculopathy. RDR is the level at which further assessment by an ophthalmologist is deemed necessary.

Subjects included in this analysis were classified as having type 1 or type 2 diabetes on clinical assessment according to the American Diabetes Association classification of diabetes (9). Those individuals who did not clinically clearly fit into this classification were excluded from the analysis.

At the time of initial presentation, when the first retinal photographs were taken, blood was obtained for baseline laboratory investigations including HbA_{1c}, lipid analyses, and serum creatinine, and urine was collected for the assessment of the microalbumin/creatinine ratio. This initial HbA_{1c} was regarded as the baseline value and used in the analysis. The HbA_{1c} was initially analyzed as Diabetes Control and Complications Trial (DCCT) percent values and then converted to International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) mmol/mol units using the formula: [DCCT percent − 2.15] × 10.929. Both DCCT and IFCC units are dually reported throughout. Subjects were considered to have hypertension if their blood pressure was found to be >140/90 mmHg taken in the right arm seated after 5-min rest and/or if they were already on antihypertensive therapy. Other variables such as BMI were not available for analysis in this study.

Statistical analysis was conducted using SPSS version 16 (SPSS) and the population characteristics described using means and SDs for normally distributed and medians and interquartile ranges (IQ) for nonnormally distributed continuous variables and percentages for categorical variables. Significance testing used: *t* tests and Mann-Whitney *U* tests for continuous variables and χ^2 for categorical variables. Stepwise logistic regression analysis was used to assess the association of clinical risk factors and the presence of any DR and RDR for persons with type 1 and type 2 diabetes separately. Odds ratios (OR) and 95% CI were calculated for each. The continuous variables (HbA_{1c} and duration of diabetes) were stratified to avoid assumptions of linearity (i.e., for type 1 diabetes): HbA_{1c} <7.0 (<53), 7.0–7.9% (53–63), 8.0–8.9% (64–74), and ≥9.0% (≥75 mmol/mol) and duration of diabetes <7, 7–15, and >15 years; and for type 2 diabetes: HbA_{1c} <6.6 (<49), 6.6–7.4 (49–57), 7.5–8.9 (58–74) and ≥9.0% (≥75 mmol/mol) and known duration of diabetes <3, 3–8, and >8 years. Different stratifications were used in those with type 1 and type 2 diabetes for HbA_{1c} and duration of diabetes to ensure an equal distribution among the strata for both diabetes types. Associations were considered significant if the *P* value was <0.05.

RESULTS—A total of 5,565 subjects were seen at the CDE in Johannesburg during 2001 and 2010. The majority of people had type 2 diabetes (71.5%), with 27.6% having type 1 diabetes. The remaining 0.9% had other forms of diabetes and were excluded from the analysis. The baseline characteristics of the population studied are listed in Table 1.

Type 1 diabetes

In persons with type 1 diabetes, those of Caucasian origin had a longer duration of diabetes ($P < 0.001$), were younger at diagnosis ($P < 0.001$), and had a lower HbA_{1c} at presentation ($P < 0.001$) compared with the non-Caucasian population. Among the non-Caucasians, indigenous Africans had a shorter duration of diabetes compared with those of mixed race ($P = 0.026$) and were older at diagnosis than either the Asian Indians ($P = 0.004$) or those of mixed race ($P = 0.004$) (Table 2).

There was no evidence of DR in 60.3% (95% CI 57.8–62.7; *n* = 927), background DR was detected in 26% (95% CI 23.8–28.2; *n* = 399), and RDR in 9.2% (95% CI 7.9–10.8; *n* = 142). The RDR category consisted of 1.2% (95% CI 0.7–1.8; *n* = 18) with preproliferative DR, 4.9% (95% CI 3.9–6.1; *n* = 75) had exudative maculopathy, 1.3% (95% CI 0.8–2.0; *n* = 20) preproliferative DR with exudative maculopathy, 1.0% (95% CI 0.6–1.6; *n* = 15)

Table 1—*Baseline* characteristics for persons with diabetes*

Characteristics	Type 1 diabetes (*n* = 1,537)	Type 2 diabetes (*n* = 3,978)	All subjects (*n* = 5,515)
Age (years) [mean (SD)]	35.4 (15.4)	56.8 (11.8)	50.8 (16.1)
Sex [*n* (%)]			
Male	846 (55.0)	2,650 (66.6)	3,496 (63.4)
Female	690 (44.9)	1,326 (33.3)	2,016 (36.6)
Unknown	1 (0.1)	2 (0.1)	3 (0.1)
Ethnicity [*n* (%)]			
Caucasian	1,247 (81.1)	2,662 (66.9)	3,909 (70.9)
Indigenous African	117 (7.6)	580 (14.6)	697 (12.6)
Asian	118 (7.7)	562 (14.1)	680 (12.3)
Mixed race	49 (3.2)	159 (4.0)	208 (3.8)
Unknown	6 (0.4)	15 (0.4)	21 (0.4)
Duration of DM (years) [median (IQ)]	11.0 (5.0–19.0)	5.0 (1.0–10.0)	6.0 (2.0–12.0)
Age at diagnosis DM (years) [mean (SD)]	22.3 (13.8)	50.1 (11.9)	42.3 (17.6)
HbA_{1c} (%) [median (IQ)]	8.4 (7.3–9.8)	7.5 (6.6–8.9)	7.7 (6.8–9.2)
HbA_{1c} (mmol/mol) [median (IQ)]	68 (56–84)	58 (49–74)	61 (51–77)
Total cholesterol (mmol/L) [mean (SD)]	5.1 (1.1)	5.0 (1.2)	5.0 (1.2)
Albumin/creatinine ratio [median (IQ)]	0.9 (0.4–2.1)	1.1 (0.5–3.6)	1.0 (0.5–3.0)
Other therapies [*n* (%)]			
ACE	253 (16.5)	1,620 (40.7)	1,873 (34.0)
Aspirin	44 (2.9)	743 (18.7)	787 (14.3)
Hypertensive [*n* (%)]	287 (18.7)	2,141 (53.8)	2,428 (44.0)
Smoker [*n* (%)]	302 (19.6)	607 (15.3)	909 (16.5)
Retinopathy [*n* (%)]			
Unassessable	69 (4.5)	194 (4.9)	263 (4.8)
NDR	927 (63.1)	2,968 (78.4)	3,895 (74.2)
Any DR	541 (36.9)	816 (21.4)	1,357 (25.8)
RDR	142 (9.7)	255 (6.6)	397 (7.5)

*At presentation to CDE.

Table 2—*Baseline* characteristics for the different ethnic groups for persons with type 1 and type 2 diabetes*

	Caucasian	Non-Caucasians	*P* value†	Indigenous African	Asian	Mixed race	*P* value‡
Type 1 diabetes							
n	1,247	284		117	118	49	
Age (years) [mean (SD)]	35.7 (15.6)	34.0 (14.5)	0.075	36.3 (16.1)	32.2 (12.1)	32.6 (15.2)	0.069
Sex [*n* (%)]			0.570				0.253
Male	690 (55.3)	152 (53.5)		66 (56.4)	65 (55.1)	21 (42.9)	
Female	556 (44.6)	132 (46.5)		51 (43.6)	53 (44.9)	28 (57.1)	
Unknown	1 (0.1)	0		0	0	0	
Duration of DM (years) [median (IQ)]	12.0 (6.0–20.0)	7.0 (3.0–13.0)	<0.001	5.0 (3.0–11.5)	8.0 (3.0–15.0)	8.0 (5.0–14.5)	0.070
Age at diagnosis (years) [mean (SD)]	21.6 (13.6)	25.0 (14.2)	<0.001	28.5 (15.5)	22.7 (11.8)	22.7 (14.6)	0.003
HbA_{1c} (%) [median (IQ)]	8.2 (7.3–9.6)	9.0 (7.7–11.2)	<0.001	9.5 (7.8–11.3)	8.7 (7.6 to 10.9)	9.0 (7.3–11.4)	0.272
HbA_{1c} (mmol/mol) [median (IQ)]	66 (56–81)	75 (61–99)	<0.001	80 (62–100)	72 (60–96)	75 (56–101)	0.272
Type 2 diabetes							
n	2,662	1,296		580	562	159	
Age (years) [mean (SD)]	59.7 (11.1)	50.9 (10.9)	<0.001	51.7 (10.0)	50.5 (11.8)	49.5 (10.7)	0.037
Sex [*n* (%)]			0.008				0.013
Male	1,810 (68.0)	829 (63.7)		382 (65.9)	362 (64.4)	85 (53.5)	
Female	851 (32.0)	471 (36.2)		197 (34.0)	200 (35.6)	74 (46.5)	
Unknown	1 (0.0)	1 (0.1)		1 (0.2)	0	0	
Duration of DM (years) [median (IQ)]	5.0 (1.0–10.0)	5.0 (2.0–10.0)	0.073	5.0 (2.0–10.0)	5.0 (1.0–10.0)	4.0 (1.0–10.0)	0.173
Age at diagnosis (years) [mean (SD)]	53.0 (11.4)	44.0 (10.7)	<0.001	44.6 (9.8)	43.5 (11.5)	43.7 (10.3)	0.199
HbA_{1c} (%) [median (IQ)]	7.3 (6.5–8.4)	8.1 (6.9–10.0)	<0.001	8.3 (7.0–10.5)	7.9 (6.9–9.4)	8.1 (7.0–10.0)	0.003
HbA_{1c} (mmol/mol) [median (IQ)]	56 (48–68)	65 (52–86)	<0.001	67 (53–91)	63(52–79)	65 (53–86)	0.003

*At presentation to CDE. †*P* value differences between Caucasians and non-Caucasians. ‡*P* value for differences across the non-Caucasian groups. DM, diabetes.

proliferative DR, and 0.9% (95% CI 0.5–1.5; *n* = 14) proliferative DR with exudative maculopathy. There were 4.5% (95% CI 3.6–5.6; *n* = 69) unassessable images mainly due to the presence of lens opacification.

Those who presented with any or RDR compared with those with NDR were older [mean (SD)]: 38.0 (13.6) and 38.6 (12.2) years versus 32.9 (15.6) years, respectively ($P < 0.001$); and were younger at diagnosis of diabetes: 19.6 (11.8) and 19.0 (11.4) years versus 23.5 (14.4) years, respectively ($P < 0.001$), with a longer duration of diabetes [median (IQ)]: 17.0 (12.0–23.0) and 18.0 (14.0–25.0) years versus 6.0 (3.0–12.0) years, respectively ($P < 0.001$). Those presenting with any or referable levels of DR compared with those without DR also had a higher HbA_{1c} level: 8.5 (7.6–9.9)% (69 [60–85] mmol/mol]), 8.7 (7.8–10.2)% (72 [62–88] mmol/mol) versus 8.3 (7.1–9.7)% (67 [54–83] mol/mol), respectively (any DR vs. NDR, $P = 0.033$; RDR vs. NDR, $P = 0.013$) and had a higher prevalence of hypertension (25.1 and 35.9% RDR versus 12.1%, respectively; $P < 0.001$). There were also more cigarette smokers with any DR or RDR compared with those without DR (22.9 and 22.5% versus 17.6%, respectively; $P = 0.013$). (Only one *P* value is shown in the text, as the *P* value is similar for the comparison between any DR versus NDR and RDR versus NDR.)

In logistic regression analyses, the presence of any DR and RDR was significantly associated with ethnicity (Table 3). Asian Indians were at an increased risk of any DR (OR 1.78) when compared with Caucasians and adjusted for age at diagnosis, sex, duration of diabetes, HbA_{1c}, hypertension, and smoking status. In comparison, indigenous Africans had an increased risk of RDR (OR 3.36). There was no significant difference for any DR or RDR comparing those of mixed race with Caucasians. Other risk factors independently associated with any DR (Table 3) were a longer duration of diabetes (OR 10.28, 7–15 years; 37.31, >15 years; reference group <7 years), an increased HbA_{1c} (OR 1.32, <7.0% [<53 mmol/mol]; 2.15, 8.0–8.9% [64–74 mmol/mol]; and 3.20, ≥9.0% [≥75 mmol/mol]; reference group >7.0% [>53 mmol/mol]), the presence of hypertension (OR 1.44), and the habit of smoking (OR 1.78). The presence of RDR was also significantly associated with duration of diabetes, HbA_{1c}, hypertension, and smoking. There was a weak but significant association between albumin/creatinine ratio and any DR and RDR in univariate analysis; however, these data were missing for many of the persons with diabetes and were therefore removed from the stepwise multivariate analyses.

Type 2 diabetes

Caucasian subjects with type 2 diabetes were older at baseline and at the time of diagnosis ($P < 0.001$) and had a lower HbA_{1c} ($P < 0.001$) than non-Caucasians (Table 2). The known duration of diabetes was similar across all ethnicities. There were differences in sex distribution, with more males of Caucasian ethnicity compared with non-Caucasians ($P = 0.008$) and more females of mixed race compared

Table 3—*Multivariate logistic regression analysis of independent risk factors for any and RDR in persons with type 1 and type 2 diabetes (adjusted for age at diagnosis of diabetes and sex)*

	Any DR (*n* = 541)		RDR (*n* = 142)	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Type 1 diabetes				
Ethnicity (*n*)				
Caucasian (1,247)	1.00	1.00	1.00	1.00
Indigenous African (117)	0.71 (0.46–1.09)	1.72 (1.00–2.97)	0.95 (0.49–1.84)	3.40 (1.40–8.26)
Asian (118)	1.10 (0.74–1.63)	2.02 (1.23–3.29)	1.05 (0.54–2.04)	2.07 (0.90–4.75)
Mixed race (49)	1.01 (0.56–1.84)	1.29 (0.62–2.69)	1.10 (0.42–2.88)	1.06 (0.36–3.18)
Duration of DM (years) (*n*)				
<7 (505)	1.00	1.00	1.00	1.00
7–15 (515)	8.89 (6.01–13.15)	10.28 (6.75–15.65)	16.19 (5.75–45.60)	20.08 (6.81–59.18)
>15 (517)	26.20 (17.62–38.95)	37.31 (23.57–59.07)	68.74 (24.89–189.88)	116.06 (38.00–354.43)
HbA_{1c} (%) (*n*)				
<7.0[a] (310)	1.00	1.00	1.00	1.00
7.0–7.9[b] (342)	1.78 (1.26–2.52)	1.32 (0.88–1.97)	1.15 (0.62–2.12)	0.95 (0.47–1.89)
8.0–8.9[c] (322)	2.15 (1.52–3.04)	2.15 (1.43–3.25)	1.79 (1.01–3.19)	1.99 (1.02–3.90)
≥9.0[d] (563)	2.05 (1.50–2.81)	3.20 (2.17–4.71)	2.06 (1.23–3.44)	4.07 (2.18–7.62)
Albumin/creatinine ratio (*n* = 647)	1.06 (1.03–1.09)		1.08 (1.04–1.01)	
Hypertension (*n* = 302)	2.44 (1.85–3.22)	1.44 (1.02–2.03)	4.08 (2.75–6.06)	2.41 (1.47–3.96)
Smoking (*n* = 287)	1.39 (1.07–1.81)	1.78 (1.28–2.47)	1.36 (0.89–2.09)	2.15 (1.27–3.65)
	Any DR (*n* = 816)		RDR (*n* = 255)	
Type 2 diabetes				
Ethnicity (*n*)				
Caucasian (2,662)	1.00	1.00	1.00	1.00
Indigenous African (580)	2.00 (1.62–2.48)	1.79 (1.40–2.30)	3.69 (2.71–5.02)	3.08 (2.14–4.43)
Asian (562)	1.83 (1.48–2.26)	1.59 (1.24–2.04)	1.93 (1.34–2.80)	1.57 (1.04–2.39)
Mixed race (159)	2.66 (1.88–3.76)	2.69 (1.80–4.02)	3.52 (2.08–5.95)	3.27 (1.78–6.04)
Known duration of DM (years) (*n*)				
<3 (1,391)	1.00	1.00	1.00	1.00
3–8 (1,360)	2.61 (2.02–3.36)	2.33 (1.80–3.03)	2.36 (1.41–3.95)	2.05 (1.21–3.46)
>8 (1,224)	11.24 (8.8–14.28)	9.59 (7.46–12.32)	18.03 (11.47–28.34)	14.98 (9.37–23.95)
HbA_{1c} (%) (*n*)				
<6.5[e] (966)	1.00	1.00	1.00	1.00
6.5–7.4[f] (1,097)	1.61 (1.25–2.09)	1.32 (1.00–1.75)	1.75 (1.05–2.94)	1.46 (0.85–2.51)
7.5–8.9[g] (1,008)	2.77 (2.16–3.55)	1.84 (1.40–2.41)	3.84 (2.38–6.18)	2.43 (1.47–4.03)
≥9.0[h] (97)	3.86 (3.01–4.95)	2.25 (1.71–2.96)	6.93 (4.37–10.99)	3.68 (2.25–6.03)
Albumin/creatinine ratio (*n* = 1,483)	1.03 (1.02–1.05)		1.04 (1.02–1.05)	
Hypertension (*n* = 607)	1.35 (1.15–1.57)		1.54 (1.18–2.00)	
Smoking (*n* = 2,141)	0.98 (0.79–1.21)		0.75 (0.51–1.10)	

[a]<53 mmol/mol. [b]53–66 mmol/mol. [c]64–74 mmol/mol. [d]≥75 mmol/mol. [e]<48 mmol/mol. [f]48–57 mmol/mol. [g]58–74 mmol/mol. [h]75 mmol/mol. DM, diabetes.

with indigenous Africans and Asian Indians ($P < 0.013$). There was also a difference in age and HbA_{1c} levels between those of non-Caucasian ethnicity with those indigenous Africans who were older ($P = 0.037$) and with higher HbA_{1c} levels ($P = 0.003$) compared with Asian Indians and mixed races (Table 2).

In the entire cohort of subjects with type 2 diabetes, the prevalence of any DR was 20.5% (95% CI 19.3–21.8), with NDR detected in 74.6% (95% CI 73.2–75.9; *n* = 2,968). The majority of DR seen was background DR: 14.1% (95% CI 13.1–15.2; *n* = 561), with 6.4% (95% CI 5.7–7.2; *n* = 255) having RDR. The category of RDR consisted of 0.7% (95% CI 0.5–1.0; *n* = 28) preproliferative DR, 3.5% (95% CI 3.0–4.2, *n* = 141) exudative maculopathy, 1.4% (95% CI 1.0–1.8; *n* = 54) preproliferative DR with exudative maculopathy, 0.2% (95% CI 0.1–0.4; *n* = 8) proliferative DR, and 0.6% (95% CI 0.4–0.9; *n* = 24) proliferative DR with exudative maculopathy. There was a similar proportion with unassessable images (4.8%; 95% CI 4.3–5.6) with type 2 diabetes as seen in the subjects with type 1 diabetes.

Those presenting with any or RDR compared with those without DR were younger at diagnosis of diabetes (mean [SD]) (45.8 [11.4] years for any DR or 43.9 [10.2] years RDR vs. 51.1 [11.7] years NDR; $P < 0.001$), had a longer known duration of diabetes (median [IQ]) (10.0 [6.0–16.0] years for any DR or 12.0 [8.0–17.0] years RDR vs. 3.0 [1.0–7.0] years NDR; $P < 0.001$), and had a higher HbA_{1c} level (8.2 [7.1–9.7]%; 66 [54–83] mmol/mol for any DR; or 8.7 [7.6–8.7]%; 72 [60–72] mmol/mol RDR vs. 7.3 [6.5–8.6]%; 56 [48–70] NDR; $P < 0.001$). There was also a higher proportion of persons with hypertension (59.2% any DR or 62.4% RDR vs. 51.9% NDR;

$P < 0.001$). There was a ($P < 0.001$) lower proportion of Caucasians than all other ethnic groups in those with any or RDR (16.8 and 4.4% Caucasians, 27.2 and 13.1% indigenous Africans, 27.0 and 7.5% Asian Indians, and 34.6 and 11.9% mixed race, respectively) compared with those without DR (78.9% Caucasian, 63.8% indigenous Africans, 69.4% Asian Indians, and 61.0% mixed race; Fig. 1). (Only one *P* value is shown in the text, as the *P* value is similar for the comparison between any DR versus NDR and RDR versus NDR.)

When compared with the Caucasian population, non-Caucasians had an increased risk of any DR (indigenous Africans 1.90, Asian 1.74, and mixed race 2.95) when adjusted for age at diagnosis of diabetes, sex, known duration of diabetes, and HbA_{1c} (Table 3). Other risk factors independently associated with any DR included a longer known duration of diabetes (OR 2.33, 3–8 years; 9.59, >8 years; reference group <3 years) and an increased HbA_{1c} (OR 1.32 6.6–7.4% [49–57 mmol/mol]; 1.84, 7.5–8.9% [58–74 mmol/mol]; and 2.25, ≥9.0% [≥75 mmol/mol]; reference group <6.6% [49 mmol/mol]). Non-Caucasian ethnicity increased known duration of diabetes and increased HbA_{1c} were also associated with RDR. Smoking was not associated with an increased risk of any DR or RDR. Although hypertension was associated with any DR and RDR in univariate analysis, it was not included in the results of stepwise multivariate analyses. Although there was a weak significant association between albumin/creatinine ratio and any DR and RDR in univariate analysis, these data were missing for the majority of patients and therefore removed from the stepwise analysis.

CONCLUSIONS—In a large cohort of persons with type 1 and type 2 diabetes undergoing retinal photography when first presenting at the CDE, the overall prevalence of DR and RDR at the time of the first visit was 24.6 and 7.2%, respectively. The prevalence of any DR was lower than in the recent survey of the global prevalence of any DR of 34.6% (9). This is the first study to be conducted in the privately funded sector in South Africa, which may account for this difference.

Ethnic differences in the prevalence and associations with the presence of any DR (5,7,8) and also severe/referable stages of DR (6,7) have previously been reported to be higher in non-Caucasian persons when compared with Caucasians or Europeans. Only two previous studies, in relative numbers of persons with diabetes, have examined differences between ethnic groups in South Africa (4,10). One study did not report any significant associations between ethnicity and DR (4), and the other found that those of an African and Indian origin had a significantly higher prevalence of severe DR than Europeans (10). In contrast, we observed clear differences in the risk of DR between the ethnic groups studied. Although the risk of any DR was increased in Asian Indians, RDR was increased for indigenous Africans with type 1 diabetes when compared with Caucasians, and the risk of both any DR and RDR was increased for all non-Caucasian populations compared with Caucasians with type 2 diabetes. These differences remained after correction for other risk factors, which include the fact that those of African and mixed-race origin had higher HbA_{1c} levels at baseline and type 2 diabetes starting at a younger age than in the non-Caucasian population. Kalk et al. (10) also reported a higher prevalence of microalbuminuria in patients of indigenous African decent when compared with a Caucasian population. This suggests that ethnic differences exist in the propensity to develop microvascular complications such as DR.

Our study demonstrated that the presence of any DR and RDR were strongly associated with increasing duration of diabetes and a higher HbA_{1c} level in persons with both type 1 and type 2 diabetes, thus confirming earlier epidemiological studies (15,16). Previous epidemiological studies and clinical trials also indicate that hypertension is an important modifiable risk factor for DR (17–19). In this study however, hypertension was shown to be a significant risk factor only in persons with type 1 diabetes. A reason for the lack of an association for persons with type 2 diabetes may be due to the more aggressive

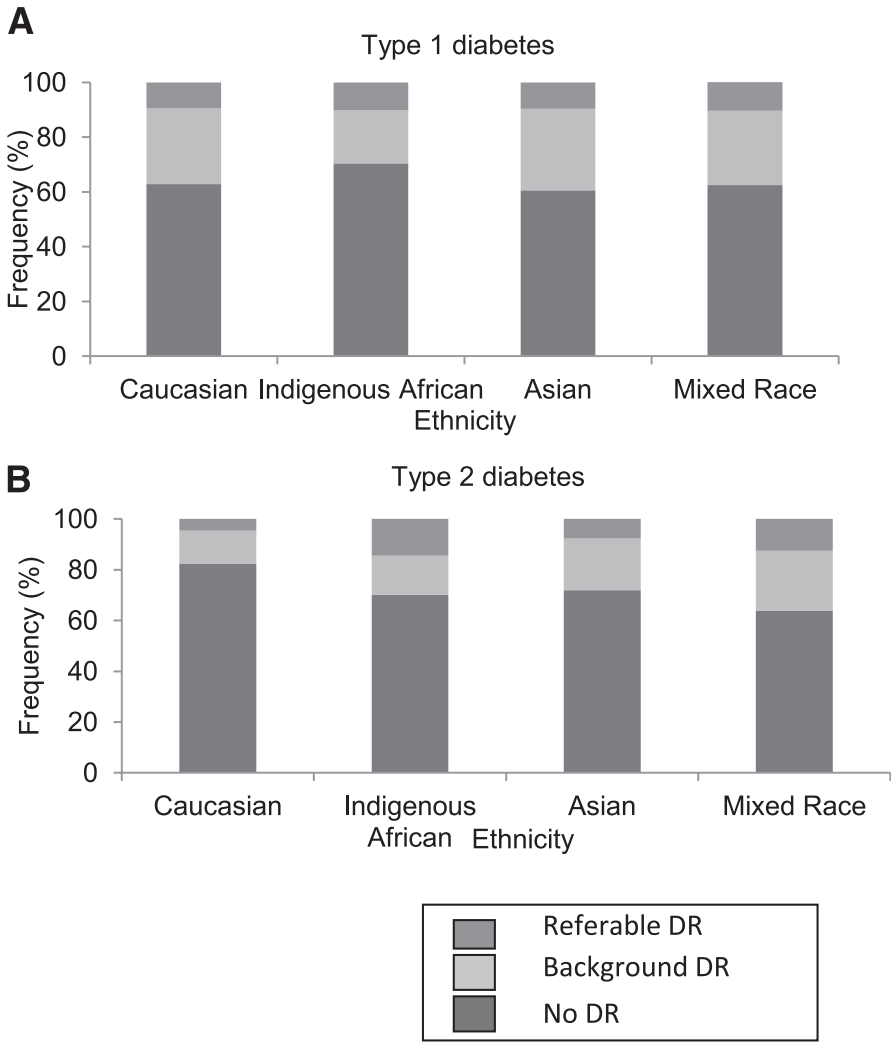

Figure 1—*Frequency of DR by ethnic groups in persons with type 1 (A) and type 2 (B) diabetes.*

treatment of hypertension and lower blood pressure targets in this patient group. The importance of smoking as a risk factor for DR is inconclusive, with some studies showing either an association (20–23) or even suggesting that smoking may be protective against the development of DR (24). In our study, smoking had a clear association with the development of referable retinopathy in patients with type 1 diabetes, but not those with type 2 diabetes.

Compared with previous population-based studies in Africa and South Africa, the strength of this study was the larger sample size and that all the data (i.e., retinal images and the putative risk factors) were derived from a single center (CDE). However, as most of the population in South Africa with diabetes uses the public health system, the population studied in this paper may not therefore be representative of this majority. Although the use of standardized digital retinal photography and grading protocol are strengths within this study, the lack of dilation may have led to a higher proportion of ungradeable images, and the availability of only one 45° field per eye may have resulted in underreporting of DR.

Long-term follow-up of the majority of the participants in this study, involving intensive diabetes and risk factor management, is underway at the CDE. This will allow assessment of the incidence of both newly developing DR and the progression of DR in this cohort of subjects with both type 1 and type 2 diabetes and will be the subject of a future report.

In this large population sample of individuals with diabetes entering a diabetes management program, there was a low prevalence of DR. Ethnicity was independently associated with the presence of DR and RDR in both type 1 and type 2 diabetes. Increasing duration of diabetes and poor glycemic control were the strongest risk factors associated with the presence of any and RDR in persons with both type 1 and type 2 diabetes. In type 1 diabetes, hypertension and smoking were additional risk factors for the presence of any and RDR.

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R.L.T., L.D., S.D.L., S.R.C., V.J.M., B.K., and D.R.O. contributed to the writing of this article and approved the final version of the manuscript. R.L.T. processed and analyzed data. L.D. was the lead for this study with the support of B.K. and D.R.O. L.D., S.D.L., B.K., and D.R.O. contributed to the concept, study design, and interpretation of data. S.R.C. contributed to the processing of data. V.J.M. collated all data. D.R.O. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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