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Proportion of people with diabetic retinopathy and macular oedema varies by ethnicity in a tertiary retinal clinic in Australia: findings from the Liverpool Eye and Diabetes Study (LEADS)

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ABSTRACT

Objective There are limited data on the influence of ethnicity on diabetic retinopathy (DR). We sought to determine the distribution of DR by ethnic group in Australia.

Design Clinic-based cross-sectional study.

Setting Participants with diabetes in a defined geographical region of Sydney, Australia, who attended a tertiary retina referral clinic.

Participants The study recruited 968 participants.

Intervention Participants underwent a medical interview and retinal photography and scanning.

Primary outcome measures DR was defined from two-field retinal photographs. Diabetic macular oedema (DMO) was defined from spectral domain optical coherence tomography (OCT-DMO). The main outcomes were any DR, proliferative DR (PDR), clinically significant macular oedema (CSME), OCT-DMO and sight-threatening DR (STDR).

Results There was high proportion of any DR (52.3%), PDR (6.3%), CSME (19.7%), OCT-DMO (28.9%) and STDR (31.5%) in people attending a tertiary retinal clinic. Participants of Oceanian ethnicity had the highest proportion of any DR and STDR (70.4% and 48.1%, respectively), while the lowest proportion was in participants of East Asian ethnicity (38.3% and 15.8%, respectively). Proportion of any DR and STDR in Europeans was 54.5% and 30.3%, respectively. Independent predictive factors for diabetic eye disease were ethnicity, longer duration of diabetes, higher glycated haemoglobin and higher blood pressure. Even after adjusting for risk factors, Oceanian ethnicity remained associated with twofold higher odds of any DR (adjusted OR 2.10, 95% CI 1.10 to 4.00) and all other forms of DR including STDR (adjusted OR 2.22, 95% CI 1.19 to 4.15).

Conclusion In people attending a tertiary retinal clinic, the proportion of people with DR varies among ethnic groups. The high proportion in persons of Oceanian ethnicity suggests a need for targeted screening of this at-risk group. In addition to traditional risks factors, ethnicity may be an additional independent predictor of DR.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study is one of the first to measure both diabetic retinopathy and diabetic macular oedema using validated methods (retinal photography and optical coherence tomography) in different ethnic groups.
⇒ Ethnicity reporting followed the recommendations of the Australian Classification of Cultural and Ethnic Groups.
⇒ Data on traditional risk factors for diabetic retinopathy were adjusted for in analyses.
⇒ The study is clinic based in a defined geographical region and does not measure the true population prevalence of diabetic retinopathy. The focus was on comparing proportions in different ethnic groups from the same clinic-based geographical region.

INTRODUCTION

Diabetic retinopathy (DR) is one of the leading causes of blindness worldwide, and is the fourth leading cause of blindness in Australia.[1 2] Studies in other countries have found that the prevalence of DR varies among different ethnic groups.[3–5] Ethnicity may thus be an important risk factor for DR.

In the USA, the Multi Ethnic Study of Atherosclerosis (MESA) found that African-Americans (36.7%) and Hispanics (37.4%) had a higher prevalence of DR compared with white non-Hispanics (24.8%) and Chinese-Americans (25.7%).[4] In the UK, the Diabetic Retinopathy In Various Ethnic groups (DRIVE) Study found that African/Afro-Caribbeans (52.4%) had the highest prevalence of DR, followed by South Asians (42.3%), then followed by white Europeans (38.0%).[3] In Singapore, the Singapore Epidemiology of Eye Disease (SEED) found that Indian Singaporeans (30.7%) had the highest prevalence of DR, followed by Chinese (26.2%) and Malay (25.5%) Singaporeans.[5]

Australia is also a multiethnic society, but there are no comparable data on ethnic differences in the prevalence of DR. Indigenous

Australians are known to have higher rates of DR,[6] and this has led to focused efforts to reduce the burden of blindness from DR in this vulnerable group. Similar data are required for other ethnic groups to identify which are most at risk and to plan interventions accordingly. We therefore conducted a survey of a multiethnic population in Australia to determine ethnic differences in DR.

MATERIALS AND METHODS

Study design

The Liverpool Eye and Diabetes Study (LEADS) is a non-interventional, clinic-based observational, cross-sectional survey of diabetic eye disease based in the Liverpool local government area of Sydney, New South Wales (NSW), Australia. The study design, aims and methodology are described elsewhere.[7]

Patient and public involvement

Patients' experiences and observations as relayed to the study team members formed the basis of the study rationale and aims. Patients will be informed of the study findings through local newsletters and media statements. The public was not directly involved in the planning of this study.

Study population

The study population are participants who attended a tertiary retinal clinic in the suburb of Liverpool in South West Sydney, NSW, Australia, that is defined by the geographical postcode 2170.[8] This clinic was chosen because it serves an ethnically diverse suburb of Sydney with 41% of residents born overseas compared with 35% in NSW overall; the most commonly spoken languages being Arabic, followed by Vietnamese, Mandarin/Cantonese and then English; has a high prevalence of diabetes (6.5% compared with 5.1% Australia-wide); and the prevalence of diabetes in the suburb increased by 158% between 2000 and 2011.[8] Participants were referred to the clinic from the Liverpool Hospital Diabetes and Endocrinology Service, local general practitioners (GPs) and local optometrists. The recruitment period was from June 2016 to December 2018.

Inclusion criteria

1. Participants with diabetes mellitus: type 1, type 2 diabetes or diabetes due to other causes (monogenic diabetes syndrome, pancreatic disease or drug-induced diabetes). Type 1 and type 2 were defined according to the referring endocrinologist or GP; if these diagnoses were not available, type 1 was defined as onset before age 40 years and current use of insulin.
2. Aged over 18 years.
3. Able to provide informed consent.
4. Residing in the Liverpool suburb with residential address postcode 2170.

Exclusion criteria

1. Age <18 years.
2. Pregnant women or women with gestational diabetes mellitus.
3. Unable to provide informed consent.
4. Residing outside the region of interest.

Examination procedures

Participants had habitual and best corrected visual acuity measured using Early Treatment Diabetic Retinopathy Study (ETDRS) charts. Both pupils were dilated with 1% tropicamide and 10% phenylephrine as recommended by National Health and Medical Research Council guidelines.[9]

A research officer conducted a medical interview and filled in a standard questionnaire obtaining information on demographics such as age, gender, self-reported ethnicity, ocular and medical history, other complications of diabetes (both microvascular and macrovascular disease) and cardiovascular risk factors. We used the Australian Bureau of Statistics Standard Classification of Cultural and Ethnic Groups[10] for this study. This was to facilitate comparability with other studies, and is the most widely used classification of ethnicity in healthcare settings in Australia. We used the first-level ('broad groups') categories and asked participants to self-report which ethnic group they belonged to. For analyses, we combined 'North-West European' and 'South and Eastern European' into one category (European); 'South-East Asian' and 'North-East Asian' into one category (East Asian); and kept the Oceanian, Middle Eastern, and South Asian categories. Further details regarding the classification and rationale for these groupings are provided elsewhere.[10]

Diabetes was defined as type 1 or type 2 according to diagnoses provided by the treating GP or endocrinologist. Hypertension and dyslipidaemia were defined from history and the medications list provided by the participants. Medications were confirmed with the referral medication list. Obesity was defined as body mass index (BMI) $\geq 30\,kg/m^2$. Peripheral neuropathy was defined from history provided by the treating endocrinologist or GP. Blood pressure, height and weight were measured during the visit. The most recent pathology tests in the past 6 months of the retinal screening, including glycated haemoglobin (HbA1c), were obtained from the referrer or GP.

Retinal imaging

All participants had digital retinal photography according to a standardised protocol. After pupil dilation, fundus photography was performed with a digital non-mydriatic retinal camera (Canon CR-DGi with a 20Diopter SLR backing, Canon, Japan). Photographs included ETDRS standard fields 1 (centred on the optic disc) and 2 (centred on the fovea). This photographic method has been shown to have high sensitivity and specificity for detecting DR[11] and is used in the UK National Health Service National Diabetic Eye Screening Programme.[12] A Heidelberg spectral domain optical coherence tomography (SD-OCT) machine took macula-centred high-density raster scans

through the fovea. OCT images were obtained on the same day, after pupil dilation. The Spectralis HRA+OCT with viewing module V.5.1.2.0 (Heidelberg Engineering, Heidelberg, Germany) was used to acquire SD-OCT images. The SD-OCT protocol included a dense horizontal linear scan centred on the fovea and the HEYEX software interface (V.1.6.2.0; Heidelberg Engineering) was used for registration and evaluation. OCT-diabetic macular oedema (OCT-DMO) was defined as cystic spaces on at least two consecutive raster scans; clinically significant macular oedema (CSME) was defined from fundus photographs according to ETDRS criteria.[13] The reproducibility of the Heidelberg SD-OCT measurements is reported to be higher than most other OCT machines.[14] OCT procedure followed the APOSTEL guidelines and further details are available on request.[15] Intraocular pressure was measured with a Tono-pen (Reichert Technologies, New York, USA).

Retinal images were reviewed and slit-lamp examination performed by a consultant ophthalmologist. Presence and severity of cataract, corneal abnormalities, vitreous posterior vitreous detachment and peripheral retinal lesions were documented. B-scan ultrasound was performed if dense cataract precluded adequate retinal examination.

DR grading

Retinal images were graded by a trained grader according to International Classification of Diabetic Retinopathy guidelines.[16] DR was considered present if any characteristic lesion as defined by the ETDRS severity scale was present: microaneurysms, haemorrhages, cotton wool spots, intraretinal microvascular abnormalities, hard exudates, venous beading and new vessels. Sight-threatening DR (STDR) was defined as presence of severe non-proliferative DR, or proliferative DR (PDR) or CSME or OCT-DMO.

Statistical analysis

DR, CSME, OCT-DMO and STDR proportion was reported as % and by ethnic group. Differences between ethnic groups were assessed using statistical tests such as χ^2 test for categorical variables, and t-test for continuous variables. Multivariable logistic regression models were constructed with age, gender, HbA1c, duration of diabetes and other relevant risk factors (including ethnicity, blood pressure, dyslipidaemia, obesity) as predictors of the outcome variable (eg, DR). The variables included in the multivariable model were chosen a priori based on previous publications of the major risk factors associated with DR, including those from Australian populations.[2–6] Although HbA1c may be on the causal pathway between ethnic group and DR, we decided to include it as our main research question was to identify if ethnicity is an independent risk factor for DR, independent of HbA1c. SAS software, V.9 (SAS Corporation) was used in the analyses.

Expected patient numbers and power calculations

The study is powered to detect a 7% difference in DMO prevalence between different ethnic groups. This represents a clinically significant difference as previous smaller studies suggest a range of between 3% and 14% in white populations.[3 17–19] Assuming a baseline DMO prevalence of 10%, 25% of the sample being of European, South Asian, East Asian and Middle Eastern ethnicity, respectively, power of 80% and false positive rate of 5%, n=1000 participants in total would need to be recruited to detect this difference. This sample size is larger than that of the MESA that reported contemporary ethnic differences prevalence of DR and DMO (n=778).[4]

RESULTS

A total of 1003 patients who attended the tertiary retinal clinic within the study time frame (June 2016–December 2018) were approached to participate in the study. Of these, 968 agreed to participate and provided signed consent, and 35 did not. We did not collect further data on the patients who refused consent.

The study recruited 968 participants with diabetes between June 2016 and December 2018, of whom 865 had type 2 diabetes (89.4%) and 103 had type 1 diabetes (10.6%). The baseline participant demographics of the study cohort are shown in table 1. Within the study cohort, the mean age was 58.2 (SD ±14.3) years with participants having mean duration of diabetes of 16.7 (±8.9) years. Mean HbA1c was 8.4 (±2.2)% (68±13 mmol/mol). Participants of Oceanian ethnicity were somewhat younger than other participants (49.6±12.2 years) compared with 56.5±15.7 years (Europeans). HbA1c was highest in South Asians (9.7%) and lowest in East Asians (7.9%). Current smoking was highest in Middle Eastern participants (23.0%) and lowest in East Asians (8.4%).

In table 2, the overall proportion of any DR was 52.3%, with the highest proportion in participants of Oceanian ethnicity (70.4%) and lowest in participants of East Asian ethnicity (38.3%). Europeans (54.5%), Middle Eastern (54.8%) and South Asians (54.8%) had similar proportion of any DR. The proportion of PDR followed a similar distribution, with an overall proportion of 6.3%, highest in Oceanian participants (18.5%) and lowest in East Asians (2.2%). The overall proportion of CSME was 19.7%, and of OCT-DMO 28.9% and followed the same distribution. Overall proportion of STDR was 31.5%, highest in Oceanians (48.1%), followed by Middle Easterns (37.4%), South Asians (31.7%), Europeans (30.3%) and East Asians (15.8%).

Table 3 explores further the influence of ethnicity on DR. Compared with Europeans as the reference group, East Asians were approximately half as likely to have any DR, PDR, OCT-DMO or STDR. Middle Easterns had similar odds of having any DR, PDR and STDR as Europeans but were more likely to have OCT-DMO (OR 1.65, 95% CI 1.03 to 2.63). South Asians had similar odds of any DR, PDR, OCT-DMO and STDR as Europeans.

Table 1 Baseline participant characteristics

	Total	European	East Asian	Middle Eastern	South Asian	Oceanian	Other
Number (%)	968 (100)	244 (25.2)	181 (18.6)	126 (13.0)	62 (6.4)	55 (5.6)	300 (31.2)
Male (%)	526 (55.3)	150 (61.5)	92 (50.6)	75 (59.5)	39 (62.9)	24 (42.6)	156 (52.0)
Diabetes type (%)							
Type 1 (%)	103 (10.6)	51 (21.0)	9 (4.5)	14 (10.4)	1 (1.6)	3 (5.6)	26 (8.7)
Type 2* (%)	865 (89.4)	193 (79.0)	83 (95.5)	112 (89.6)	61 (98.4)	52 (94.4)	274 (91.3)
Age (mean (SD); in years)	58.8 (14.3)	56.5 (15.7)	61.3 (12.8)	57.6 (15.0)	56.7 (12.3)	49.6 (12.2)	61.6 (13.4)
Body mass index (mean (SD); kg/m^2)*	30.9 (7.6)	32.4 (8.7)	25.9 (4.6)	31.3 (6.8)	28.0 (4.8)	36.9 (7.0)	32.0 (7.3)
Duration of diabetes (mean (SD); in years)*	16.7 (8.9)	17.7 (10.2)	14.6 (8.3)	16.2 (8.3)	16.6 (8.5)	13.5 (6.0)	17.9 (8.6)
HbA1c (%)*† (mmol/mol)	8.4 (2.2) 68 (13)	8.6 (2.3) 70 (14)	7.9 (2.1) 63 (12)	8.0 (1.9) 64 (10)	9.7 (2.9) 83 (16)	8.0 (2.3) 64 (14)	8.4 (2.2) 68 (13)
Hypertension (%)	633 (65.3)	165 (67.5)	123 (68.2)	75 (59.5)	34 (54.8)	33 (59.3)	203 (67.7)
Dyslipidaemia (%)	671 (69.3)	159 (65.2)	130 (71.6)	85 (67.5)	42 (67.7)	34 (61.1)	221 (73.8)
Peripheral neuropathy (%)	278 (28.7)	70 (28.7)	40 (21.8)	37 (29.4)	11 (17.7)	26 (46.3)	96 (31.9)
Smoking status (%)							
Non-smoker	515 (53.2)	103 (42.2)	118 (65.4)	70 (55.6)	48 (77.4)	21 (37.4)	156 (51.9)
Ex-smoker	303 (31.3)	97 (39.8)	48 (26.3)	27 (21.4)	6 (9.7)	23 (40.7)	104 (34.6)
Current smoker	150 (15.4)	44 (18.0)	15 (8.4)	29 (23.0)	8 (12.9)	12 (22.2)	41 (13.6)

*Significant at the level of p<0.05.
†HbA1c data were only available for n=621 participants (64.2%).
HbA1c, glycated haemoglobin.

Oceanians were more likely to have any DR (OR 1.98, 95% CI 1.05 to 3.74), PDR (OR 2.85, 95% CI 1.24 to 6.60) and STDR (OR 2.13, 95% 1.16 to 3.92) than Europeans. Persons reporting ethnicity as 'other' were more likely to have OCT-DMO (OR 1.51, 95% CI 1.04 to 2.21) than Europeans.

In univariable analyses, age, gender, BMI and smoking were not associated with any DR, PDR, OCT-DMO or STDR. Type 1 diabetes was associated with lower risk of any DR (OR 0.51, 95% CI 0.33 to 0.80) compared with type 2 diabetes, but not with PDR, OCT-DMO or STDR. Table 4 shows the variables that were associated with any DR in univariable analyses. Multivariable analyses including all the variables in table 4 were conducted to determine the independent risk factor for DR East Asian ethnicity was a protective factor, with half the risk of developing STDR (adjusted OR 0.43, 95% CI 0.26 to 0.71) and other forms of DR. Middle Eastern ethnicity

Table 2 Proportions of diabetic retinopathy (DR)

	Total	European	East Asian	Middle Eastern	South Asian	Oceanian	Other
N (%)	968 (100)	244 (25.2)	181 (18.6)	126 (13.0)	62 (6.4)	55 (5.6)	300 (31.2)
No DR (%)	462 (47.7)	111 (45.5)	112 (61.7)	57 (45.2)	28 (45.2)	3 (29.6)	138 (46.0)
Any DR (%)	506 (52.3)	133 (54.5)	69 (38.3)	69 (54.8)	34 (54.8)	3 (70.4)	162 (54.0)
Mild NPDR (%)	159 (16.4)	45 (18.6)	28 (15.6)	20 (15.8)	11 (17.7)	6 (11.1)	48 (15.9)
Moderate NPDR (%)	198 (20.4)	52 (21.3)	26 (14.4)	28 (22.2)	9 (14.5)	15 (27.8)	67 (22.2)
Severe NPDR (%)	64 (6.6)	18 (7.4)	7 (3.9)	7 (5.6)	8 (12.9)	6 (11.1)	18 (6.0)
PDR (%)	61 (6.3)	18 (7.4)	4 (2.2)	8 (6.4)	4 (6.5)	10 (18.5)	17 (5.6)
CSME (%)	191 (19.7)	45 (18.4)	17 (9.4)	32 (25.4)	19 (30.7)	15 (27.8)	63 (20.9)
OCT-DMO (%)	280 (28.9)	63 (25.9)	25 (13.7)	46 (36.6)	21 (33.9)	22 (38.5)	104 (34.6)
STDR (%)	305 (31.5)	74 (30.3)	29 (15.8)	47 (37.4)	20 (31.7)	27 (48.1)	106 (35.3)

STDR defined as presence of either severe NPDR or PDR or CSME or OCT-DMO.
CSME, clinically significant macular oedema; NPDR, non-proliferative DR; OCT-DMO, optical coherence tomography-defined diabetic macular oedema; PDR, proliferative DR; STDR, sight-threatening DR.

Table 3 Association between ethnicity and diabetic retinopathy (DR)

	Any DR	PDR	OCT-DMO	STDR
European	1.00	1.00	1.00	1.00
East Asian	0.52 (0.35 to 0.77)	0.29 (0.10 to 0.86)	0.45 (0.27 to 0.76)	0.43 (0.27 to 0.71)
Middle Eastern	1.01 (0.66 to 1.56)	0.85 (0.36 to 2.02)	1.65 (1.03 to 2.63)	1.37 (0.87 to 2.17)
South Asian	1.01 (0.58 to 1.78)	0.87 (0.28 to 2.66)	1.46 (0.80 to 2.67)	1.36 (0.76 to 2.43)
Oceanian	1.98 (1.05 to 3.74)	2.85 (1.24 to 6.60)	1.78 (0.95 to 3.35)	2.13 (1.16 to 3.92)
Others	0.98 (0.70 to 1.37)	0.75 (0.38 to 1.49)	1.51 (1.04 to 2.21)	1.26 (0.87 to 1.81)

ORs (95% CIs), expressed in comparison with the Europeans as a group. STDR defined as presence of either severe NPDR or PDR or CSME or OCT-DMO.
*Significant at the level of p<0.05.
CSME, clinically significant macular oedema; NPDR, non-proliferative DR; OCT-DMO, optical coherence tomography-defined diabetic macular oedema; PDR, proliferative DR; STDR, sight-threatening DR.

was associated with increased risk of OCT-DMO (adjusted OR 1.63, 95% CI 1.02 to 2.61) but not other forms of DR. South Asian ethnicity was not associated with higher rates of any form of DR compared with Europeans. Oceanian ethnicity was associated with twofold higher rates of any DR (adjusted OR 2.10, 95% CI 1.10 to 4.00) and all other forms of DR including STDR (adjusted OR 2.22, 95% CI 1.19 to 4.15). Duration of diabetes was independently associated with increased risk of any DR, OCT-DMO and STDR. Higher HbA1c was associated with higher rates of PDR and STDR, while higher systolic blood pressure was associated with increased rates of OCT-DMO. BMI and dyslipidaemia were not independently associated with higher rates of any DR or other forms of DR.

DISCUSSION

To our best knowledge, the LEADS is the first report of DR and DMO in a multiethnic Australian population. The survey found a high proportion of any DR (52.3%), PDR (6.3%), CSME (19.7%), OCT-DMO (28.9%) and STDR (31.5%) overall. The highest rates of any DR and STDR were in participants of Oceanian ethnicity (70.4% and 48.1%, respectively), while the lowest rates were in participants of East Asian ethnicity (38.3% and 15.8%, respectively). Rates of any DR and STDR in Europeans were mid-way at 54.5% and 30.3%, respectively.

The overall prevalence of any DR found in our study is close to that reported from similar clinic-based studies in Australia and overseas. For example, a 2013 Australian clinic study reported any DR prevalence of 59.4% in clinic participants,[9] while the 2017 population-based National Eye Health Survey found lower rates in the general population with self-reported diabetes of 28.5%.[6] Our main findings of differences in ethnic rates of DR are also consistent with overseas reports, where we found lower rates of any DR in Europeans and East Asians. For example, the US

Table 4 Independent predictors for diabetic retinopathy (DR) (adjusted in multivariable models for variables in the table below)

	Any DR	PDR	OCT-DMO	STDR
Ethnicity				
European	1.00	1.00	1.00	1.00
East Asian	0.50 (0.34 to 0.75)*	0.30 (0.10 to 0.80)*	0.44 (0.26 to 0.74)*	0.43 (0.26 to 0.71)*
Middle Eastern	1.00 (0.65 to 1.54)	0.86 (0.36 to 2.04)	1.63 (1.02 to 2.61)*	1.37 (0.87 to 2.17)
South Asian	1.01 (0.58 to 1.77)	0.88 (0.29 to 2.70)	1.46 (0.80 to 2.67)	1.35 (0.75 to 2.43)
Oceanian	2.10 (1.10 to 4.00)*	2.56 (1.09–6.00)*	1.96 (1.03 to 3.75)*	2.22 (1.19 to 4.15)*
Other	0.98 (0.69 to 1.38)	0.81 (0.40 to 1.62)	1.48 (1.01 to 2.17)*	1.26 (0.87 to 1.83)
Duration of diabetes (per 5 years)	1.81 (1.52 to 2.14)	1.29 (0.95 to 1.74)	1.21 (1.05 to 1.40)	1.26 (1.10 to 1.45)
HbA1c (per 1%)†	1.10 (0.98 to 1.23)	1.30 (1.03 to 1.64)	1.12 (0.99 to 1.26)	1.14 (1.00 to 1.30)
Systolic BP (per 10 mm Hg)	1.12 (0.99 to 1.27)	1.20 (0.87 to 1.64)	1.15 (1.02 to 1.31)	1.10 (0.98 to 1.23)
Body mass index	1.00 (0.98 to 1.01)	1.01 (0.98 to 1.05)	1.00 (0.98 to 1.02)	1.00 (0.98 to 1.02)
Dyslipidaemia	0.84 (0.64 to 1.11)	0.75 (0.44 to 1.30)	0.79 (0.58 to 1.07)	0.74 (0.55 to 1.00)

*Significant at the level of p<0.05.
†HbA1c data were only available for n=621 participants (64.2%).
BP, blood pressure; HbA1c, glycated haemoglobin; OCT-DMO, optical coherence tomography-defined diabetic macular oedema; PDR, proliferative DR; STDR, sight-threatening DR.

population-based MESA Study found white non-Hispanics (24.8%) and Chinese-Americans (25.7%) had lower rates of any DR than African-Americans (36.7%) and Hispanics (37.4%).[4] The Singapore population-based SEED Study found Indian Singaporeans (30.7%) had the highest rates of DR, followed by Chinese (26.2%) and Malay (25.5%) Singaporeans.[5] Our results are most similar to the clinic-based UK DRIVE Study where white Europeans (38.0%) had the lowest rates of any DR, followed by South Asians (42.3%), while African/Afro-Caribbeans (52.4%) had the highest prevalence of DR.[3]

OCT-DMO is a more accurate and objective measure of DMO than photographic CSME,[20] and our study is the first to report on OCT-DMO in a multiethnic population. This is significant as OCT-DMO is now recognised as the main cause of visual impairment in diabetic eye disease.[21] Our study found that the influence of ethnicity on rates of OCT-DMO is similar to the influence on any DR, with the highest proportion in Oceanians, followed by Middle Easterns, South Asians, Europeans and East Asians.

Relative to Australian Europeans, participants of Oceanian ethnicity had over twice the risk of having any DR, PDR, OCT-DMO and STDR. This suggests that there is a need for targeted screening of this at-risk group. Efforts similar to 'closing the gap' efforts to improve diabetic eye care in Indigenous Australians may be needed for participants of Oceanian ethnicity.

Independent modifiable predictive factors for any DR, OCT-DMO and PDR were longer duration of diabetes, higher HbA1c and higher blood pressure. Average HbA1c of 8.4% likely reflects the less well-controlled diabetes of patients referred from the local hospital endocrinology service. Ethnicity was another independent risk factor, but obviously cannot be modified. Ethnic differences in any DR rates persisted after adjusting for the above known risk factors, suggesting other factors may also play a role. Such ethnic-specific risk factors may include differential insulin resistance, variations in access to healthcare systems, dietary and lifestyle habits (eg, proportion of carbohydrates in diet, cultural attitudes to healthcare), genetic susceptibility and epigenetics.[3] Future studies may need to study these potential ethnic differences in greater detail. It is likely that the higher rates of DR in Oceanians are related to many of the same ethnic-specific factors that underlie the higher rates in Indigenous Australians,[22] such as low income, less access to quality food and diabetes medical care, and other culture-specific health behaviours. These areas may need to be studied further in order to reduce the gap in DR rates between different ethnic groups.

Strengths of the LEADS include the survey area with high diabetes prevalence and a multiethnic population. Participants were all surveyed with the same retinal photographic and SD-OCT equipment, and information on diabetic risk factors for multivariable analysis was collected. The mean age and gender distribution, glycaemic control and other risk factors in our study are similar to those from other Australian clinic cohorts of participants with diabetes,[9] suggesting our study population is representative and recruitment was not biased. The recruitment site is the only tertiary retinal clinic providing public diabetic eye care in the region. Healthcare for diabetic eye disease is provided at this clinic at no cost to patients. Healthcare costs are a barrier to accessing eye care,[23] and people on lower incomes from minority ethnic groups may be disproportionately affected. As this clinic is accessible to all patients regardless of income, we believe this would reduce any potential selection bias based on access. We reduced detection bias by using OCT as an objective measure of DMO. Limitations include the clinic-based nature of recruitment, consequently the proportions reported here are not applicable to the general population but only to participants presenting to eye clinics. Further, while this study considered rates of hypertension, dyslipidaemia and smoking status among its participants, it did not capture comorbidities such as microalbuminuria, which is often prevalent in individuals with Oceanian ethnicity.[24 25] Finally, HbA1c data were missing in 35.8% of the sample. Limiting analyses only to participants with the full dataset including HbA1c data did not change the findings materially, suggesting the data were likely missing at random.

Nonetheless, our available data are useful for planning service provision and in public health efforts to reduce blindness from diabetic eye disease. Another limitation is we did not collect data on the reasons for referral to the retinal clinic. This information would be useful in determining if there are differences in the way people from different ethnic groups access diabetic eye care services, and future studies could consider collecting these data. Finally, GLP-1 agonists have been linked with DMO,[26] but as only 30 subjects in our cohort were on GLP-1 agonists, we were not able to assess any association of GLP-1 agonists and DMO.

In summary, the LEADS of DR in a multiethnic Australian population found a high rate of any DR, OCT-DMO and STDR overall. Participants of Oceanian ethnicity had the highest proportions of any DR and STDR, with over twice the proportion in participants of European ethnicity. Our study demonstrated that in addition to traditional predictive factors for diabetic eye disease (duration of diabetes, HbA1c and blood pressure), ethnicity is also an independent risk factor. The high rates in Oceanians, even after accounting for known risk factors, suggest a need for targeted screening of this at-risk group.

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Contributors GL, VW, SO and I-VH conceived the hypotheses and study design. GL, VW, I-VH, MS, BM and TT collected the data. MS and GL performed the analyses. GL and VW wrote the first draft. GL, VW, SO, LMK, I-VH, MS, BM and TT reviewed and edited the final version. GL is responsible for the overall content as the guarantor.

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Patient consent for publication Not required.

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REFERENCES

1 Welfare AIoHa. Vision problems among older australians. 2019. Available: https://www.aihw.gov.au/getmedia/fc608984-1c92-48d0-b9fc-1ced9acec3ee/bulletin27.pdf.aspx?inline=true2019
2 Foreman J, Xie J, Keel S, *et al*. The prevalence and causes of vision loss in indigenous and non-indigenous australians: the national eye health survey. *Ophthalmology* 2017;124:1743–52.
3 Sivaprasad S, Gupta B, Gulliford MC, *et al*. Ethnic variation in the prevalence of visual impairment in people attending diabetic retinopathy screening in the United Kingdom (drive UK). *PLoS One* 2012;7:e39608.
4 Wong TY, Klein R, Islam FMA, *et al*. Diabetic retinopathy in a multi-ethnic cohort in the United States. *Am J Ophthalmol* 2006;141:446–55.
5 Tan GS, Gan A, Sabanayagam C, *et al*. Ethnic differences in the prevalence and risk factors of diabetic retinopathy: the singapore epidemiology of eye diseases study. *Ophthalmology* 2018;125:529–36.
6 Keel S, Xie J, Foreman J, *et al*. The prevalence of diabetic retinopathy in australian adults with self-reported diabetes: the national eye health survey. *Ophthalmology* 2017;124:977–84.
7 Liew G, Wong VW, Saw M, *et al*. Profile of a population-based diabetic macular oedema study: the liverpool eye and diabetes study (Sydney). *BMJ Open* 2019;9:e021884.
8 Australian Bureau of Statistics. 2011 census statistics. 2021. Available: http://www.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/POA2170?opendocument&navpos=220
9 Kaidonis G, Abhary S, Daniell M, *et al*. Genetic study of diabetic retinopathy: recruitment methodology and analysis of baseline characteristics. *Clin Exp Ophthalmol* 2014;42:486–93.
10 Australian Bureau of Statistics. Australian classification of cultural and ethnic groups. 2019. Available: https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1249.0Main+Features12019?OpenDocument
11 Stellingwerf C, Hardus PL, Hooymans JM. Two-field photography can identify patients with vision-threatening diabetic retinopathy: a screening approach in the primary care setting. *Diabetes Care* 2001;24:2086–90.
12 Scanlon PH. The English national screening programme for diabetic retinopathy 2003-2016. *Acta Diabetol* 2017;54:515–25.
13 Grading diabetic retinopathy from stereoscopic color fundus photographs--an extension of the modified airlie house classification. ETDRS report number 10. Early treatment diabetic retinopathy study research group. *Ophthalmology* 1991;98:786–806.
14 Bressler SB, Edwards AR, Chalam KV, *et al*. Reproducibility of spectral-domain optical coherence tomography retinal thickness measurements and conversion to equivalent time-domain metrics in diabetic macular edema. *JAMA Ophthalmol* 2014;132:1113–22.
15 Cruz-Herranz A, Balk LJ, Oberwahrenbrock T, *et al*. The Apostel recommendations for reporting quantitative optical coherence tomography studies. *Neurology* 2016;86:2303–9.
16 Wilkinson CP, Ferris FL, Klein RE, *et al*. Proposed international clinical diabetic retinopathy and diabetic macular edema disease severity scales. *Ophthalmology* 2003;110:1677–82.
17 Cheung N, Mitchell P, Wong TY. Diabetic retinopathy. *Lancet* 2010;376:124–36.
18 Sivaprasad S, Gupta B, Crosby-Nwaobi R, *et al*. Prevalence of diabetic retinopathy in various ethnic groups: a worldwide perspective. *Surv Ophthalmol* 2012;57:347–70.
19 Ding J, Wong TY. Current epidemiology of diabetic retinopathy and diabetic macular edema. *Curr Diab Rep* 2012;12:346–54.
20 Wang YT, Tadarati M, Wolfson Y, *et al*. Comparison of prevalence of diabetic macular edema based on monocular fundus photography vs optical coherence tomography. *JAMA Ophthalmol* 2016;134:222–8.
21 Tan GS, Cheung N, Simó R, *et al*. Diabetic macular oedema. *Lancet Diabetes Endocrinol* 2017;5:143–55.
22 Drinkwater JJ, Davis WA, Turner AW, *et al*. Differences in retinopathy prevalence and progression between anglo-celt and Aboriginal Australians: the Fremantle diabetes study phase II. *Intern Med J* 2022;52:590–8.
23 Chou C-F, Sherrod CE, Zhang X, *et al*. Barriers to eye care among people aged 40 years and older with diagnosed diabetes, 2006-2010. *Diabetes Care* 2014;37:180–8.
24 Shah K, Gandhi A, Natarajan S. Diabetic retinopathy awareness and associations with multiple comorbidities: insights from diamond study. *Indian J Endocrinol Metab* 2018;22:30–5.
25 Rowley KG, Iser DM, Best JD, *et al*. Albuminuria in Australian Aboriginal people: prevalence and associations with components of the metabolic syndrome. *Diabetologia* 2000;43:1397–403.
26 Saw M, Wong VW, Ho I-V, *et al*. New anti-hyperglycaemic agents for type 2 diabetes and their effects on diabetic retinopathy. *Eye (Lond)* 2019;33:1842–51.