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Diabetic retinopathy in a remote Indigenous primary healthcare population: a Central Australian diabetic retinopathy screening study in the Telehealth Eye and Associated Medical Services Network project

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What's new?

- Screening for diabetic retinopathy [DR] using a five-field imaging protocol performed by non-ophthalmic staff in a remote Indigenous primary-care clinic and certified non-clinician graders in an urban grading centre has not previously been undertaken.
- Prevalence of DR, especially sight-threatening DR, was higher than reported in previous Indigenous population-based and ophthalmic clinical studies.
- Impaired vision rates were more than double the 2016 non-Indigenous rates.
- One in four cases of sight-threatening DR was untreated.
- DR screening in a remote clinic for Indigenous Australians conducted by trained non-ophthalmic staff was clinically effective in the earlier detection of impaired vision, any DR and untreated sight-threatening DR.

Abstract

Aim To determine diabetic retinopathy prevalence and severity among remote Indigenous Australians.

Methods A cross-sectional diabetic retinopathy screening study of Indigenous adults with Type 2 diabetes was conducted by locally trained non-ophthalmic retinal imagers in a remote Aboriginal community-controlled primary healthcare clinic in Central Australia and certified non-ophthalmic graders in a retinal grading centre in Melbourne, Australia. The main outcome measure was prevalence of any diabetic retinopathy and sight-threatening diabetic retinopathy.

Results Among 301 participants (33% male), gradable image rates were 78.7% (*n* =237) for diabetic retinopathy and 83.1% (*n* =250) for diabetic macular oedema, and 77.7% (*n* =234) were gradable for both diabetic retinopathy and diabetic macular oedema. For the gradable subset, the median (range) age was 48 (19–86) years and known diabetes duration 9.0 (0–24) years. The prevalence of diabetic retinopathy was 47% (*n* =110) and for diabetic macular oedema it was 14.4% (*n* =36). In the fully gradable imaging studies, sight-threatening diabetic retinopathy prevalence was 16.2% (*n* =38): 14.1% (*n* =33) for clinically significant macular oedema, 1.3% (*n* =3) for proliferative diabetic retinopathy and 0.9% (*n* =2) for both. Sight-threatening diabetic retinopathy had been treated in 78% of detected cases.

Conclusions A novel telemedicine diabetic retinopathy screening service detected a higher prevalence of 'any' diabetic retinopathy and sight-threatening diabetic retinopathy in a remote

primary care setting than reported in earlier surveys among Indigenous and non-Indigenous populations. Whether the observed high prevalence of diabetic retinopathy was attributable to greater detection, increasing diabetic retinopathy prevalence, local factors, or a combination of these requires further investigation and, potentially, specific primary care guidelines for diabetic retinopathy management in remote Australia.

Clinical Trials registration number: Australia and New Zealand Clinical Trials Register (ANZCTR): ACTRN 12616000370404.

Introduction

Diabetic retinopathy (DR) is a major cause of vision loss, globally [1], and disproportionately affects vulnerable populations, such as those in low-income countries and Indigenous populations [2,3]. DR screening has been widely promoted for decades; however, adherence to recommendations remains suboptimal, particularly among those at higher risk of DR and vision loss [4–7].

Approaches that simultaneously target DR screening, eye disease management and service delivery may be more effective than those targeting eye care alone. One such example that incorporates a camera-based screening protocol (local retinal imaging, remote DR grading and quality assurance) has contributed to the reduction in diabetes-related blindness certifications in England and Wales so that DR is no longer the leading cause of blindness in working-age adults [8].

Telehealth, the provision of health-related services and information using telecommunication-based technologies, is under-utilized and has been adopted in few Australian government-funded initiatives. The primary exception is videoconference consultations between a specialist clinician and patient [9]. This is in stark contrast to the high uptake of mobile health by individuals, globally [10]. Consequently, we aimed to undertake telehealth-based DR screening to obtain DR prevalence data in a remote Indigenous primary care clinic in Central Australia to augment existing eye care practices. We hypothesized that a primary care camera-based screening service employing non-ophthalmic imagers and graders would provide data comparable with earlier population-based and ophthalmic clinical studies of DR prevalence among Indigenous Australians with diabetes.

Methods

Indigenous adults (age ≥18 years; *n*=301) with diagnosed Type 2 diabetes were recruited from a remote primary care clinic (Fig. 1), using both active and opportunistic recruitment methods. Sample size was calculated for the larger telehealth project, not specifically for the diabetic

retinopathy screening sub-study between 2014 and 2016, as previously published [11]. Consecutive patients were invited by study staff or referred by the treating clinician until the recruitment target of 300 was achieved. The main features of the DR screening were as follows: presenting vision was recorded, either unaided or aided. Dilating drops (one each of 1% tropicamide and 2.5% phenylephrine) were instilled by an experienced imager or clinician or by non-clinical or inexperienced imagers if clinical supervision was available, unless undilated pupils were large (≥ 4 mm) or mydriatic drops were contraindicated. Five 45-degree retinal fields and one anterior eye/external field per eye were imaged using a Canon CR-2 fundus camera. Image sets, automatically captured by the Global Retinal Imager software application, were securely transmitted as converted (DICOM) HL7 messages over a Secure Socket Layer encrypted tunnel to the Melbourne Centre for Eye Research Australia (CERA) server. DR was graded by CERA-certified imagers. Presence and number of retinal lesions underpinned a grading algorithm to obtain a preliminary DR grade, either accepted or modified by the grader who allocated a 'worse-eye' grade. Referral was based on the current National Health and Medical Research Council of Australia (NHMRC) guidelines for DR management [12]. An electronic report was securely transmitted to the primary care electronic health record system. The relevant clinician actioned the report based on the participant's prior ocular history.

Statistical analysis

Sociodemographic and clinical characteristics of the participants were obtained from clinical records and compared by using either independent *t*-tests for normally distributed continuous variables or non-parametric tests for non-normally distributed continuous variables, and chi-squared tests for categorical variables. ANOVA was used for between-group analyses. A calculated probability of $P< 0.05$ was considered statistically significant. The face validity of DR grade was assessed by examination of DR severity across tertiles of known diabetes duration. The association between DR, gradable studies and various exposures, including diabetes duration and screening characteristics, adjusted for age and gender, was assessed by using multivariable logistic regression to identify predictors of DR and gradable cases. Regression coefficients, 95% CIs and *P* values were used to evaluate these associations. Statistical analyses were conducted with IBM SPSS Statistics software (version 22).

Ethical considerations

The University of Melbourne and the Central Australian Human Research Ethics Committees approved the conduct of the present study. All participants provided written informed consent.

Results

Participants

The mean (range) age of screened participants was 48 (19–86) years. More women than men were screened (66.7% vs 33.3%; Table 1), and 79.9% of those screened were residents of Alice Springs.

Prevalence

In the subset gradable for DR, the prevalence of DR was 47% and the prevalence of proliferative DR (PDR) was 2.5% (Table 2). In the subset gradable for diabetic macular oedema (DMO), the prevalence of DMO was 14.4%. DR was present in all DMO cases gradable for DR and DMO. DMO was associated with both DR presence (P<0.0001) and stage (P<0.0001); that is, DMO was present in 0% of 'absent' DR, 4.4% of minimal DR, 47.1% of mild DR, 47.8% of moderate DR, 53.9% of severe non-proliferative DR, and 66.7% of proliferative DR (PDR) cases. In the subset gradable for both DR and DMO, the prevalence of sight-threatening DR (STDR) was 16.2%, comprising 14% clinically significant DMO, 1.3% PDR and 0.9% combined PDR and clinically significant DMO (Fig. 2). In the 76.9% (n =463) of gradable eyes, the most common non-DR findings were suspect optic disc appearance and cataract, with prevalence rates of 10% (n =46) and 6% (n =27), respectively.

Tertiary treatment coverage

Of the 35 cases with clinically significant DMO, 27 had already been treated, representing 77% treatment coverage (Table 2). Four of the five cases detected with PDR had been treated, representing 80% treatment coverage. Overall, SDTR treatment coverage was 78%.

Non-modifiable factors and the association with diabetic retinopathy

Duration of diabetes

The mean (95% CI; range) known diabetes duration was 8.6 (7.7–9.4; 0–24) years. The distribution was right-skewed; 24.8% of gradable DR cases had known diabetes for ≤3 years and 11% had known diabetes for ≤1 year. Diabetes duration was associated with DR and DR severity, as shown in Fig. 3. One in five people with newly diagnosed diabetes had DR.

Age at baseline and age at diabetes diagnosis

The mean (95% CI; range) age at baseline was 48.2 (46.7–49.7; 19–86) years, and the median age was 48.0 years. The mean (95% CI; range) age at diabetes diagnosis was 39.5 (38.0–41.0; 16–71) years. Age was not associated with DR (P=0.750), but younger age at diabetes diagnosis was associated with DR severity (P=0.046).

Demographics

Men and women had similar prevalence rates of DR (47.5% vs 43.4%; P=0.328) and DMO (13.5% vs 14.3%; P=0.567). Urban status (Alice Springs resident or not) was not associated with either DR (P=0.428) or DMO (P=0.486).

Protocol factors

Ungradable rate

The ungradable rates for DR, DMO and both were 21.3%, 16.9% and 22.3%, respectively. Of the ungradable eyes, 87% were attributable to technical error and 13% to media haze, mainly cataracts. The gradable and ungradable cases were associated with similar mean diabetes duration, but the ungradable group were on average 9 years older [mean (range) age 57.1 (54.0–60.3) years; $P<0.0001$], and were 7 years older at diabetes diagnosis [mean (range) age 47.0 (43.8–50.1) years; $P<0.0001$]. The presence of non-DR ocular findings was associated with a higher DR ungradable rate ($P<0.0001$) and older age at baseline (52.3 vs 47.4 years; $P=0.004$).

Pupil dilation

Opportunistic pharmacological dilation was used in 54% (n =162) of those screened. Pharmacological pupil dilation was associated with more gradable imaging studies ($P= 0.023$). Of the ungradable subset of cases, 68.8% were performed by less experienced imagers ($P=0.016$).

Imaging protocol

In a regression model of predictors of gradable studies, the full 10-retinal image protocol (completed in 72.5% of those screened) and pharmacological pupil dilation were associated with gradable imaging studies, after adjustment for participant age ($P<0.0001$ and $P=0.019$, respectively). In the subset gradable for DR, 82.6% underwent the full and 17.4% underwent a partial imaging protocol. Of the ungradable subset (consequently referred for a comprehensive dilated eye examination), 66.1% underwent a partial imaging protocol and 33.9% underwent the full imaging protocol ($P<0.001$).

Vision

Of 289 (96%) participants for whom vision data were available, the median (interquartile range) level of presenting binocular vision was 6/6 (6/6–6/9.5), and presenting binocular vision, which includes uncorrected refractive error, was 6/6 or better in 52.2% (n =104), 6/12 or better in 84.1% (n =196), 6/18 or better in 88.6% (n =256), worse than 6/18 in 11.4% (n =33), of which vision was 6/60 or worse in 2.1% (n =6). Overall, 4.5% of participants had mild visual impairment (presenting binocular vision worse than 6/12 to 6/18, inclusive), 11.4% had moderate to severe visual impairment (presenting binocular vision worse than 6/18 to 3/60, inclusive). None were blind (presenting binocular vision <3/60).

Discussion

The observed 47% DR and 16.2% STDR prevalence rates in the present study setting were higher than in previous DR studies in Indigenous populations (Table 3): in previous studies [2,13–22], the crude DR prevalence rate ranged between 16.8% and 43.5% and for STDR it ranged between 5.0% and 10.8%. DR prevalence rates in non-Indigenous population studies

were between 21.9 % and 36.4% [23]. The most recent Australian prevalence survey [2] reported prevalence in a non-Indigenous population of 28.5% for DR and 4.5% for STDR. A 2012 review of the global prevalence of DR, DMO and STDR reported rates of 34.6%, 6.8%, and 10.2%, respectively [24].

A range of factors may have contributed to study differences (Table 3). Variation in healthcare resources will have an impact on diabetes complication rates. Clinical populations generally report higher rates of a condition than surveys of the broader community. The clinic-based setting of the present study may have contributed to higher DR rates because of a higher referral rate to DR screening of those with less metabolically well-controlled or more complicated diabetes. Increases in life expectancy in the Indigenous population since 1998 will also contribute to the increase in prevalence rates.

Imaging protocols also vary among studies, resulting in differences in retinal area viewed, and therefore in DR detection. Methodological differences include minimum pupil size/dilation protocol, examiner or imager experience/expertise, number and size of imaged fields of view and imaging technology. Retinal coverage was greater in the present study than in other camera-based DR surveys because more 45-degree retinal fields of view were captured (five per eye) compared with one or two per eye in most other comparable studies (Table 3). This may have contributed to improved detection of DR, especially at earlier stages of DR. Of the participants with DR, 59% had minimal or mild DR. This is important because non-referable, non-STDR can be effectively managed by systemic risk factor control and monitored in primary care. Furthermore, 20% of those with newly diagnosed diabetes had DR, a similar rate to that reported in other studies [25]. This finding reconfirms the importance of DR screening at Type 2 diabetes diagnosis and indicates diabetes may have been present for years pre-diagnosis.

Until recently, only STDR was treated (with laser and/or intraocular injections of either anti-VEGF and/or corticosteroids) and only in a tertiary care setting; namely, ophthalmology clinics. Consequently, the main goal of DR screening programmes to date has been the early detection of STDR. Control of established risk factors, particularly hyperglycaemia and hypertension, has long been the mainstay of DR prevention and risk reduction [26] and this method was further validated in a subsequent epidemiological study [27]. Moreover, the Fenofibrate Intervention and Event Lowering in Diabetes and Action to Control Cardiovascular Risk in Diabetes Eye studies showed that medical management of non-STDR in Type 2 diabetes with oral fenofibrate reduced risk of DR and DMO progression to STDR by 37–49% [28,29] and oral fenofibrate is approved for use in Australians with Type 2 diabetes and existent DR. The current goal of DR screening, therefore, is to detect any retinopathy, that is, both non-STDR and STDR, as soon as possible. Timely treatment of all DR is now the best option for preventing vision loss in people

with diabetes. Increased national funding for diabetes-related eye examinations over the past decade has contributed to improved adherence rates to recommended eye examinations from 50% to almost 80% for non-Indigenous and from 20% to ~50% for Indigenous Australians [4]. In 2016 the Australian government extended benefits beyond existing ophthalmic services and funded the provision for retinal photography-based DR assessment in primary care and diabetes clinics [30]. This important initiative should further improve DR screening coverage, especially in primary care clinics in remote Australia.

Local factors may also have influenced DR prevalence rates; it has been suggested that in remote settings, healthier individuals may prefer to live in their communities, while those who are less well may need or prefer to be closer to healthcare services [17]. This may have contributed to the lower DR prevalence observed in an ocular health study in remote Central Australian Indigenous communities, which excluded Alice Springs residents. By contrast, 80% of those screened for DR in the present study were Alice Springs residents.

Diabetes duration was similar to that in previous Australian DR studies (Table 3), so a difference in known diabetes duration between studies could not explain the higher DR and STDR prevalence observed in the present study. As expected, DR prevalence was associated with known diabetes duration, such that the subgroup without DR had known diabetes for 6.5 years (95% CI 5.5–7.5) compared with 11.0 years (95% CI 9.9–11.2) for the DR subgroup.

Age-related factors were associated with DR prevalence: Indigenous participants were, on average, 10 years younger than in the recent National Eye Health Survey (48 vs 58 years), but had a higher prevalence of both DR and STDR. As younger age at diabetes diagnosis was associated with DR severity in the present survey, the wide age range of participants may have contributed to the observed higher prevalence of both any DR and STDR compared with DR surveys restricted to older Indigenous adults (Table 1). Consistent with the established epidemiology of DR, whereby one-third of those with DR have STDR [25], the high STDR rate detected in this population is in line with the correspondingly high DR prevalence. Importantly, the STDR treatment coverage is also high (77% for clinically significant DMO, 80% for PDR and 78% overall) and compares favourably with the recently published STDR treatment coverage rates for both Indigenous and non-Indigenous Australian populations (75% and 79%, respectively) [2].

Gender was associated with participation but not prevalence rates: as expected, DR and DMO prevalence rates were similar for Indigenous men and women in the present study; however, in contrast to DR studies in Australian non-Indigenous populations (Table 3), the male participation rate in the present DR survey was low (33%). As diabetes prevalence in Australia is

slightly higher among Indigenous women than men, lower diabetes prevalence may have contributed marginally to a lower male participation rate in the present study. Local and cultural factors may also be contributory: an Indigenous men's health clinic close to the general clinic may have affected the gender distribution in the general clinic where the DR screening took place. Table 1 shows that in the recent National Eye Health Survey [2], Indigenous male participation was generally relatively low (38%), as with earlier DR surveys in Indigenous populations (Table 1), suggesting other factors may influence Indigenous male participation in DR screening.

Gradable retinal image rates (79% for DR and 83% for DMO) were associated with greater imager experience, dilated pupils, better image quality and a completed multi-field imaging protocol, and were similar to the 84% reported in the recent clinical/hospital audit of one study, the Kimberley Diabetic Retinopathy Screening Program [19]. Consistent with our findings, previous studies that included mandatory pupil dilation/minimum pupil size and only qualified or experienced imagers or retinal examiners had even higher gradable rates of between 89% [17] and 93% [2]. Importantly, the federal funding for camera-based DR assessment in non-ophthalmic settings is only payable for a DR report based on gradable images. Ungradable cases require referral for a comprehensive eye examination, including pupil dilation. This avoidable referral represents a potential waste not only of finite primary care but also of limited remote eye service resources. Many people referred as a result of ungradable/failed DR screening will not have STDR, and those screening referrals of people with pathology and/or impaired vision, based on a gradable screening, may wait longer for comprehensive assessment and management. The inconvenience and increased burden caused by an ungradable/failed DR screening service may also deter some from returning for routine DR screening.

Strengths of the present study include clinically diagnosed diabetes status and type; DR studies based on self-reported diabetes tend to overestimate DR because of the 'missing' subgroup with undiagnosed diabetes. The wide participant age range is also a strength: Indigenous Australians have an increasingly younger age of Type 2 diabetes onset, which is associated with higher risk of both DR and STDR. In addition, our estimates of STDR and treatment coverage are likely to be accurate as the 'expected' STDR rate based on observed DR prevalence matched the 'observed' STDR rate, and we know laser was first-line therapy for STDR during the data collection period. Furthermore, the five-retinal field imaging protocol would have increased sensitivity for DR detection compared with other Indigenous DR imaging studies. Finally, a separate vascular risk factor study in this clinical population is underway and may provide some guidance for primary care regarding additional intervention strategies for reducing the risk of

DR, DMO and STDR beyond camera-based screening, fenofibrate and systemic risk factor control.

Limitations of the present study include the lack of stereoscopic retinal images and/or optical coherence tomography, which reduced the sensitivity of DMO detection. Consequently, early DMO was probably underdetected. A universal pupil dilation protocol would probably have reduced our ungradable rate. Furthermore, the presence of unmeasured confounders may have influenced our findings, including interactions between retinopathy risk factors, such as age and diabetes duration. A fellow manuscript will explore a range of factors, both established retinopathy risk factors and Indigenous-specific factors, that may contribute to a better understanding of the exposures potentially associated with the higher prevalence observed in this study.

Based on the present results and those of reviewed DR studies, future updates of Indigenous primary care guidelines and/or the 2008 Australian guidelines for clinical management of DR might consider specific recommendations for camera-based DR screening, including: evidence-based protocols for pupil dilation, initial and continuing imager and grader certification, minimum two-field (macular- and disc-centred) imaging for cameras with 60-degree or smaller fields of view and for continuous quality assurance. These are core elements of the camera-based DR screening programme that has contributed to a significant reduction in diabetes-related blindness certifications in England and Wales [8].

In conclusion, our survey findings highlight the clinical effectiveness of and need for telehealth DR screening in remote Australia to augment existing eye care services. The challenge going forward is to provide quality diabetes eye care that is affordable and accessible to the rapidly increasing number of Indigenous Australians with diabetes. Our telehealth-based DR screening model as described in the present report, specific to diabetes care in remote Australia, could be implemented widely. Pivotal to this process and to improving eye health and vision outcomes for people with diabetes in remote Australia is the need for an effective telehealth closed-loop image storage and communication platform between primary and ophthalmic care. Team-based diabetes care provides the best outcomes and should be embraced, underpinned by an expanding role for all primary care health professionals. If diabetes management in primary care is to achieve the benefits that DR research has made possible, DR must now be tackled at both the primary care and ophthalmic service levels.

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Competing interests

None declared.

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FIGURE 1 Flow diagram for participation in diabetic retinopathy screening study.

FIGURE 2 Prevalence of diabetic retinopathy (DR) and diabetic macular oedema (DMO), according to sight-threatening status. PDR, proliferative diabetic retinopathy.

FIGURE 3 Association between duration of diabetes and diabetic retinopathy (DR) stage. DMO, diabetic macular oedema; STDR sight-threatening diabetic retinopathy.

Table 1 Study and participant characteristics in Indigenous, non-Indigenous and global diabetic retinopathy surveys

	DR surveys in Australian Indigenous populations											Global and Australian DR surveys in non-Indigenous populations	
Study name	Present study: Telehealth Eye and Associated Services Network Study (TEAMSnet)	National Eye Health Survey (NEHS) Indigenous data only	Lions Outback Vision (LOV) DR screening program	Kimberley Diabetic Retinopathy Screening Program (KDRSP)	National Indigenous Eye Health Survey (NIEHS)	Central Australian Ocular Health Survey (CAOHS)	Goldfields Eye Health Survey (GEHS)	Darwin Region Urban Indigenous Diabetes (DRUID)	South Australian Eye Health Program (SAEHP)	Katherine Region DR Study (KRDRS)		National Eye Health Survey (NEHS) Non-Indigenous data	Global Diabetic Retinopathy Prevalence Study (GDRPS)
First author [reference no.]	Brazionis	Keel [2]	O'Halloran [20]	Moynihan [19]	Xie [22]	Landers [17]	Clark [13]	Maple-Brown [18]	Durkin [15]	Jaross [16]	Diamond [14]	Keel [2]	Yau [24]
Publication year	2017	2017	2017	2017	2011	2010	2010	2008	2006	2003	1998	2017	2012
Study data collection period	2014–2016	2015–2016	2014–2015	2010–2014	2008	2005–2008	1995–2007	2003–2005	1999–2004	1996	1995	2015–2016	2012
Location	Alice Springs, Central Australia	30 sites Australia-wide	Urban and remote Western Australia	Kimberley Region, Western Australia	30 sites Australia-wide	Central Australia [excluding Alice Springs]	Remote Western Australia	Darwin, Northern Territory	Remote South Australia	Katherine, Northern Territory	Pilbara, rural Western Australia	30 sites Australia-wide	US, Europe, Asia, Australia

Recruitment method	Primary care clinic-based survey	Population-based cluster sampling	Clinic-based survey	Retrospective audit of 17 sites - clinic, hospital, community	Population-based cluster sampling	Outreach eye clinic-based survey	Outreach eye clinic-based survey	Community-based survey	Clinic-based survey	Chronic disease register	Outreach eye clinic-based survey	Population-based cluster sampling	18 image-based population studies
Participant Number	301	645	222	723	393	1073	329	99	771	239	164	431	12,620
Diabetes status	Diagnosed	Self-reported	Diagnosed	Self-reported	Self-reported	Self-reported	Diagnosed	Diagnosed	Diagnosed	Diagnosed	Diagnosed	Self-reported	Variable
Diabetes duration (years)	9	13	n/a	n/a	11	–	–	8	–	–	8 (1-35)	10	8
Age target	≥18 years	≥40 years	n/a	n/a	≥40 years	≥20 years	All ages	≥15 years	≥15 years	All ages	≥16 years	≥50 years	20–79
Mean age (range/SD)	48 (19–86)	58 (10)	54 (18–84)	53	53	49 (20–93)	48 (16–89)	53	–	50 (16–94)	48 (16–81)	68 (9)	58 (3–97)
Gender (% male)	33	38	53	44	40	37	41	24	32	35	Not reported	57	48

DR, diabetic retinopathy.

Table 2 Diabetic retinopathy and maculopathy prevalence among Indigenous Australians with Type 2 diabetes attending a primary care clinic in remote Central Australia (*n* =301)

	DR grade by participant and eyes	
	Worse-eye* ***n* (%)**	**All gradable eyes** ***n* (%)**
DR severity level for gradable subset	237 (100)	447 (100)
1. DR absent	127 (53)	266 (60)
2. Minimal NPDR	47 (20)	71 (16)
3. Mild NPDR	18 (7.5)	35 (8)
4. Moderate NPDR	26 (11)	42 (9)
5. Severe NPDR	14 (6)	24 (5)
6. Proliferative without evidence of laser treatment	1 (0.5)	1 (0)
7. Proliferative with evidence of laser treatment	4 (2)	8 (2)
DMO severity level for gradable subset	250 (100)	465 (100)
1. Absent	214 (85.6)	413 (88)
2. Non-clinically significant	1 (0.4)	3 (1)
3. Clinically significant without evidence of laser treatment	8 (3.2)	12 (3)
4. Clinically significant with evidence of laser treatment	27 (10.8)	37 (8)
STDR for gradable subset (worse-eye)	234 (100)	

1. DR and DMO absent	126 (55.1)	
2. Non-STDR (NPDR and/or DMO present)	70 (30.8)	
3. STDR a) Clinically significant DMO	33 (14.1)	
b) PDR	3 (1.3)	
c) Clinically significant DMO and PDR	2 (0.9)	
Other findings for eyes gradable for non-retinal findings		463 (100)
1. Absent		341 (74)
2. Cataract		27 (6)
3. Optic disc appearance		46 (10)
4. Other		49 (10)

DMO diabetic maculopathy; DR diabetic retinopathy; NPDR non-proliferative diabetic retinopathy; PDR proliferative diabetic retinopathy; STDR sight-threatening diabetic retinopathy.

* Excludes all cases with ungradable eyes. These cases were subsequently referred for a full eye examination.

† Based on 2008 National Health and Medical Research Council of Australia Guidelines for the Management of Diabetic Retinopathy.

Table 3 Diabetic retinopathy prevalence and screening protocols in surveys of Indigenous Australians, non-Indigenous Australians and globally

	DR surveys in Australian Indigenous populations											Global and Australian DR surveys in non-Indigenous populations	
Study name	Present study: Telehealth Eye and Associated Services	National Eye Health Survey	Lions Outback Vision (LOV) DR screening	Kimberley Diabetic Retinopathy Screening	National Indigenous Eye Health Survey	Central Australian Ocular Health Study	Goldfields Eye Health Survey	Darwin Region Urban Indigenous	South Australian Eye Health Program	Katherine Region DR Study	Diamond and co-workers	National Eye Health Survey (NEHS) Non-	Global Diabetic Retinopathy Prevalence

	Network Study (TEAMSnet)	(NEHS) Indigenous data only	program	Program (KDRSP)	(NIEHS)	(CAOHS)	(GEHS)	Diabetes (DRUID)	(SAEHP)	(KRDRS)		Indigenous data	Study (GDRPS)
Prevalence of DR (% participants) ¶													
Any DR	47.0	43.5/39.4*	32.3	22.5	29.7	22.2	27.1	21	22.0	20.9	16.8 [eyes] ‡	28.5/28.5*	35.4
PDR	2.5	6.0/4.4*	1.4	0.4	3.1	2.8	0.9	–	5.4	1.3	-	1.5/1.5*	7.2
DMO	14.4	14.7/13.8*	12.0		8.9	5.3	14.3	–	6.5	10	-	5.5/5.1*	7.5
STDR	16.2	10.8/9.5*	5.0	5.1	11.1	7.0	15.2	–	11.9	11.7	10.7 eyes†	4.5/4.5*	11.7
DR screening protocols													
Screening Staff	Experienced and locally-trained imagers and remote graders	Eye health clinicians and CERA trained staff	Trained imagers and retinal graders	Trained imagers, Remote eye health graders	Eye health clinicians and CERA trained staff	Eye health clinicians	Eye health clinicians	Locally trained imagers and remote graders	Eye health clinicians	Eye health clinicians	Experienced ophthalmic photographer and clinician graders	Eye health clinicians and CERA trained staff	n/a
Grading	Fundus images	Fundus images	Fundus images	Fundus images	Fundus images	Clinical exam	Clinical exam	Fundus images	Clinical exam	Clinical exam	Polaroid photo and dilated exam	Fundus images	Fundus images
Images per eye	5	2	1	1	2	-	-	2	-	-	1	2	1 - 9
Pupil dilation protocol	Selective (authorized imager)	Selective	Selective (if <3mm pupil)	All eyes dilated	All eyes dilated	All eyes dilated	All eyes dilated	Selective (49%)	All eyes dilated	All eyes dilated	Selective for imaging only (n=136 eyes)	Selective	Variable

Gradable/Total screened cases	250/301DMO 237/301 DR	587/645 DMO 600/645 DR	69/80 DR -DRS 98/142 DR -OCT	719/868 DR	1073/1089DR	957/1073 DMO	n/a	87/99 DR	n/a	n/a	285/328 DR [n=eyes]	398/431 DMO 404/431 DR	n/a

CERA, Centre for Eye Research Australia; DMO diabetic macula oedema; DR diabetic retinopathy; DRS Diabetic retinopathy screening; n/a, not available; OCT, optical coherence tomography; PDR proliferative diabetic retinopathy; STDR, sight-threatening diabetic retinopathy (PDR and/or clinically significant DMO).

*Crude/age-standardized. †Detected from combined photos and clinical examination. ‡22.6% (74/328) eyes had diabetic retinopathy detected from combined photos and clinical examination, i.e. 19/328 missed by photos alone and 30/328 missed by ophthalmoscopy alone; §not applicable; ¶NEHS, NIEHS rates are age-adjusted. **DRS camera compared with Maestro Duo OCT-camera combination.

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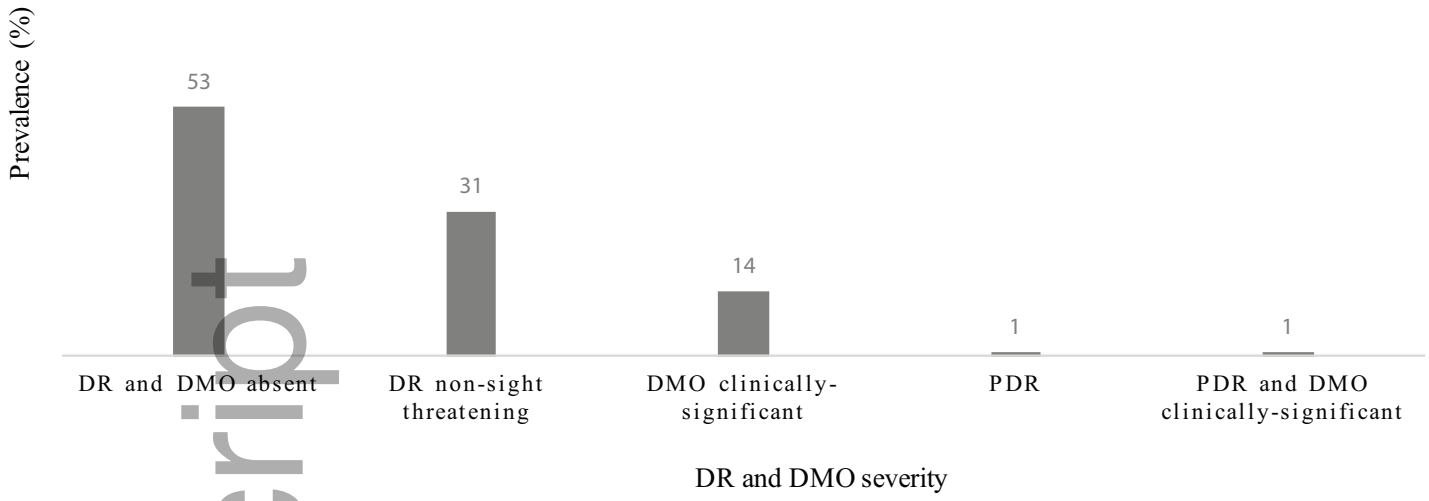

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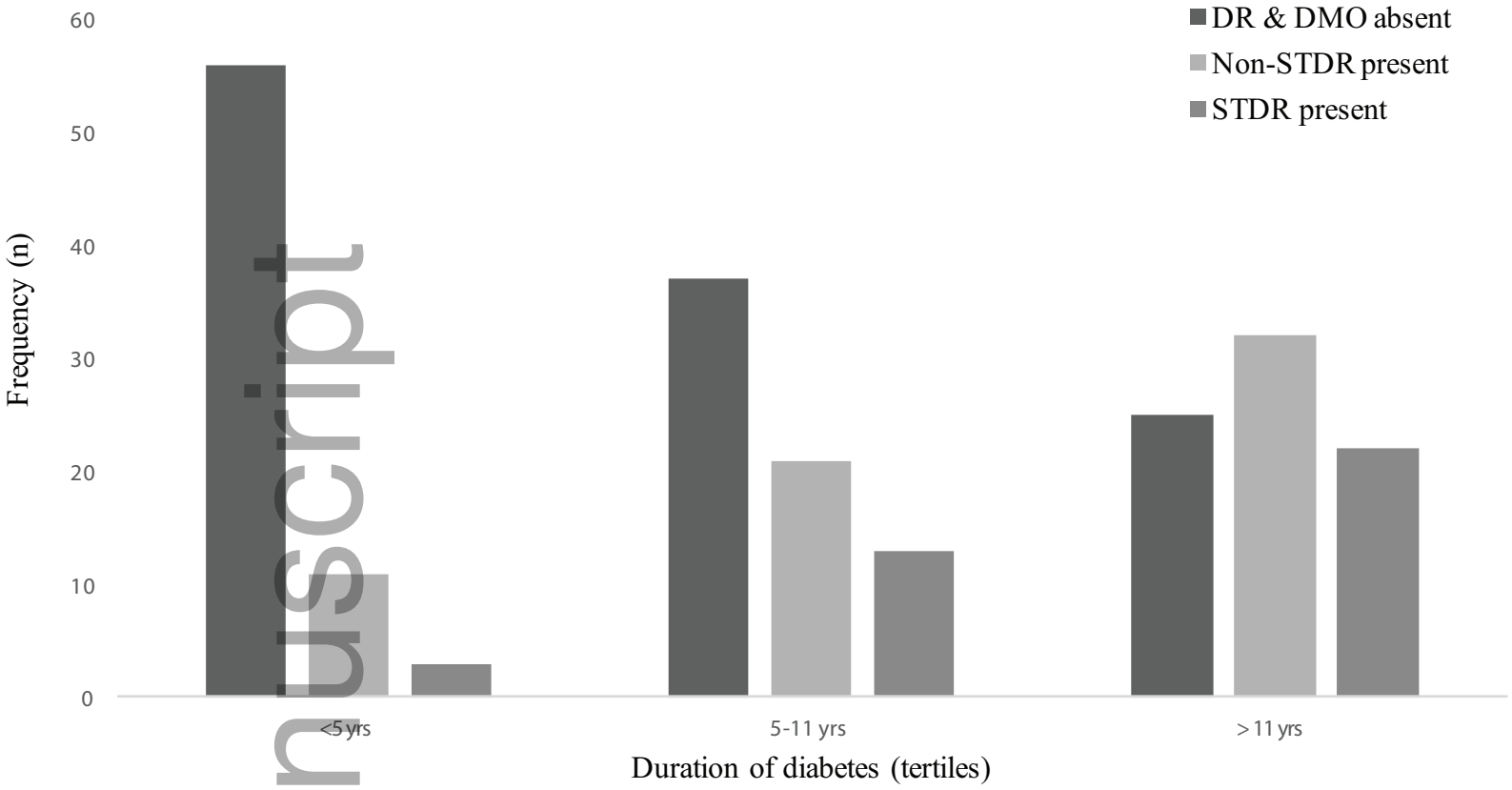

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