The Journal of Pacific Research

PHD PACIFIC HEALTH DIALOG

Original Research **OPEN ACCESS**

Engagement with Diabetes Retinal Screening: An analysis of secondary data from the Pacific Eye Institute in Suva

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ABSTRACT

Objective: Diabetic retinopathy (DR) is one of the primary causes of preventable vision loss and blindness. Diabetic retinopathy screening (DRS) is essential to detect microvascular damage to the retina; it can be performed in primary care or specialist eye health clinics. The system of referral, screening and treatment relies on an organised primary care referral pathway, accessible services and at least a basic level of health literacy among those living with or under threat of developing Diabetes Mellitus (DM).

Methods: Routinely collected patient data from the Pacific Eye Institute (PEI) in Fiji was analysed to describe a) clinical and demographic DR patient characteristics and b) characteristics of patients demonstrating higher clinic engagement (using multiple logistic regression)

Findings/Outcomes measure: Of 9287 patients who first attended the PEI for DRS between 2012 and 2017, 22% presented with sight-threatening diabetic retinopathy (STDR) in at least one eye. The average duration of DM was 3 years; self-reported glycaemic control was poor. Indo-Fijian or other ethnicity (both vs iTaukei, OR=2.30, 95%CI 1.96-2.70 and OR=2.18, 95% CI 1.63-2.92, respectively; p<0.001), high blood sugar (OR 1.39, 95%CI 1.10-1.75, p=0.006), longer duration of disease (OR=1.21, 95%CI 1.02-1.43, p=0.027), peripheral neuropathy (OR=1.43, 95%CI 1.24-1.65, p<0.001) and STDR (OR=3.30, 95%CI 2.78-3.92, p<0.001) were associated with greater odds of higher clinic engagement. Male gender (Odds Ratio (OR)=0.83, 95% Confidence Interval (CI) 0.72-0.95, p=0.006), younger or older age (both vs 40-70 years; <40 years, OR=0.48, 95%CI 0.37-0.63, ≥70 years OR=0.61, 95%CI 0.48-0.76, p<0.001), year of first clinic visit (2013 vs 2012 OR=0.58, 95%CI 0.50-0.69, p<0.001; 2014 vs 2012 OR=0.36, 95%CI 0.30-0.43, p<0.001) and moderate visual impairment (OR=0.67 95%CI 0.56-0.80, p<0.001) were associated with lower odds of high clinic engagement.

Conclusions: Our results identify patient groups that may be more vulnerable to lower engagement with eye health services. Increasing engagement may help reduce delays in screening and treatment. Given the projected continued rise in DM in the Pacific region, investing in robust electronic data systems that collect and connect public health and clinical data is imperative. Health literacy is important for the prevention of DM, timely DM diagnosis and screening for complications such as DR

Key words: Diabetes mellitus, Diabetic Retinopathy, Screening, engagement

INTRODUCTION

Diabetic Retinopathy (DR) is the most common microvascular complication of both Type 1 and Type 2 diabetes mellitus (DM). Global estimates of prevalence of DR suggest of among people living with diabetes, 34.6% have DR with around one in ten having sight-threatening DR (STDR).[1-3] To date, the most effective strategies to prevent DR and STDR come via public health approaches, including population level screening and diagnosis followed by appropriate treatment with laser photocoagulation or anti-VEGF (vascular endothelial growth factor) agents.[4]

However, diagnosis remains one of the major barriers to preventing vision loss from DR as the condition has few precipitating symptoms and disease progression is typically non-linear. Retinal screening is critical for expediting the detection of DR and initiating prevention efforts. In all settings, access to timely diagnosis and screening can be challenging; in low resource and remote settings these challenges are compounded. Chua *et al* [5] stress the importance of prevention of DR through effective referral and screening systems to quality, cost effective and acceptable treatment options.

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Rec: 28.04.2021 **Acc**: 01.12.2021 **Pub: 30.12.2021**

Citation: Cronin-Lampe J, *et al.* Engagement with Diabetes Retinal Screening: An analysis of secondary data from the Pacific Eye Institute in Suva *Pacific Health Dialog 2021; 21(8): 485-495.* DOI: 10.26635/phd.2021.141

Fiji faces a growing burden of non-communicable disease, with 40% of people over 40 years with diabetes.[6] In response to this need, the Pacific Eye Institute (PEI) established in 2006 delivers Pacific-led ophthalmology and specialist eye health training and eye health service delivery in partnership with the national Fiji Ministry of Health and Medical Services. The PEI provides end-to-end diabetic eye health services from the clinic base in Suva, Fiji, a mobile eye clinic and regional outreach clinics.

Key challenges to improving screening uptake in the Pacific Islands region are consistent with other low resource and remote settings. For eye health, a historical lack of trained eye specialists, a shortage of primary care level screening equipment and structural issues within a referral system are likely to contribute to late presentation at eye health clinics. Yet, the Pacific region benefits from investment in locally trained ophthalmologist and specialist eye care nurses.[7] The benefits of a strong primary care system, willingly utilised by a population, are undisputed.[8] Specialist services, such as anti-VEGF therapy or vitreo-retinal surgical services are currently unavailable in the Fiji public health system, therefore those with severe STDR face substantial out-of-pocket costs or must travel abroad for surgical intervention.[9] Timely diagnosis is therefore vital to enable utilisation of referral pathways to screening services and therapeutic interventions. An earlier study found that primary care doctors in Fiji tended to place a lower priority on eye health compared to other microvascular complications among their patients with diabetes.[6] Another study identified that despite rating eye health as a personal priority, few patients with diabetes actively engaged health care services. [10] According to the PEI screening guidelines, DR screening should be initiated at the time of diagnosis on Type 2 DM and at the time of puberty in Type 1 DM.[11] Regular yearly screening is recommended following diabetes diagnosis. Patients who do not attend clinic for initial appointments, or who fail to return as scheduled for subsequent screening, risk irreversible vision loss. The reasons for which patients do not attend clinics for initial or follow-up appointments is unclear, but this information is fundamental to improve engagement, build rapport and trust with the clinical teams to protect eye health for people living with diabetes.

We utilised routinely collected de-identified patient data from the Pacific Eye Institute in Suva between 2012 and 2017 to address the following aims: a) to describe the socio-demographic and clinical characteristics of people who present to the PEI for diabetic retinopathy screening and b) to describe the characteristics of those more likely to return for follow-up screening (higher clinic engagement).

METHODS

Clinical Processes

The PEI runs DRS in accordance with the Pacific guidelines New Zealand's National Diabetes Retinal Screening, Grading System and Referral Guidelines [11]. The application of standardised guidelines has been central to ensuring that service-delivery is consistent, evidence-based, and feasible for the health systems within the region.

The PEI screening programme consists of two clinics: the photo-monitoring clinic to screen new patients or those with no or minimal DR; and the Diabetes Eye Clinic (DEC) where ophthalmic examinations and consults take place for those with diagnosed DR. Referrals to the PEI come from a range of sources including; sub divisional health centres, local diabetes hubs, inpatient & outpatient hospital consults, private clinics, specialist outpatient departments, and self-referrals (walk-ins).

At the time of analysis, the PEI clinic had a daily schedule of up to 33 ophthalmic consults and 17 laser therapy sessions; photo-monitoring appointments are conducted depending on need (appointments and walk-ins), the percentage of attendees, and the number of staff available. Direct urgent referrals, such as those with low visual acuity or sudden vision loss, are given priority access to ophthalmic consults. When at operational capacity, the photo-monitoring suite triages patients based on severity. Although

there is no internal formal policy to send proactive reminders, where there is extra capacity, proactive reminders are delivered by telephone; with high-priority appointments being expedited.

Patients with a prior diagnosis of DR or who have formerly had laser therapy are recommended to have more frequent examinations based on the severity of the DR grade and other clinically relevant risk factors as determined by an ophthalmologist. In severe instances of STDR, individuals are booked in for laser therapy within a week. After examination and grading, patients are assigned a follow-up photo-monitoring (if they have minimal or no DR) or referred for an ophthalmic consult or treatment. As patients leave the clinic and a follow-up appointment is scheduled, they are given an appointment card specifying the date and time of their appointment. Depending on the appointment type, this could be scheduled up to a year in advance. As there is no formal policy canvassing proactive retrieval procedures, this appointment card is often the only pre-appointment reminder.

Screening

The PEI typically screens and grades DR using a non-mydriatic retinal camera as opposed to direct ophthalmoscopy or slit-lamp biomicroscopy through dilated pupils. Though relatively expensive, non-mydriatic retinal photography has many advantages for use in the Pacific Islands context. Firstly, as digital photography does not require mydriasis, the patient experience of frequent screening is reportedly less distressing, a factor that may diminish future barriers to screening. Secondly, the immediacy of the digital photographs enables clinicians to use them as a patient-education tool. Images can be referred to as clinicians discuss the results with patients, framing the communication process in a personalised way and aiding in effective knowledge transfer. Cataloguing photographs along with patient records in a repository also allows the PEI to keep a clean and objective history of grading that can be audited for quality assurance, screener performance, or used to map an individual's disease progression, regression, or their response to treatment.

Data Collection, management and cleaning

The PEI routinely collects and stores patient demographic and clinical data in a computerised database (**Table 1**). The PEI began to routinely collect referral source upon arrival to the clinic in 2017. Data required for this analysis was extracted from the clinical database and de-identified. Ethical approval to undertake the secondary data analysis was provided by the Fiji National Research Ethics Review Committee (ID: 2018.123.NW).

Patient data was extracted into Excel comprising 54 clinical and sociodemographic variables for 49,853 records from 13,463 individuals presenting to the clinic between 01 Jan 2012 to 31 Dec 2017. With consultation from the PEI, input errors and anomalies were corrected or removed from the dataset. Data quality differed across variables; more routinely collected data (such as patient gender, ethnicity or diabetes type) contained relatively few input errors and missing fields. Numerical variables such as duration of disease or random blood sugar level (non-fasted blood sugar level at the time of the appointment) contained more frequent input errors, inconsistent use of units and missing fields. Some variables (such as HbA1c) were not routinely collected, whilst others (such as referral source) were only collected for part of the study period. These variables were included in descriptive analysis, with the number of valid cases being the denominator for percentages and the missing cases noted. Patients are recorded as new or follow-up as they present to the clinic. To characterise the clinical severity and socio-demographics of newly presenting patients, and to measure their clinic engagement over time, records for any individuals who already had existing patient records were excluded, leaving 9287 new patients remaining for analysis.

Data Analysis

A descriptive analysis was first performed of all new patients presenting to the PEI between 2012 and 2017 (objective 1), including description of patient characteristics and variables related to patient disease and vision at the time of their first visit. Blood sugar level and HbA1c (%) were taken from a patients first visit. Continuous variables such as age, duration of disease, glycaemic control and visual impairment were categorised. Variables were summarised using counts and percentages. As DR grade and visual acuity were taken for each eye, these were re-coded to give an indication of the presence of visual impairment or STDR at the individual level, defined as the presence of DR grade ≥ R4 and/or a maculopathy grade of ≥ M3.

Panel data were analysed for individuals who first presented to the PEI between January of 2012 and December of 2017 to approximate patient retention (objective 2). The annual cohort size was calculated to give an indication of follow-up over time following the first appointment.

Table 1. Routinely collected data by the Pacific Eye Institute and collection methods

Variables	**Description and Collection Method**
Name, Age, Ethnicity, Gender & Address	Self-reported upon arrival to the clinic and entered into database as a health record.
New or Follow-up	Reception asked if the patient had attended the PEI before and search database for previous files.
Appointment type	Appointments were stratified by clinic into photo-monitoring, laser therapy or diabetes eye clinic. This will be determined either by source of referral or determined by resident ophthalmologist when organising a follow-up appointment.
Referral Source	Upon arrival the patient was asked about referral or where they heard about the service. Referral sources are entered as one of the following: Primary Health Centre, Diabetes Hub, In-patient, Outpatient, Private, SOPD or Walk-in.
Duration of Disease	Is the time elapsed since a formal diagnosis of diabetes and was gleaned from a patient's diabetes record book, or if they do not have one, self-reported.
Diabetes Type	Diabetes type is stratified into: Types I & II as well as gestational diabetes (GDM) and is ascertained from their diabetes record book or from the referrer.
Visual Acuity	Patient's visual acuity was determined using a Snellen chart at 'station one'. Unaided visual acuity was recorded in all individuals, whilst "best-corrected" pinhole acuity, was measured when unaided vision is less than 6/12. As per previous studies conducted at the PEI the visual acuity bands used were as follows: Good ≥ 6/18, Moderate 6/24-6/60, or Poor <6/60.
Presence of Comorbidities	This information is also collected in the visual acuity at station one. Individuals medical history are obtained from the patient's diabetes records by a nurse of eye health technician, or if the patient doesn't have one, are self-reported. The presence of neuropathy (stratified into peripheral, autonomic and amputation) and renal neuropathy is indicated by a 'Yes' or 'No/blank'.
Medication	Also gathered from the diabetes record book and/or self-reported at station 1. Medication use is stratified into tablet/metformin, insulin, diet-alone or non-compliant and an indication of use is given by 'yes' or 'no'.
Glucose control	Both glycaemic control and random blood sugar levels were routinely collected. The level of glycaemic control was taken from the patients last blood sugar reading in their diabetes record (either measured at home or at a health centre) and was defined as good (< 7.00 mmol/L), moderate(7-9 mmol/L) or poor (>9.1 mmol/L) based on current guidelines; 11mmol/L is the cut-off for a random sugar level. Random blood sugar levels conducted in the clinic were recorded as a separate variable. Though not routinely collected throughout the study period, many patients also had their HbA1c levels recorded as a percentage using DCCT (Diabetes Control and Complications Trial) units, providing a more robust surrogate marker of recent glycaemic control.
DR treatment history	The PEI database was searched for patient records specifying any previous DR therapy or diagnosis. In new patients this information was gained from the patients diabetes book or self-reported.

Clinic engagement, as measured by the total number of records in the database per individual, was summarised separately according to whether patients were first referred to the photo-monitoring clinic, the DEC or the laser therapy clinic. The photo-monitoring clinic is the feeder clinic to both DEC and the laser clinic, hence the majority of patients would be seen first in the photo-monitoring clinic. Any patients referred directly to the DEC or the laser clinic were likely to have advanced disease and therefore higher number of follow-up appointments. A subsample of patients first presenting for screening to the PEI photo-monitoring clinic between 2012 and 2014 was then defined in order to evaluate the total number of appointments being attended over the entire study period (to 2017), as a proxy measure for clinic engagement over time (objective 3). Restriction to individuals with their first appointment before the end of 2014 was to allow for sufficient follow up over time to assess compliance with the standardised Pacific guidelines for frequency of diabetes retinal screening. These clinical guidelines state that follow-up appointments should occur at least annually, therefore all individuals in this subsample had the capacity to generate four appointments or more. Patients that generated at least one record per year of follow-up on average over the study period were then coded into a 'higher-engagement' group, with the remaining classified as a 'lower-engagement' group. Patients first attending the PEI in 2012 were followed for 6 years and therefore required at least 6 records to be considered 'higher engagers'. For those with initial appointments in 2013 and 2014, at least 5 and 4 records, respectively, were required for 'higher engagers'. Chi-squared tests were used to assess univariate differences in the compositions of the two groups. Variables of interest were then included in a multiple adjusted logistic regression model and reported as odds-ratios (ORs) and 95% confidence intervals (CIs). Covariates that met statistical significance were added to the multiple logistic regression model in a stepwise manner until peak predictive power was reached.

Statistical significance was determined using a p-value < 0.05. SPSS software version 25 (SPSS Inc, Chicago, IL, USA) and Stata version 16 (StataCorp, College Station, TX, USA) were used for analyses.

RESULTS

Description of new patients first attending the clinic during the study period

Table 2 shows that of the 9287 new patients presenting to the PEI over the study period, a higher proportion were female (61% versus 39%). The average age was 56 years, with 13% of new patients being aged under 40 years. The majority of new patients reported being of Indo-Fijian ethnicity (62.4%), followed by the iTaukei (31%) and those of 'other' ethnicities (6.6%). The vast majority of new clinic attendees were referred to the photo-monitoring clinic for their first appointment (96.4%), with few patients being directly referred to the DEC (2.9%) or the laser therapy suite (0.5%). Type 2 DM was the most common presentation, followed by gestational diabetes (GDM) and then Type 1 DM (Table 2). Approximately 1 in 10 patients were recorded as not having DM, indicating issues with diagnosis and referral. In those who had HbA1c (%) measured (n=487), only 15.1% were below the recommended threshold of 7.0%. Nearly 4 in 10 individuals had a random blood sugar level of above 11 mmol/L, the cut-off for a diabetes diagnosis, highlighting the problem of hyperglycaemia in the study population. The median duration of disease was 3 years, however the distribution had a strong right-tailed skew with over a quarter of patients having a duration of above 10 years. Diabetes complications were reasonably common; 34.7% suffered from peripheral neuropathy, and over 300 patients had renal disease, suggesting these patients may be quite far along the disease progression curve upon attendance and thus at risk for STDR and subsequent vision loss. The majority of patients (90.5%) had their vision assessed at the time of their first visit, with 20.3% of these having at least moderately impaired vision.

Cohort retention

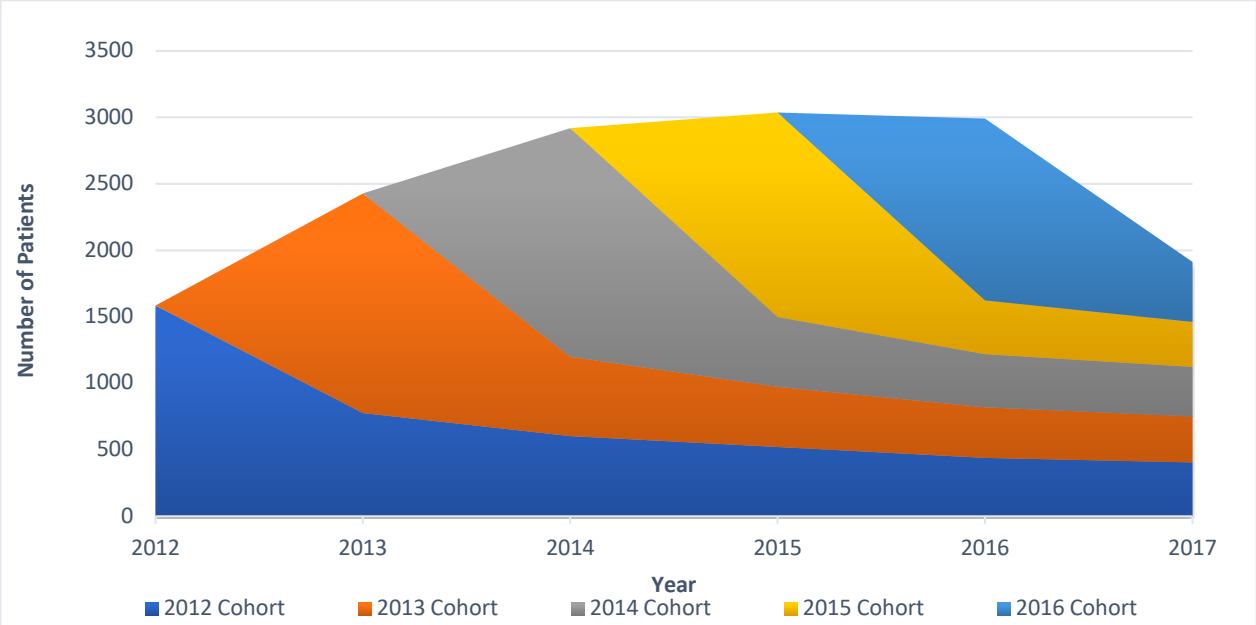
Figure 1 depicts the cohort retention over time for patients first attending a clinic between 2012 and 2016, showing a steady increase in the size of the study population over the study period, however with the contribution of each yearly cohort dropping throughout. For each year, Figure 1 shows a clear drop in patient retention after the first appointment, ranging from 20% to 30% depending on the year of first visit. For example, of those first attending a clinic in 2012, only 25.5% (n=404) returned for a clinic visit in 2017. Of those first attending clinic in 2012, only 34.3% (n=543) did not attend any further appointments in a later year, compared to 67% (n=917) of those first attending in 2016.

Table 2. Characteristics of 9,287 patients who first attended the PEI from 2012 to 2017

Characteristic	**Category**	**N patients (% valid)**	**N missing**
Gender	Female	5502 (60.9)	251
	Male	3534 (39.1)	
Age (years)	< 40	1197 (12.9)	0
	40-50	1555 (16.7)	
	50-60	3057 (32.9)	
	60-70	2369 (25.5)	
	70+	1109 (11.9)	
	Mean ± SD	*56.1 ± 14.8*	
Ethnicity	Indo-Fijian	5502 (62.4)	467
	iTaukei	2733 (31.0)	
	Other Pacific Islander	3 (0.0)	
	Other	582 (6.6)	
Clinic Type of first visit	Photo-monitoring	8,965 (96.4)	5
	Diabetes Eye Clinic	270 (2.9)	
	Laser	47 (0.5)	
Diabetes Type	No diabetes	952 (10.5)	210
	Type 1	214 (2.4)	
	Type 2	7334 (80.8)	
	GDM	577 (6.4)	
	Not Applicable	212 (2.9)	
Duration of Disease (years)	< 5	5180 (55.8)	9
	5 – 10	1760 (19.0)	
	10+	2338 (25.2)	
	Median (IQR)	*3 (0.9-10)*	
Medication	Tablets only	6990 (75.3)	0
	Insulin only	560 (6.0)	
	Tablets and insulin	153 (1.7)	
	None recorded	1584 (17.1)	
HbA1c (%)	< 6	20 (4.1)	8745
	6 – 7	54 (11.0)	
	7.00+	412 (84.8)	
	Mean ± SD	*9.53 ± 2.3*	
Random Blood Sugar (mmol/L)	< 7	799 (12.6)	2932
	7 – 11	3076 (48.4)	
	11+	2480 (39.0)	

	Median (IQR)	*10.4 (8-14)*	
Renal Disease	None	2678 (88.5)	6260
	Mild Nephropathy	299 (9.9)	
	Incipient Failure	18 (0.6)	
	Dialysis/Transplant	32 (1.1)	
Neuropathy	Peripheral	3218 (34.7)	
	Autonomic	7 (0.1)	
	Amputation	85 (0.9)	
	None/ missing	5977	
Visual Impairment at first visit	None/Minimal	6,696 (79.7)	882
	Moderate/worse (VA score ≤ 6/24)	1,709 (20.3)	
Total		**9287**	

Figure 1. Cohort retention for patients first attending a clinic between 2012 and 2016



Clinic engagement

Of the 1774 new arrivals in 2017, the two most common referral pathways were from primary health centres (32%) and walk-ins (31%). Tertiary care referrals accounted for approximately a quarter of all referrals, with 9% coming from in-patient clinics and 14% from out-patient clinics. The remaining referrals were from the diabetes hub (9%), specialist outpatient departments (3%) or private clinics (2%).

The number of clinic visits was assessed according to the type of clinic (e.g. photo monitoring, DEC, laser clinic). As the photo-monitoring clinic is the feeder clinic to both the DEC and the laser clinic, the majority of patients (96.4%) were seen first in the Photo-monitoring clinic. Any first appointments recorded as direct entries to the DEC (2.9%) or laser clinic (0.5%) would be following a referral from an ophthalmologist, who saw the patient in general eye clinic, discovered the advanced disease on eye examination in the general eye clinic and then decided to book the patient directly to Laser Clinic or Diabetes Eye Clinic. Since these patients would already have advanced disease, they would have needed multiple follow-ups. Indeed, amongst all patients attending the PEI between 2012 and 2017, those who first attended the laser clinic had the highest average number of total visits (median=6, IQR 3-11), followed by the

DEC (median=4, IQR 2-8) and the photo-monitoring clinic (median=2; IQR 1-3).

Of the 4,731 patients who first attended the photo-monitoring clinic of the PEI between 2012 and 2014, the average number of appointments over the study period was 2 (IQR 1-3 visits), the distribution of clinic engagement was non-normal with a strong right-skew. The expected number of appointments in congruence with DRS guidelines would be at least six for the 2012 cohort, five for the 2013 cohort and four for the 2014 cohort. In this subsample, only 24.9% of all new patients (n=1,178) attended at least the expected number of appointments according to the DRS guidelines and were classified for further analysis as "higher-engagers".

Table 3 presents results from the univariate and adjusted logistic regression evaluating the odds of 'high-engagement' according to different patient characteristics at the time of first visit. In univariate analysis, year of first visit, age at first appointment, ethnicity, STDR, duration of disease, blood sugar levels and peripheral neuropathy were all significantly associated with clinic engagement. There was no association by gender or visual impairment. In an adjusted logistic regression model, those with a first appointment in 2013 or 2014 had significantly lower odds of 'high-engagement' compared to those first attending the clinic in 2012. Males, those aged <40 or 70+ and those with at least moderate visual impairment were also significantly less likely to become 'high-engagers'. iTaukei patients had lower odds of engagement than Indo-Fijians or those of other ethnicities. On the other hand, the presence of STDR, longer durations of disease, higher random blood sugar levels and presence of peripheral neuropathy were all significantly associated with the likelihood of higher clinic engagement (**Table 3**). Although the multivariate logistic regression model was valuable in showing the differences in relative odds of engagement for these variables, the model showed some evidence of a poor goodness-of-fit (Hosmer-Lemeshow p=0.01) and had a Pseudo R2 coefficient of 0.112, indicating that the covariates in the model explained only a small degree of the overall variation in clinic engagement.

DISCUSSION & CONCLUSION

Our study describes the clinical and demographic characteristics of patients who attended the Pacific Eye Institute for DR screening between 2012 and 2017, their engagement with clinical services for screening and treatment of DR. The most common referral route was via primary health centres (32%) and walk-ins (31%). Tertiary care referrals followed by referrals from in-patient clinics and out-patient clinics; patients were less likely to be referred via the diabetes hub, specialist outpatient departments or private clinics. In a subsample of patients who first attended the photo-monitoring clinic of the PEI between 2012 and 2014, we found that younger or older age, with iTaukei ethnicity, later year of first clinic visit and moderate visual impairment were associated with lower odds of high clinic engagement. Those with higher odds of clinic engagement were also those with more symptoms, i.e. STDR/peripheral neuropathy, higher blood sugar and longer duration of disease. In addition, engagement with screening services declined for all over the study period.

Given the projected increase in DM in the Pacific Islands region, promoting the value of timely screening to avoid preventable visual impairment of blindness is warranted.[7] Yet, several factors are involved in this process. Building a robust, efficient and trusted primary health care sector, including DR screening services needs to be a priority for Fiji and other Pacific Island countries as part of wider efforts in promoting universal health coverage.[12] The cornerstone of UHC is an accessible and culturally responsive primary health system that facilitates referral pathways to specialist care. Our results describe the clinical and sociodemographic characteristics of high engagers (or conversely, low engagers). The referral pathway needs to be clear and unambiguous, stemming from and connecting back to the primary health care system. Importantly, for DR screening to be effective, patients need to perceive value from the effort required to attend appointments.[13] Future research may address perceptions of eye health, risk of developing DR and other factors that might be implicated in attendance for screening among users. Screening for DR is an evidence-based and cost-effective strategy to preserve vision and reduce the incalculable costs of preventable vision impairment and blindness.

While using routinely collected clinical data to address research questions has merit in terms of cost-effectiveness, there are limitations to this approach. As the data was collected by different clinical and administration staff over the time period there were coding irregularities.

Table 3. Comparisons of characteristics by level of clinic engagement (lower vs higher engagers) in 4,731 patients with their first clinic visit taking place at the photo-monitoring clinic between 2012 and 2014

Variable	**Category**	**N (%) 'higher engagers' 1,178 (24.9%)**	**Unadjusted P-value***	**Odds-Ratio for 'higher-engagement' (95% CI)**	**Adjusted P-value****
Year of first visit	2012	417 (28.5)	<0.001	Reference	
	2013	381 (23.8)		0.58 (0.50,0.69)	<0.001
	2014	380 (22.7)		0.36 (0.30,0.43)	<0.001
Gender	Female	704 (24.9)	0.681	Reference	
	Male	467 (25.3)		0.83 (0.72,0.95)	0.006
Age at first appointment (years)	< 40	62 (11.4)	<0.001	0.48 (0.37,0.63)	<0.001
	40-70	1016 (28.0)		Reference	
	70+	100 (18.1)		0.61 (0.48,0.76)	<0.001
Ethnicity	Indo-Fijian	871 (29.5)	<0.001	2.30 (1.96,2.70)	<0.001
	iTaukei	212 (14.8)		Reference	
	Other	88 (29.1)		2.18 (1.63,2.92)	<0.001
STDR	Absence	483 (18.3)	<0.001	Reference	
	Presence	518 (49.1)		3.30 (2.78,3.92)	<0.001
	Missing	*177 (17.0)*		*0.90 (0.75,1.07)*	*0.23*
Duration of disease (years)	<5	457 (18.9)	<0.001	Reference	.
	5-10	268 (28.1)		1.16 (0.97,1.38)	0.104
	10+	450 (33.3)		1.21 (1.02,1.43)	0.027
Random Blood Sugar (mmol/L)	<7.00	119 (20.7)	<0.001	Reference	
	7-11	365 (23.7)		1.21 (0.96,1.53)	0.114
	11.0+	461 (27.6)		1.39 (1.10,1.75)	0.006
	Missing	*233 (24.5)*		*1.45 (1.12,1.87)*	*0.005*
Peripheral Neuropathy	No	691 (22.1)	<0.001	Reference	
	Yes	481 (30.5)		1.43 (1.24,1.65)	<0.001
Visual Impairment	None/Minimal	777 (23.7)	0.080	Reference	
	Moderate/worse***	268 (26.4)		0.67 (0.56,0.80)	<0.001
	Missing	*466 (30.4)*		*1.28 (1.02,1.60)*	*0.035*

*High clinic engagement is defined as at least 1 visit per year on average over the potential follow-up time; *Unadjusted P-values are from chi-square tests; **Adjusted P-values from multiple logistic regression model including n=4,610. A complete case analysis was performed except for variables with >5% missing values, which were included in the model using a "missing" category.* ***Visual acuity score ≤ 6/24

Furthermore, as data collection and management has reflected the evolving needs and capacity of the PEI overtime, many variables of interest were incomplete or missing. For instance, we were not

able to account for patients in this sample who might have died during the study period. Information on HbA1c, which is representative of the overall glycaemic control, was also not collected due to the lack of HbA1c analysers in Fiji at this time (up until 2017). DR grade and visual acuity recorded for each eye were re-coded to provide a proxy measure of visual impairment or STDR at the individual level. This was defined as the presence of DR grade ≥ R4 and/or a maculopathy grade of ≥ M3. A simple M3 cannot generally be graded as STDR. However, M3 with clinically significant macular oedema (CSMO) is STDR. Unfortunately, CSMO was only recorded in the computer system (VIP.Net) at PEI from 2017 and was therefore not captured in any of our data. Investment in data systems are the backbone to quality healthcare; the advent of electronic data systems, for patient clinical data, referral processes and patient reminders is important to the provision of safe, accessible and equitable health care. Health information technology systems, if appropriate for the setting, user-friendly and are able to perform multiple tasks (for patient records and data extraction for research and evaluation) the value to clinical staff and patients can be significant. Our results demonstrate differences in engagement with eye health services between social demographic and clinical categories; these differences may have important clinical implications and yet are preventable. Locally driven research to examine indigenous models of eye health promotion would be valuable to underpin any initiatives aimed at promoting engagement with eye health services in Fiji.

Given the projected continued rise in DM in the Pacific region investing in robust electronic data systems that collect and connect public health and clinical data is imperative.[5] Our results indicate groups who are more vulnerable to lower engagement with eye health services. Delays in screening and treatment can be costly.[14] At another level, population-level health communications are also well recognised as a fundamental facet of a strong health system; increasing population health literacy regarding the importance of prevention of DM, timely DM diagnosis and screening for complications such as DR is essential.[15]

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