Appendix B. Patient-Related Factors and Adherence Characteristics

INTRODUCTION

In order to investigate the possible reasons for non-adherence of vision-threatening diabetic retinopathy (VTDR) patients to referral for specialty eye care, the correlates between patients' characteristics and their adherence status were tested. While there are only two published studies that have previously reported this[1,2], a number of others have looked at correlates to adherence to the recommended annual diabetic retinopathy screening (DRS) examination or subsequent follow-up screening.[3-9] It is likely that some of the same factors that correlate with adherence to DRS examinations, relate to keeping an Ophthalmology referral appointment as well. A summary of the findings in these studies are presented in Table B1.

Table B1. Summary of Published Studies on the Correlation of Adherence to Recommended Management and Selected Patient Characteristics.

PUBLICATION	END POINT	VARIABLES WITH SIGNIFICANT CORRELATION
Keenum [1]	Keeping first Ophthalmology appointment	Older age +; knowing HbA1c +; *agreeing to assistance making appt* -
van Dyck [2]	Specialty referral	Older age +; higher socioeconomic status +
Shi [3]	DRS	White race +; older age +; insured +; male +; education level +
Tannenbaum [4]	DRS	Age +; h*igh school degree compared to none*-; health insured +
Will [5]	DRS	Sev NPDR or PDR +; participation in diabetes educational program +
Lee [6]	DRS	Distance from care site -; public transport available +
Brechner [7]	DRS	Older age +; socioeconomic status +; attend diabetes education class +
Angermann [8]	Keeping follow-up appointment	Advanced age -
Murchison [9]	Repeat DRS	Severe DR +; severe DR and advanced age -; visual acuity impairment +; nonsmoking +; self-reported HbA1c, or blood sugar value in chart +; health insured +
Obeid [10]	Keeping follow-up appointments after treatment	Age +; race (white > non-white) +; adjusted gross income +

+ sign indicates increased adherence with increase in the variable; - sign indicates decreased adherence with an increase in the variable.
DRS, diabetic retinopathy screening; DR, diabetic retinopathy; NPDR, nonproliferative diabetic retinopathy; PDR, proliferative diabetic retinopathy

There were some consistencies among the studies. There is greater adherence among patients with:

older age (except for advanced age[8]); white race; worse retinopathy (unless coupled with advanced age)[9]; higher socioeconomic status; education factors (higher education level; attendance at diabetes education classes); health insurance. Occasional anomalous results were reported (italicized in Table B1): patients with a high school degree adhered less than those without a high school degree[4]; patients accepting help with making a referral appointment adhered less than those that refused the help.[1]

In the correlational analyses in the present study, we looked at many of the same variables as they related to keeping a first Ophthalmology appointment, and we included some characteristics of the health system as well.

METHODS

Data Selection and Covariates

Description of Variables, Data Sources and Data inclusion Criteria
The following list of demographic, biomedical, and health system factors were selected as variables, based primarily on the previously published studies in Table B1. The variables were collected mainly from the medical records (MRs): paper chart and/or electronic medical record (EMR). This was supplemented by information from the diabetic retinopathy screening database, collected by the photographer at the time of the screening or derived from the screening retinal image evaluation.[11] Two variables that were especially time-sensitive (HbA1c and health insurance status) were required to come from a clinic visit within a specified time from the date of the DRS for them to be included in the statistical calculation. (See 'Data Inclusion Criteria' in Table B2.)

Table B2. Description of Variables, Data Sources and Data Inclusion Criteria

VARIABLE	DESCRIPTION	DATA SOURCE		DATA INCLUSION CRITERIA
		Medical Record	Diabetic Retinopathy Screening Database	
Age	Age (years) at time of DRS (calculated from date of birth)	✓		
Gender	Binary Male/Female	✓		
Ethnicity	Latin American/ Hispanic; African-American/African descent; Caucasian/White, not Hispanic; Other	✓	✓	
Duration Diabetes	Years of known diabetes as of DRS date	✓	✓	
Insulin Taking	Yes/No	✓		

HbA1c	Result closest to date of DRS	✓		Measured within one year (+/-) of DRS date
Comorbidity	ICD-10 Codes; Closest to date of DRS	✓		Deyo-adapted[12] Charlson Comorbidity Score [13], excluding diabetes with or without complication
Retinopathy Severity	No retinopathy to moderate NPDR; Severe NPDR; PDR		✓	
Health Insurance Category	Insured (Medicare; MediCal; MISP; Private); Uninsured (no insurance; charity; self-pay) Unknown	✓		Documented within one year (+/-) of DRS date
Time Period for DRS and Medical Record Type	2012-2014: paper charts only 2015-2016: paper charts and EMR 2017{ EMR only)	✓		
Primary Care Site	Family Care Clinic; Internal Medicine Clinic; Satellite clinic	✓		

DRS, Diabetic Retinopathy Screening; MISP, Medically Indigent Services Program; ICD-10, International Classification of Diseases-10th Edition; EMR, Electronic Medical Record; HbA1c, Hemoglobin A1c; NPDR, non-proliferative diabetic retinopathy; PDR, proliferative diabetic retinopathy.

Statistical Analysis

Table B3 (below) lists the frequency distribution of patients' demographic and clinical characteristics by the status of keeping the first Ophthalmology appointment during the follow-up period documented by the chart review (hereafter designated the 'chart review period'). Chi square tests were performed to test the difference of characteristics by the status of adherence. The Cox proportional hazards model was fitted to examine the effect of covariates on the adherence. The event for the model was defined as keeping the first Ophthalmology appointment anytime during the entire chart review period. Patients who did not have Ophthalmology appointments were censored. Time-to-event was the number of days from the date of screening to the date of the first Ophthalmology appointment or number of days from the date of screening to the last chart review date. Adjusted hazard ratios for covariates are listed in Table B4. All statistical analyses were performed on SAS 9.4 (SAS Institute Cary, NC.). Statistical significance was set at $P<0.05$, using 2-tailed tests.

RESULTS

Bivariate Analysis of Patient Characteristics and the Status of Keeping the First Ophthalmology Appointment During the Chart Review Period

As reported in the main text of this publication, very few patients kept a first Ophthalmology appointments within the recommended referral interval. Table B3 shows the relationship of patient characteristics by the status of keeping the first Ophthalmology appointment, both for anytime during the follow-up period covered by the chart review (Outcome 1) as well as for within one year of the DRS (Outcome 2).

Table B3. Patient characteristics by the status of keeping the first Ophthalmology appointment.

Characteristics	All		Keeping the first ophthalmology appointment during follow up			Keeping the first ophthalmology appointment within one year after screening		
	n	Column %	n	Row %	p-value [a]	n	Row%	p-value [a]
Total	408	100.0	263	64.5		217	53.2	
Time period					0.0113			0.0908
2012-2014	147	36.0	83	56.5		70	47.6	
2015-2017	261	64.0	180	69.0		147	56.3	
Age group					0.5977			0.4312
18-49	145	35.5	97	66.9		82	56.6	
50-60	164	40.2	101	61.6		81	49.4	
60+	99	24.3	65	65.7		54	54.5	
Gender					0.1394			0.4237
Female	203	49.8	138	68.0		112	55.2	
Male	205	50.2	125	61.0		105	51.2	
Ethnicity					0.0004			0.0332
Non-Hispanic	114	27.9	58	50.9		51	44.7	
Hispanic	294	72.1	205	69.7		166	56.5	
Retinopathy severity					0.6495			0.1035
<SNPDR	210	51.5	131	62.4		104	49.5	
SNPDR	61	15.0	40	65.6		30	49.2	
PDR	137	33.6	92	67.2		83	60.6	
Clinically Significant Macular Edema					0.9231			0.3049
No	77	18.9	50	64.9		45	58.4	
Yes	331	81.1	213	64.4		172	52.0	
Comorbidity Index					0.0500			0.0039
0	351	86.0	219	62.4		176	50.1	
1+	52	12.7	39	75.0		36	69.2	
Unknown	5	1.2	5	100.0		5	100.0	
Primary Care site					0.0134			0.0077
Family Care Clinic	259	63.5	165	63.7		140	54.1	
Internal Medicine Clinic	112	27.5	81	72.3		66	58.9	
Satellite clinics	37	9.1	17	45.9		11	29.7	
Insulin use					0.6688			0.8173
No	120	29.4	74	61.7		61	50.8	
Yes	281	68.9	185	65.8		152	54.1	
Unknown	7	1.7	4	57.1		4	57.1	

Type of diabetes					0.5536			0.8529
I	24	5.9	13	54.2		12	50.0	
II	381	93.4	248	65.1		203	53.3	
Unknown	3	0.7	2	66.7		2	66.7	
Diabetes duration					0.2341			0.0409
0-5 yrs.	88	21.6	59	67.0		54	61.4	
6-10 yrs.	86	21.1	50	58.1		36	41.9	
10+ years	229	56.1	149	65.1		123	53.7	
Unknown	5	1.2	5	100.0		4	80.0	
HbA1C value					0.4838			0.7792
<6.0	15	3.7	9	60.0		7	46.7	
6.0-9.0	147	36.0	96	65.3		79	53.7	
>9.0	164	40.2	100	61.0		84	51.2	
Unknown	82	20.1	58	70.7		47	57.3	
Insurance category					0.7176			0.4741
Insured	223	54.7	147	65.9		123	55.2	
Uninsured (charity, self-pay, uninsured)	79	19.4	51	64.6		43	54.4	
Unknown	106	26.0	65	61.3		51	48.1	
Insurance type					0.1138			0.1304
Medicare	27	6.6	23	85.2		17	63.0	
MediCal	151	37.0	92	60.9		80	53.0	
Charity	3	0.7	3	100.0		3	100.0	
Self-pay/uninsured	76	18.6	48	63.2		40	52.6	
Unknown	106	26.0	65	61.3		51	48.1	
Private	6	1.5	3	50.0		1	16.7	
Medically Indigent Services Program	39	9.6	29	74.4		25	64.1	

SNPDR, severe non-proliferative diabetic retinopathy; PDR, proliferative diabetic retinopathy

[a] P-value from Chi square test or Fisher exact test for difference of patient characteristics by the status of keeping the first Ophthalmology appointment

For Outcome 1, there were 64.5% of patients who kept the first Ophthalmology appointment during the chart review period. In bivariate analysis for adherence and patient characteristics, patients screened in Time Period B had a higher adherence rate (69.0%) than those in Time Period A (56.5%) (p=0.0113). Other characteristics that were correlated with higher adherence rates were Hispanic ethnicity (69.7% vs 50.9% in non-Hispanic p=0.0004), and having one or more comorbid conditions (75.0% vs 62.4% among patient without any comorbid condition, p=0.05). Patients who visited Internal Medicine Clinics for Primary Care also had a higher adherence rate (72.3%) than patients who went to Family Care Clinic (63.7%) or other satellite clinics (45.9%) (p=0.0134). Insurance categories were not associated with adherence in bivariate analysis. The results for Outcome 2 were similar, except that the time period no longer reached statistical significance, and patients with diabetes duration of 0-5 years showed a higher adherence rate than patients with longer duration diabetes.

Multivariate Cox Model: Adjusted hazard ratio of patient characteristics for keeping the first Ophthalmology appointment during the chart review period

The results of a multivariate analysis of patient characteristics using a time-to-event model, where keeping a first Ophthalmology appointment anytime during the chart review period was the event, is shown in Table B4. The hazard ratio is the likelihood of the event occurring compared to the reference patient characteristic.

Table B4. Adjusted hazard ratio of patient characteristics for keeping the first Ophthalmology appointment during the chart review period.

Characteristics	Hazard ratio and 95% Confidence Interval			p value
Time period				
2012-2014		Ref		
2015-2017	1.40	1.05	1.87	0.023
Age group				
18-49		Ref		
50-60	0.85	0.64	1.12	0.2451
60+	0.90	0.65	1.25	0.5311
Gender				
Female		Ref		
Male	0.89	0.69	1.15	0.371
Ethnicity				
Non-Hispanic		Ref		
Hispanic	1.48	1.09	2.00	0.0122
Retinopathy Severity				
<SNPDR		Ref		
SNPDR	1.13	0.79	1.62	0.5195
PDR	1.47	1.11	1.95	0.0081
Comorbidity Index				
0		Ref		
1+	1.43	1.00	2.03	0.0481
Primary Care site				
Family Care Clinic		Ref		
Internal Medicine Clinic	1.17	0.89	1.54	0.2518
Satellite clinics	0.65	0.39	1.07	0.0907
Diabetes duration				
0-5 yrs.		Ref		
6-10 yrs.	0.68	0.46	1.00	0.048
10+ years	0.85	0.62	1.16	0.304
Unknown	1.19	0.46	3.06	0.714
Insurance category				
Insured	0.94	0.68	1.31	0.7107
Uninsured (charity, self-pay, uninsured)		Ref		
Unknown	0.84	0.58	1.23	0.3748

SNPDR, severe non-proliferative diabetic retinopathy; PDR, proliferative diabetic retinopathy.

The multivariate Cox model showed that patients who were in time period B were more likely to be adherent compared to patients in time period A (HR=1.40, 95% confidence interval (1.05, 1.87), p=0.023). Other covariates that were significantly associated with greater adherence were Hispanic patients, patients with proliferative diabetic retinopathy (compared to less than severe non-proliferative diabetic retinopathy), patients with one or more comorbid conditions (compared to no comorbid condition) and diabetes duration 0-5 years (compared to 6-10 years).

DISCUSSION

While previously published studies have reported on patient-related factors that correlate with whether individual patients adhere to diabetic retinopathy screening (DRS) recommendations[3-7, 9], only two prior studies[1,2] have reported on adherence to referrals from Primary Care clinics to Ophthalmology specialty care. This, of course, is a critical measure, since the success of most Primary Care-based telemedicine DRS programs depends on patients' attending specialty eye care after vision-threatening diabetic retinopathy (VTDR) has been detected by screening.

Because the present study began with patients screened from 2012-2014, when only paper charts were in use, but included patients screened from 2015-2017, when both paper charts and EMRs were in use, we were able to compare the adherence characteristics of patients from these two time periods. We found that among patients referred with VTDR, the likelihood of keeping a first Ophthalmology appointment during follow-up after screening was significantly higher in the later period, after adjustment by multivariate regression analysis. This was also borne out by the 'Time-to-Event' Kaplan Meier curves reported in the main text of this publication (See Figure 2).

Some of the differences that distinguish the earlier and later time periods are detailed in Table 1 of the main text. In the later time period, there were more patients in the older (60+) age group, a higher proportion of patients of Hispanic ethnicity, and a higher proportion of patients with PDR and those with health insurance. Of these variables, both Hispanic ethnicity and the presence of PDR were shown by multivariate Cox model regression analysis to independently relate to greater referral adherence. While previous publications have identified non-white patients as showing poorer adherence characteristics compared to white patients[1,10], in the present study setting, where the majority (72%) of all patients were Hispanic, adherence was greater among Hispanic compared to non-Hispanic patients; the latter included non-Hispanic whites, African Americans, and Asians.

The greater adherence among patients with more severe retinopathy found in the present study has also been previously reported for initial and for repeat diabetic retinopathy screening[5, 9]. The greater likelihood of visual impairment with worse retinopathy has been cited as a possible patient-motivating factor to explain this. In the present study, we did not have comprehensive data on patients' visual acuities or visual complaints. This would be important information to collect in future studies of this sort, and is now being routinely measured and collected during DRS in the Family Care Center at RUHS.

Patients with a comorbidity index of 1 or greater showed a higher adherence rate compared to those with an index of 0, both by bivariate and by multivariate regression analysis. This appears contrary to our previous findings in a qualitative ethnographic study of adherence to eye specialty referral, conducted, in part, on a sample from the same population as the present study.[14] In our previous study, comorbidity was cited by patients as a prominent barrier to keeping an Ophthalmology referral appointment. Both the competition for time by other specialty appointments as well as health-related disabilities were identified as contributing barriers. Conversely, one could argue that patients who are used to dealing with the complications of diabetes and with other life-threatening diseases might be more likely to take referral recommendations seriously. Also, the comorbidity index does not take into account non-life-threatening conditions, such as foot ulcers and clinical depression, that could contribute to non-adherence with recommended referral appointments. We did look for this in the study population, but found a relatively small number of patients with these conditions (3 with foot ulcer and 5 with clinical depression).

The higher proportion of patients with health insurance in the later time period, especially for MediCal, most likely reflects the expansion of Medicaid in California with the introduction of the Affordable Care Act during 2014.[15] This has been associated with increased access to and utilization of health care services.[15, 16] However, in the present study, health insurance was not significantly related to adherence, either in bivariate or in multivariate analyses. This suggests that having health insurance, by itself, is not sufficient to increase adherence to referral from Primary Care to Ophthalmology. A similar conclusion was reached with respect to screening for diabetic retinopathy[17] as well as for mammography and cervical cancer screening.[18]

We attempted to similarly analyze the adherence to follow-up Ophthalmology appointments after the first Ophthalmology appointment, but were hindered by the smaller sample size and selection bias. Only about half of the original study population could be included in the subset analysis. Also, for patients who were screened in the more recent years of the study, the follow-up times were not long enough to fully capture the course after the first Ophthalmology visit.

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