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Patterns of Teleretinal Diabetic Retinopathy Screening Completion at a Safety-Net Institution

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Abstract

Purpose: Diabetic Retinopathy (DR) is the most common microvascular complication of diabetes mellitus. Screening for DR and subsequent early intervention can reduce vision loss. We sought to evaluate differences between patients who completed Teleretinal Diabetic Retinopathy Screening (TDRS) and those who did not at a safety-net institution.

Methods: Retrospective chart review of patients eligible for TDRS at the safety-net institution Denver Health and Hospital Authority in Denver, Colorado from January 1, 2022 through December 31, 2022. The main outcome evaluated was completion of TDRS and associated demographic and clinical factors.

Results: A total of 8,031 patients qualified for TDRS, of which 42.9% completed screening. The total cohort was 56.6% female, 61.3% Hispanic, 38.4% had a primary language of Spanish, and the mean age was 57.3 (SD: 13.6). Significant factors associated with TDRS completion in multivariable analysis included Hispanic ethnicity (odds ratio [OR] 1.3, 95% CI 1.1-1.5, p=0.0006), Spanish as primary language (OR 1.5, CI 1.3-1.7, p<0.0001) and total number of Primary Care Provider (PCP) visits. Patients with inactivated patient portals (OR 0.64, 95%CI 0.48-0.84, p=0.0016) and those who were retired (OR 0.70, 95% CI 0.58-0.84, p<0.0001) or disabled (OR 0.84, 95% CI 0.71-0.99, p=0.0427) were associated with lower odds of completing screening. Age, sex, and insurance type were not significantly associated with TDRS completion.

Conclusions: The higher likelihood of Hispanic and Spanish-speaking patients completing TRDS in our study cohort are novel findings. TDRS may be a useful tool for improving DR screening compliance, particularly among specific patient populations.

Introduction

An estimated 37.3 million individuals in the United States have diabetes mellitus (DM) [1]. Diabetic Retinopathy (DR) is a common and potentially vision-threatening complication of DM; it is the leading cause of vision loss among working age adults [2,3]. Of diabetic adults 40 years and older in the United States, it is estimated close to one third have DR, and 4.4% have vision-threatening DR [4]. The likelihood of developing DR increases with disease duration [5]. The DR screening guidelines by the American Academy of Ophthalmology (AAO) and American Diabetes Association (ADA) recommend annual exams for individuals with diabetes, and up to biennial in those with good

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blood glucose control and no abnormal retinal findings [6]. With effective treatment, severe vision loss from DR can be reduced by 94% [7]. It is estimated that DR screening compliance by all diabetic patients in the United States would yield annual savings of $624 million United States dollars [8].

Despite the importance of screening, less than 60% of adults with DM in the United States completed an annual dilated eye exam in 2020, consistent with estimated screening rates of 50-60% in literature [8-10]. Barriers to screening include low socioeconomic status, limited health literacy, lack of transportation, and insufficient infrastructure (i.e. personnel, fundus cameras) [11,12]. Over the past decade, teleretinal screening has emerged as a promising DR screening modality. Non-mydriatic fundus cameras require little technical skill to operate, and photos can be evaluated remotely by an ophthalmologist, trained grader, or automated retinal image Analysis Systems (ARIAS) [13-15]. A report with recommendations to refer or observe is generated based on the Early Treatment Diabetic Retinopathy Study (ETDRS) definitions of nonproliferative and proliferative diabetic retinopathy as well as presence of diabetic maculopathy [16].

Teleretinal Diabetic Retinopathy Screening (TDRS) has shown high diagnostic accuracy for detecting any DR as well as referrable DR [17]. Further, implementation of TDRS in the primary care setting has improved DR screening among healthcare systems such as the Veterans Health Administration [18].

While outcomes of TDRS have been well-studied, data is still limited on patient compliance with TDRS [14,19-22]. Therefore, the present study aimed to evaluate differences between patients who completed TDRS and those who did not at a safety net institution. Denver Health and Hospital Authority is a fully integrated health care system that serves nearly a quarter of the residents of Denver, Colorado, which is among the top 20 most populous counties in the United States.

Methods

The present study was a retrospective Electronic Medical Record (EMR) review of patients who were eligible for TDRS at the Denver Health and Hospital Authority primary care clinics from January 1, 2022 through December 31, 2022. Demographic information as well as clinical metrics including Haemoglobin A1c (HbA1c) and total annual Primary Care Physician (PCP) encounters were recorded. Additionally, the Diabetes Composite Score (DCS) and Preventative Care Gap Score (PCGS) were available metrics and abstracted from the EMR. The DCS is a set of five diabetes treatment goals developed by Minnesota Community Measurement (MNCM), specifically blood pressure control, cholesterol control, blood glucose control, tobacco-free status, and aspirin if recommended [23]. The PCGS is an internal metric of how many of the nine preventative care screenings a patient has not completed (Supplementary table 1). Data was de-identified for statistical analyses. This study was deemed exempt by the Colorado Multiple Institutional Review Board (COMIRB #23-0228). The study complied with the tenets of the Declaration of Helsinki.

Inclusion criteria

The Epic electronic medical record system (Verona, WI, USA) was used to identify all adults who were eligible for TDRS within the Denver Health Medical System from January 1, 2022 through December 31, 2022. This cohort was designated by a Best Practice Advisory (BPA) criteria within the EMR. Eligible adults were those with DM not established with the eye clinic determined by no previous documented ophthalmic diagnosis in the EMR and no recorded eye exam in EMR within the past 12 months. The TDRS protocol in clinic is elaborated below.

Demographics

Patient age, sex, race, ethnicity, preferred language, insurance, and employment status were collected from the EMR. Sex, race, ethnicity and preferred language were self-reported. Sex was categorised as male or female; race as White or Caucasian, Black or African American, Asian, American Indian or Alaska Native or Other, with "Other" race being an option for the patient to self-identify. Employment status was self-reported as full time, part time, not employed, self-employed, retired, disabled or other. Type of insurance was categorised into commercial, Medicaid, Medicare, discounted care, or no insurance. Of note, discounted care in the category of insurance type refers to patients who receive Colorado Indigent Care Program (CICP) or Denver Health Financial Assistance Program (DFAP). These programs offer discounted care to low-income families at participating hospitals and clinics. They do not constitute forms of health insurance, but were grouped as an insurance type for statistical analysis. Clinical data including last HbA1c, DCS, PGCS, total primary care encounters, and patient portal status were recorded. Patient portal refers to the free online MyChart portal available to all patients. Status categories were comprised of activated, inactivated, not used, or patient declined.

Teleretinal imaging protocol

Patients who met aforementioned TDRS eligibility criteria have a best practice advisory generated in the electronic medical record upon presenting for their primary care visit at either the main campus or any of the nine satellite clinic locations. This notification alerts the Medical Assistant (MA) to complete screening as part of the work-up prior to the patient's encounter with their PCP. The BPA can be marked as completed by the MA if the screening is completed during that visit. If not completed, the BPA will be generated again at the patient's next PCP encounter. The primary care provider can also see the BPA recommendations specific to the visit. Images are acquired with the RetinaVue 700 non-mydriatic fundus camera (Welch Allyn, Inc, Skaneateles Falls, NY, USA) and are subsequently interpreted remotely by an ophthalmologist using the RetinaVue care delivery model. Results generally result within a few business days and appear in the patient's chart. The report summarises whether a referral is needed based on the findings. If a referral is warranted, it is placed by the PCP. Quarterly training was provided to medical staff on the use of the RetinaVue camera by a Welch-Allyn representative.

Statistical analysis

Statistical analysis was performed using SAS version 9.4 (SAS Institute Inc, Cary, NC, USA). The study cohort was stratified by TDRS completion or not. Basic frequencies and percentages were used to describe categorical variables, and the two groups were compared with the Pearson Chi-square test. Means and Standard Deviations (SD) were used to summarise age, in addition to median and range for continuous variables that were not normally distributed. Unpaired two-tailed t-tests were used for statistical comparisons for normally distributed continuous variables, and Wilcoxon rank-sum testing was used for continuous variables that were not normally distributed. Lastly, a multivariable logistic regression modelled with primary outcome of screened patients was conducted for variables that were sig-

nificant in univariate analysis. Odds ratios and 95% confidence intervals are presented for measures of association. A p-value <0.05 was considered statistically significant.

Results

A total of 8,031 patients qualified for TDRS, of which 3,447 (42.9%) completed screening (Table 1). Mean ages were similar between the screened and unscreened cohorts at 56.7±13.2 and 57.8±13.2 years old, respectively, although were statistically different. Both cohorts had a slight predominance of female patients and the entire cohort was 56.6% female. The screened cohort had a higher proportion of patients who self-identified as White or Caucasian and lower proportion of patients who self-identified as Black or African American compared to patients who did not complete screening. In terms of ethnicity, the screened cohort had a higher proportion of patients of Hispanic, Latinx or Spanish Origin ethnicity (hereafter referred to as Hispanic for brevity) (n=2,304, 66.8%) than the unscreened cohort (n=2,620, 57.2%), which was statistically significant (p<0.0001). The screened cohort had a higher proportion of patients who spoke Spanish as a primary language, 45.2% compared to 33.2% (p<0.0001). Patients who spoke languages other than English or Spanish totalled 621, or 7.7% of the total cohort and included 58 languages (Supplementary table 2). The group that completed screening also had fewer mean total primary care encounters, 1.5 (SD: 1.1) versus 1.9 (SD: 1.7, p<0.0001). While statistically significant, there were marginal differences in mean last HbA1c, DCS, and PCGS between the two cohorts (Table 2).

Multivariable analysis

Compared to the White or Caucasian patients, those who reported their race as Other were less likely to complete screening (odds ratio [OR] 0.78, 95% CI 0.68-0.99, p<0.0001, Table 3). This odds ratio is interpreted as patients with "Other" race had 22% lower odds of completing screening compared to White or Caucasian patients. Hispanic patients were more likely to complete screening (OR 1.28, CI 1.11-1.48, p=0.0006). Those whose primary language was Spanish or other non-English language were more likely to complete screening compared to English speakers (OR 1.45, CI 1.28-1.66, p<0.0001 and OR 1.27, CI 1.03-1.57, p=0.0276 respectively). Patients with more total primary care encounters were less likely to complete screening (OR 0.76, CI 0.73-0.79, p<0.0001). Patients with higher HbA1c and DCS were more likely to complete TDRS (OR 1.04, CI 1.01-1.06, p=0.0038 and OR 1.16, CI 1.10-1.22, p<0.0001, respectively). Patients with inactivated patient portal status were less likely to complete TDRS compared to patients with activated portals (OR 0.64, CI 0.48-0.84, p=0.0016). Compared to not-employed patients, those who were retired, disabled or with reported 'other' employment status were less likely to complete screening (OR 0.70, CI 0.58-0.84, p=0.0001; OR 0.84, CI 0.71-0.99, p=0.0427; OR 0.68, CI 0.49-0.93, p=0.0162, respectively). Lastly, variables that were not statistically significant in multivariable analysis included age, sex, insurance type and PCGS.

Table 1: Patient Demographics.

	Diabetic Retinopathy Screening		Completion Rate (%)	P value
	Screened	Unscreened		
Total	3447	4584	42.9	-
Age, years				**0.0004**
Mean (SD)	56.7 (13.2)	57.8 (13.9)		
Sex				
Male (%)	1491 (43.3)	1990 (43.4)	42.8	0.8905
Female (%)	1955 (56.7)	2593 (56.6)	43.0	
Not reported (%)	1 (0.0)	1 (0.0)	50.0	
Race				
White or Caucasian (%)	2231 (64.7)	2717 (59.3)	45.1	**<0.0001**
Black or African American (%)	439 (12.7)	800 (17.5)	35.4	
Asian (%)	148 (4.3)	160 (3.5)	48.1	
American Indian or Alaska Native (%)	30 (0.9)	49 (1.1)	38.0	
Other (%)	599 (17.4)	858 (18.7)	41.1	
Ethnicity				
Hispanic, Latinx, or Spanish Origin (%)	2304 (66.8)	2620 (57.2)	46.8	**<0.0001**
Not Hispanic, Latinx, or Spanish Origin (%)	1143 (33.2)	1964 (42.8)	36.8	
Primary Language				
English (%)	1612 (46.8)	2716 (59.2)	37.2	**<0.0001**
Spanish (%)	1559 (45.2)	1523 (33.2)	50.6	
Other (%)	276 (8.0)	345 (7.5)	44.4	
Insurance				
Commercial	457 (13.3)	633 (13.8)	41.9	**<0.0001**
Medicaid	1423 (41.3)	1857 (40.5)	43.4	
Medicare	904 (26.2)	1432 (31.2)	38.7	
Discounted Care*	525 (15.2)	496 (10.8)	51.4	
None	138 (4.0)	166 (3.6)	45.4	

Employment				
Full Time (%)	694 (20.1)	846 (18.5)	45.1	
Part Time (%)	265 (7.7)	312 (6.8)	45.9	
Not Employed (%)	1309 (38.0)	1487 (32.4)	46.8	
Self Employed (%)	101 (2.9)	117 (2.6)	46.3	**<0.0001**
Retired (%)	599 (17.4)	972 (21.2)	38.1	
Disabled (%)	410 (11.9)	730 (15.9)	36.0	
Other (%)	69 (2.0)	120 (2.6)	36.5	

Statistically significant different variables (p<0.05) are bolded
*patients who receive Colorado Indigent Care Program (CICP) or DFAP (Denver Health Financial Assistance Program). These programs offer discounted health care but are not health insurance
Demographics of patients eligible for TDRS grouped by screening completion status.

Table 2: Clinical Characteristics.

	Diabetic Retinopathy Screening		Completion Rate (%)	P value
	Screened	Unscreened		
Last HgbA1c, %				
Mean (SD)	7.7 (1.9)	7.6 (1.9)	-	**<0.0001**
Median	7.2	7.1		
Range	4.6-14.0	4.1-14.0		
Total Primary Care Encounters				
Mean (SD)	1.5 (1.1)	1.9 (1.7)	-	**<0.0001**
Median	1	1		
Range	1-19	1-25		
No PCP (%)	15 (0.4)	29 (0.6)	34.1	0.2354
Patient Portal Status				
Activated (%)	2446 (71.0)	3164 (69.0)	43.6	
Inactivated (%)	81 (2.3)	178 (3.9)	31.3	**0.0008**
Not Used (%)	848 (24.6)	1128 (24.6)	42.9	
Patient Declined (%)	72 (2.1)	114 (2.5)	38.7	
Diabetes Composite Score				
Mean (SD)	3.8 (0.98)	3.6 (1.0)	-	**<0.0001**
Median	4	4		
Range	0-5	0-5		
Preventative Care Gap Score				
Mean (SD)	3.3 (1.1)	3.4 (1.2)	-	**0.0085**
Median	3	3		
Range	0-7	0-7		

Statistically significant different variables (p<0.05) are bolded PCP, primary care physician
Clinical characteristics of patients eligible for TDRS grouped by screening completion status.

Table 3: Multivariable Analysis.

Variable	Odds Ratio (95% CI)	P-value
Age	1.0 (0.99-1.00)	0.6606
Gender		
Male	Reference	-
Female	0.96 (0.87-1.06)	0.4184
Race		
White or Caucasian	Reference	-
Black or African American	0.97 (0.83-1.14)	0.7266
Asian		
American Indian or Alaska Native	1.28 (0.96-1.69) 0.97 (0.61-1.54)	0.0897 0.8853
Other	**0.77 (0.68-0.88)**	<0.0001

Discussion

We found Hispanic patients were more likely to complete screening compared to White or Caucasian patients, as were patients whose primary language was Spanish compared to those whose primary language was English. This finding is in contrast to previous studies reporting lower rates of Hispanic patients completing DR exams [11,28]. Given the higher prevalence of DM and DR in Hispanic patients, completion of DR screening is critical to prevent vision loss [1,29,30]. To our knowledge, no studies have quantitatively compared TDRS adherence between Spanish-speaking and English-speaking individuals. One qualitative study noted that a barrier to DR screening among Spanish speakers was low perceived risk of vision loss, particularly when asymptomatic. The same study also reported that the majority of patients, regardless of language spoken, relied on healthcare

Ethnicity		
Hispanic, Latinx, or Spanish Origin	**1.28 (1.11-1.48)**	0.0006
Not Hispanic, Latinx, or Spanish Origin	Reference	-
Primary Language		
English	Reference	-
Spanish	**1.45 (1.28-1.66)**	<0.0001
Other	**1.27 (1.03-1.57)**	0.0276
Insurance		
Commercial	Reference	-
Medicaid	1.08 (0.93-1.25)	0.3339
Medicare	1.12 (0.93-1.35)	0.2330
Discounted Care	1.04 (0.86-1.26)	0.6499
None	0.88 (0.67-1.15)	0.3422
Employment		
Full Time	0.94 (0.82-1.08)	0.3749
Part Time	0.95 (0.79-1.14)	0.5749
Not Employed	Reference	-
Self Employed	1.02 (0.76-1.35)	0.9095
Retired	**0.70 (0.58-0.84)**	0.0001
Disabled	**0.84 (0.71-0.99)**	0.0427
Other	**0.68 (0.49-0.93)**	0.0162
Last HgbA1c, %	**1.04 (1.01-1.06)**	0.0038
Total Primary Care Encounters	**0.76 (0.73-0.79)**	<0.0001
Patient Portal Status		
Activated	Reference	-
Inactivated	**0.64 (0.48-0.84)**	0.0016
Not Used	0.91 (0.82-1.02)	0.1079
Patient Declined	0.99 (0.73-1.36)	0.9400
Diabetes Composite Score	**1.16 (1.10-1.22)**	<0.0001
Preventative Care Gap Score	0.97 (0.93-1.01)	0.0940

Statistically significant odds ratios (CI >1 or <1) are bolded

Multivariable analysis of patients eligible for TDRS with screening completion as reference.

system reminders for screening [31]. Thus, the external prompt from an MA at a routine PCP visit may be dually effective among Spanish-speaking patients – it both reinforces the risk of vision loss and serves as a reminder to complete screening. An additional factor in improved screening is that patients prefer racial/ethnic concordance with their providers [32]. In our study, it is possible that racial/ethnic concordance between patients and healthcare workers also contributed to the higher likelihood of TDRS completion among Hispanic patients. This correlation of provider concordance and patient compliance with DR screening has been noted by Ravindranath *et al [33]*. However, we did not capture data on MA ethnicity and languages spoken in this study and cannot confirm this theory. Given this data, TDRS may be a promising solution to help address the gap in DR screening among the Hispanic and non-English-speaking populations.

Overall, the TDRS completion rate of this study was 42.9%, lower than the national average of 58.3% [9]. Nevertheless, this rate is higher than the 33.9% reported for in-person diabetic retinopathy screening exam within a Missouri healthcare system serving a low-income metropolitan population [24]. While there is room for improvement, our study suggests there is utility for TRDS in the primary care setting. The protocol of completing TRDS as part of primary care encounters may help mitigate certain barriers to DR screening, such as time and transportation. Additionally, the screening is initiated by the MA rather than the patient, which can bypass the lack of awareness of DR and DR screening guidelines. Further, one of the most significant predictors for screening completion is physician recommendation [25]. It is possible that the recommendation by a MA, another individual within the healthcare system, may also have some positive effect, and reports of patient satisfaction with TDRS are well-documented in the literature [26,27]. However, its efficacy should ultimately be measured by its ability to trigger a successful referral to an ophthalmologist for monitoring and treatment where needed.

Another finding in this study was that patients with more total PCP encounters were less likely to complete TDRS. While this was statistically significant, it is important to note that the mean cumulative PCP encounters between the two groups was relatively similar (1.5 for the screened cohort vs. 1.9 for the unscreened). Thus, the clinical significance of this finding is limited. However, one theory for this difference may be that number of PCP encounters may be a proxy for health comorbidities. In patients with multiple chronic comorbidities in addition to DM, clinic visits may be streamlined to focus on these comorbidities rather than on TDRS.

While the screened cohort had a higher DCS (better) and a lower PCGS (better) than the unscreened cohort, the mean difference was 0.2 and 0.1 different, respectively. Thus, the clinical significance of this finding is limited. A similar scenario applies to patients with an inactivated patient portal status; only a small percentage of patients had inactivated patient portals, and thus the statistically significant odds ratio of 0.64 has limited clinical significance.

In multivariable analysis, retired patients were less likely to complete TDRS (OR 0.70). This is consistent with the mean age of the screened cohort being younger than the unscreened cohort. It is unclear what factors may explain this discrepancy; it is possible that as an older cohort, retired patients tend to have more complex comorbidities that require more time to address during primary care visits and thus leave less time for screening such as TDRS. Additionally, it may be possible that older patients prefer an in-person screening visit rather than undergoing tele-screening, particularly because that is what they have historically used. A prior study has noted that of patients who underwent TRDS, older patients were more likely to complete a subsequent ophthalmology referral visit if indicated [31].

While other studies have reported lack of insurance to be a barrier to DR screening completion, we did not find a difference in our study [11,28,34]. We suspect the reason for this is the integration of TDRS as part of the PCP encounter. Rather than making a separate appointment with additional associated costs, our patients could complete the screening in a single visit.

While capturing fundus photographs in the primary care setting helps remove barriers to screening, TDRS can pose challenges for clinic personnel. Non-mydriatic fundus cameras are designed to be easy to use, but staff may be limited by time or manpower to complete TDRS for all eligible patients. Moreover, the quality of the screening is limited by the quality of the photograph, which may itself be limited by many factors, including media opacity, fixation difficulty, and challenges with patient positioning. Additionally, there may be insufficient financial reimbursement in a capitated healthcare model to cover the cost of camera equipment, photo interpretation fees, and personnel [20].

Strengths and limitations

Study strengths include a large sample size within a safety-

net institution, allowing a robust assessment of TDRS in a population at high risk for complications of DR. This specific cohort, though, may not be representative of other populations, which limits the generalizability of our findings. Additionally, our reported screening rate does not capture patients who were willing to undergo screening but were not offered TDRS during their visit. Patients who were examined by an ophthalmologist or optometrist outside of the Denver Health System would still have been included in the BPA, many of whom would not participate in screening, which could artificially decrease the screening completion rate. Further, given the TDRS BPA is only generated for patients who present to clinic, our studied cohort is comprised of patients already seeking medical care. We acknowledge there is a separate cohort of patients that does not present for care and we therefore have limited insight into their motivation to complete screening.

Anecdotally, there has been relatively high turnover of medical assistants and insufficient staffing at the primary care centres which can translate to either lack of training or time to complete TDRS for every eligible patient. Additionally, patients themselves may decline screening due to lack of knowledge of screening guidelines for diabetic retinopathy [12], or perhaps to focus on a more pressing medical condition during their encounter. Lastly, at the time of the study, a BPA was not generated for diabetic patients with previous ocular diagnosis that had not had an ophthalmic exam in the last 12 months. While patients with existing ophthalmic conditions may need routine in-person ophthalmology clinic visits, a system-generated notification for patients whose last ophthalmic exam was over 12 months ago could help ensure DR screening compliance.

Conclusion

In this large study of TDRS completion at a safety-net institution, we report a completion rate of 42.9%. Age, sex, and insurance type were not significantly associated with TDRS completion. Patients who were of Hispanic ethnicity and primarily Spanish-speaking were more likely to complete TDRS, as were patients with fewer annual cumulative PCP encounters. These findings are novel and suggest TDRS may be a useful tool for improving DR screening compliance in historically underserved populations.

Author declarations

Declaration of conflicting interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethics approval statement

This study received ethical approval from the Colorado Multiple Institutional Review Board (COMIRB #23-0228) on February 23,2023. This is an IRB-approved retrospective study, all patient information was de-identified and patient consent was not required. Patient data will not be shared with third parties.

Data availability statement

The data that support the findings of this study are available from the corresponding author, HC, upon reasonable request.

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