

# Ocular screening adherence across Hispanic/Latino heritage groups with diabetes: results from the Ocular SOL ancillary to the Miami site of the Hispanic Community Health Study/Study of Latinos (HCHS/SOL)

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## ABSTRACT

**Objective:** The objective of this study was to examine the prevalence and correlates of ocular screening adherence among select Hispanics/Latinos living with diabetes.

**Research design and methods:** Data were obtained through an ancillary study of the Hispanic Community Health Study/Study of Latinos (Miami site). Participants included Hispanics/Latinos aged 40+ years who underwent a baseline examination/risk factor assessment (2008–2011) and then completed a survey on vision health/knowledge (conducted October 2011–September 2013; sample n=1235; diabetic subsample=264). The dependent variable was having a dilated eye examination within the past 12 months.

Covariate candidate selection for entry into sequential multivariable logistic regression models was guided by Anderson's Behavioral Model of Health Services Use and the Behavioral Model for Vulnerable Populations. **Results:** Participants aged 65+ were more likely to have dilated eye examinations (OR 2.62, 95% CI 1.22 to 5.60) compared with those aged 40–54 years. Participants less likely to have dilated examinations had a high school degree or general educational development (GED) (OR 0.30, 95% CI 0.10 to 0.96, compared to no degree) and those currently uninsured or never insured ((OR 0.34, 95% CI 0.14 to 0.83) and (OR 0.19, 95% CI 0.07 to 0.51)) compared to those currently insured. Participants who heard or saw something about eye health from two or more sources (eg, media outlets, doctor's office, relatives/friends) compared to those who reported no sources in the past 12 months were more likely to have a dilated eye examination (OR 2.82, 95% CI 1.26 to 6.28).

**Conclusions:** Lack of health insurance is strongly associated with low screening uptake in Hispanics/Latinos living with diabetes. Health promotion strategies stressing the importance of annual dilated eye examinations and increasing sources of information on eye health are other potential strategies to increase screening uptake in Hispanics/Latinos.

## Key messages

- Our results show poor adherence to ocular screening among Hispanics/Latinos with diabetes as well as poor awareness of the disease diabetic retinopathy.
- Lack of health insurance and underinsurance is strongly associated with low screening uptake in Hispanics/Latinos with diabetes.
- Greater exposure to sources of eye health information may be a predictor of having had a dilated eye examination in the past year among Hispanics/Latinos with diabetes.

## INTRODUCTION

The prevalence of diabetes mellitus has increased by roughly 75% in the past 20 years.<sup>1</sup> As more American adults live with diabetes, the incidence of complications from this condition is also increasing; these complications include diabetic retinopathy, the risk of which increases with the number of years living with this illness.<sup>2</sup> Diabetic retinopathy is a leading cause of blindness in the USA and can be particularly devastating if left undiagnosed and untreated. Vision-threatening diabetic retinopathy is preventable through strict blood sugar control; in addition, regular dilated eye examinations are essential to blindness prevention as they identify early disease that is more easily treated and results in better outcomes.<sup>2</sup> Management through injections, as well as laser and traditional surgery, is also critical to preventing progressive vision loss when diabetic retinopathy is present and may potentially restore vision in those who have sustained related complications. The American Academy of Ophthalmology and

the American Diabetes Association recommend annual dilated eye examinations for patients with type 1 and type 2 diabetes, while allowing less frequent examinations after several normal readings.<sup>3 4</sup> However, poor awareness of screening guidelines has been demonstrated among individuals living with diabetes with or without a diabetic retinopathy diagnosis.<sup>5</sup>

Hispanics/Latinos overall in the USA have a higher prevalence of diabetes (16.9%)<sup>6</sup> than non-Hispanic whites (10.2%)<sup>7</sup> and a slightly higher prevalence of prediabetes (38% and 35%, respectively),<sup>8</sup> although there is variability by Hispanic/Latino ethnicity.<sup>6</sup> Hispanics/Latinos with diabetes also have a higher prevalence of diabetic retinopathy than African-Americans and non-Hispanic whites.<sup>9 10</sup> Moreover, there is vast cultural heterogeneity among Hispanics/Latinos residing in the USA<sup>11</sup> including genetic diversity in diabetic retinopathy,<sup>10</sup> heritage as well as differences in how varying Hispanic/Latino populations process health-related communications given by healthcare providers.<sup>12</sup>

Ocular health, risk factors, and healthcare screening have been shown to impact overall health, functioning, and mortality among Hispanics/Latinos with diabetes.<sup>13–19</sup>

The National Eye Institute has funded several large epidemiologic studies of ocular health in those of Mexican heritage,<sup>20–23</sup> but to date there has not been a comprehensive evaluation of ocular health issues, including screening adherence, to improve the ocular health across all Hispanic/Latino populations with diabetes, and in particular seldom studied heritage groups, for example, Cubans and Central and South American Hispanics/Latinos.

The main objectives of this study were, first, to document the distribution of dilated ocular screening prevalence in less studied Hispanic/Latino heritage groups with and without diabetes; and second, to identify predisposing, enabling, need, and knowledge determinants associated with screening guideline adherence among those with diabetes.<sup>3 4</sup>

## RESEARCH DESIGN AND METHODS

### Sample

Data for our study were obtained through an ancillary study of the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). The HCHS/SOL is an ongoing multisite epidemiologic study of prevalence of and risk factors for disease among Hispanics/Latinos (<http://www.csc.unc.edu/hchs>). A detailed depiction of HCHS/SOL has been previously described.<sup>24</sup> There are a total of 4087 participants at the HCHS/SOL Miami site, and the ethnic background of the Miami site sample is 57% Cuban heritage, 26% Central American heritage, 12% South American heritage, 2% Puerto Rican heritage, 2% Dominican heritage, and 1% Mexican heritage. Participants in our ancillary study at the HCHS/SOL Miami site included Hispanics/Latinos aged 40 years and older who underwent a baseline clinical examination and

risk factors assessment in 2008–2011 and then completed our survey on vision health and knowledge of ocular disease (n=1235). Of eligible Miami sites participants, 43.4% completed our ocular health survey. This ancillary study, hereafter referred to as the Ocular Study of Latinos (Ocular SOL), was conducted between October 2011 and September 2013 and was comprised of a convenience sample of HCHS/SOL participants not previously enrolled in two other ancillary studies to the HCHS/SOL. After data collection, Ocular SOL data were merged with HCHS/SOL parent study baseline data to obtain additional demographic, clinical, and health-related variables. This study was approved by the HCHS/SOL publications committee and by the Institutional Review Board of the University of Miami.

### Variables

Unless otherwise noted, we employed variable definitions utilized in previous HCHS/SOL and Ocular SOL publications.<sup>6 25</sup> The outcome variable of interest was, ‘When was your last complete eye examination, one that included dilating your pupils, where the doctor used bright lights to look into the back of your eyes? This would have made you temporarily sensitive to bright light’. This variable was categorized as having had a dilated eye examination within the past 12 months (yes, no). Participants who were clinically diagnosed with diabetes and reported having had a dilated eye examination in the previous 12 months were considered adherent.<sup>3 4</sup> Our sample was stratified by diabetes status. Diabetes status was clinically determined at the baseline study, and based on the American Diabetes Association definition using serum glucose (controlling for length of fasting), post-oral glucose tolerance test glucose levels (if available), glycosylated hemoglobin percentages, and oral diabetic medication usage, diabetes status was a dichotomous variable (yes, no).<sup>26</sup>

For our models, we used Andersen’s Behavioral Model of Health Services Use<sup>27</sup> and the Behavioral Model for Vulnerable Populations,<sup>28</sup> both previously and similarly categorized in other HCHS/SOL analyses,<sup>25</sup> and knowledge of eye care, to determine the selection and retention of relevant covariates in the following categories: (1) predisposing factors (traditional), (2) predisposing factors (vulnerable), (3) enabling factors, (4) need factors, and (5) knowledge factors. Predisposing factors were considered non-modifiable, enabling factors characterized resources of participants, and need factors prodded participants toward healthcare use and behavioral change. Knowledge factors included knowing about eye care, sources of eye health information, diabetes status, and diabetic retinopathy. All five categories of independent variables were evaluated for their influence on adherence to dilated eye examination within the past 12 months.

### Traditional predisposing factors

Independent variables in the category included age (40–54, 55–64, 65+ years), gender (male and female),

Hispanic/Latino heritage (Cuban, Central/South American, Other), marital status (single, married or living with partner, and separated, divorced, or widowed), education (<high school (HS) degree or general educational development (GED), HS degree or GED, greater than HS degree), and employment (employed, retired and not currently employed, unemployed).

### Vulnerable predisposing factors

These independent variables included place of birth (USA born vs foreign born), years lived in USA ( $\leq 5$ , 6–14, 15+ years), and two subscales from a modified version of Short Acculturation Score for Hispanics/Latinos (SASH):<sup>29</sup> the SASH Language Use subscale, which assesses respondents' preferred language in various settings, and the SASH Ethnic Social Relations subscale, which assesses the ethnicity of people in respondents' social circles/interactions. The SASH subscales range from 1 (least acculturated) to 4 (most acculturated).

### Enabling factors

These independent variables included health insurance (currently insured, currently uninsured, never insured), vision insurance separate from health insurance (yes, no), income (<\$20 000, \$20 000–\$40 000, >\$40 000), difficulty communicating with healthcare provider in the past 12 months (yes, no, did not see provider in past 12 months), and inability to get needed healthcare in past 12 months due to cost (yes, no).

### Need factors

These independent variables included self-reported eyesight (excellent/good, fair, poor/very poor), National Eye Institute-Visual Functioning Questionnaire (NEI-VFQ) score,<sup>30</sup> mean SF-12v2 physical health score,<sup>31</sup> mean SF-12v2 mental health score,<sup>31</sup> mean of 6-item neurocognitive score,<sup>32</sup> mean word fluency score,<sup>32</sup> mean digital symbol score,<sup>32</sup> self-reported chronic diseases (none, one, two or more), smoking status (never, former, current), National Institute on Alcohol Abuse and Alcoholism (NIAAA) defined alcohol use (non-drinker, low-risk drinker, at-risk drinker), self-reported compliance with 2008 physical activity guidelines (yes, no), and mean glycosylated hemoglobin. The NEI-VFQ is a composite score comprised of 25 items that assess the impact of self-reported visual health on emotional well-being and social functioning.<sup>30</sup> The score is an average of the subscales within the 25 items and has a range of 0 (worst eye health) to 100 (best eye health). Self-rated general health from the HCHS/SOL baseline examination was used to calculate the general health subscale of the NEI-VFQ. One item of the vision-related mental health subscale of NEI-VFQ was not included in the calculation ('How much of the time do you worry about your eyesight') as it was omitted from the survey; the mental health subscale was,

therefore, averaged over the three existing mental health subscale items. This modification did not affect the total scoring of NEI-VFQ, and our NEI-VFQ scores are comparable with that of other studies.<sup>23–33</sup> The SF-12v2 physical and mental health scores are calculated from the 12-item surveys that measure self-reported functional health and well-being.<sup>31</sup> Scores are norm-based standardizations to a mean of 50 and an SD of 10. They range from 0 (poorest health) to 100 (best health).

### Knowledge factors

There were several independent variables included in the knowledge factors: participant knowledge of having a diabetes diagnosis (yes, if participant answered yes to 'Has a doctor ever said that you have diabetes (high sugar in blood or urine)?' AND if women answered no or there was missing information when asked the follow-up question, 'Was this during pregnancy only?', otherwise, no to knowledge of diabetes diagnosis). Other independent variables were the total number of all sources where individuals could have seen or heard about eye health or disease (specific sources asked to participants are listed in online supplementary table S1), with possible responses categorized as, have not heard or seen anything about eye health or disease, one source, or two or more sources; awareness of diabetic retinopathy (('Have you ever heard of an eye disease called diabetic retinopathy?' (yes, no/not sure)), and mean General Eye Knowledge Summary scale. The General Eye Knowledge Summary scale was created from participants in Ocular SOL who were administered a series of 14 questions about factors that may help prevent eye disease or preserve vision as identified in the research literature.<sup>34–35</sup> A principal components factor analysis with a varimax (orthogonal) rotation found eight items that loaded onto a single factor (Cronbach's  $\alpha$  internal consistency reliability=0.78). These items were based on the response to the following question: 'Which of the following help prevent eye disease and help preserve your vision?'. Responses were 'Seeing an eye doctor regularly', 'Not smoking', 'Controlling blood pressure', 'Controlling cholesterol', 'Wearing sunglasses', 'Eating dark green leafy and orange vegetables', 'Controlling blood sugar', and 'Avoiding becoming diabetic'. All questions had yes, no, or not sure as response options. The 'no' and 'not sure' items were combined. Items were summed to create the scale with scores ranging from 0 to 8 with 8 indicating greater knowledge.

### Statistical analysis

We used SAS V.9.3 (SAS Institute, Cary, North Carolina, USA) for all analyses and adjusted for the survey design. Descriptive analyses of participant data stratified by diabetes status were conducted to produce percent and SE for categorical variables and mean and SE for continuous variables. Multivariable logistic regression analyses with our binary outcome of interest were conducted to produce ORs and 95% CIs by adding the five categories

of variables in this block sequential order: (1) predisposing traditional factors, (2) predisposing vulnerable factors, (3) enabling factors, (4) need factors, and (5) ocular knowledge factors. Only variables significant at  $p < 0.2$  from each sequential model were retained in the subsequent block such that at model 5 only relevant predictors that were sequentially retained for analysis were presented for the final model; in the final model, only predictors significant at the  $p < 0.05$  level were retained. Owing to its clinical importance, we retained age throughout models 1–4 regardless of it breaching the 0.2 cut-off. In addition to being conceptually grounded, this sequential block approach is helpful with small samples as it allows us to evaluate these factors without examining complex models that produce small analytic cell sizes.

## RESULTS

Of the 1235 participants in the Ocular SOL, 264 (21.4%) had clinically confirmed diabetes and 971 (78.6%) did not have diabetes at baseline. Descriptive information of the predisposing (traditional and vulnerable), enabling, need, and knowledge factors of the study sample, stratified by diabetes status, is displayed in [table 1](#). The majority of participants with diabetes compared to those without diabetes self-reported having a dilated eye examination within the last 12 months (61.8% vs 36.5%). Participants with a diabetes diagnosis were more likely to be aged 65 and older (41.3% vs 12.9% no diabetes), employed (26.1% vs 10.2% no diabetes), and were more likely to have health insurance (67.9% vs 40.1% no diabetes); few in either group reported having separate vision insurance (11.5% vs 6.5% no diabetes). The majority of participants living with diabetes self-reported two or more chronic diseases (61.1% vs 13.0% no diabetes), were not alcohol drinkers (57.4% vs 39.7% no diabetes), did not meet 2008 physical activity guidelines (56.6% vs 43.4% no diabetes), and had not heard of diabetic retinopathy (53.3% vs 65.1% no diabetes). Only 58.7% of those with a clinically determined diagnosis of diabetes at baseline also self-reported diabetes status at the baseline examination.

Results of all multivariable logistic regression models predicting dilated eye examination in persons with diabetes within the past 12 months are depicted in [table 2](#). Regression coefficient estimates are presented only for independent variables significant at  $p < 0.2$  for the first five models and at the  $p < 0.05$  for the final model. In this final model, participants aged 65 years and older were more than 2.5 times as likely to have a dilated eye examination (OR 2.62, 95% CI 1.22 to 5.60) compared with those aged 40–54 years. Participants less likely to have a dilated eye examination included those with a high school degree or GED (OR 0.30 95% CI 0.10 to 0.96) compared to no degree and those currently uninsured or never insured ((OR, 0.34; 95% CI 0.14 to 0.83) and (OR, 0.19; 95% CI 0.07 to 0.51), respectively)

compared to those currently insured. Participants who heard or saw something about eye health from two or more sources in the past 12 months were more likely to have a dilated eye examination than those who did not hear or see any information (OR 2.82, 95% CI 1.26 to 6.28).

## CONCLUSIONS

This study builds on our previous broader investigation of healthcare utilization in the same population of Hispanic/Latino heritage groups for the following outcomes: (1) ever had an eye examination, (2) eye examination within the past 2 years, and (3) difficulty getting needed eye care in the past year.<sup>25</sup> The present multivariable analysis was limited to those living with diabetes. We demonstrated poor adherence with recommended ocular screening among Hispanics/Latinos with diabetes, one of the most important preventive measures against vision loss in diabetic retinopathy. Comparing Hispanics/Latinos with diabetes to those without diabetes, we found that the former group was much more likely to report having a dilated eye examination within the previous 12 months (61.8% vs 36.5%). While the finding that persons with diabetes had higher screening rates is encouraging, the fact that nearly 40% of those living with diabetes had not met the current diabetic screening guidelines is troubling because early diagnosis of retinal disease is more easily managed and treated than disease found in the later stages.

Furthermore, it should be noted that, with a signed release, selected results of participant baseline examinations were sent to the participants and their designated healthcare provider, which included notification of results suggestive of a diabetes diagnosis. Therefore, the overall post-baseline level of diabetes awareness in our sample theoretically should have increased as an unknown proportion of these participants would have sought follow-up care for their newly discovered diabetes. Moreover, since the follow-up ocular survey took place 1–2 years following the baseline examination, all of these newly diagnosed cases had adequate time to obtain a dilated eye examination. In addition, since 41.3% of persons who were clinically diagnosed with diabetes were apparently unaware of their disease at baseline, this speaks to a larger issue of general healthcare access and screening.

Post hoc analysis of adherence with dilated eye examination recommendations, stratified by awareness of diabetes diagnosis at baseline, demonstrated that despite being notified of their diabetes status after their baseline examination, only 26.4% reported a subsequent dilated eye examination by the time of Ocular SOL. This screening rate is far lower than for Ocular SOL participants who were aware of their diabetes status at baseline (68.7%). The need for dilated eye examinations in those newly diagnosed is paramount and should be immediately

**Table 1** Prevalence of dilated eye examination in the past 12 months by eye examination history and predisposing, enabling, need, and ocular knowledge factors of Ocular SOL participants by diabetes status

	No diabetes (N=971)			Diabetes (N=264)		
	n	%/Mean	SE*	n	%/Mean	SE*
Last complete dilated eye examination						
Within last 12 months	296	36.52	2.13	135	61.80	3.54
1–3 years ago	274	29.65	2.00	64	22.45	3.10
3–5 years ago	103	11.31	1.22	16	6.37	1.98
>5 years ago	151	17.77	1.60	21	6.49	1.33
Never	47	4.75	0.76	7	2.89	1.12
<i>Predisposing factors (traditional)</i>						
Age group (years)						
40–54	602	61.37	2.33	89	26.81	3.35
55–64	306	25.71	1.95	119	31.86	3.05
65+	63	12.92	1.62	56	41.33	4.38
Gender						
Women	606	54.44	1.77	151	49.48	3.80
Men	365	45.56	1.77	113	50.52	3.80
Hispanic Latino background						
Cuban	580	72.52	2.20	168	76.27	3.32
Central/South American	329	20.35	1.75	78	14.91	2.46
Other	62	7.13	1.21	18	8.82	2.44
Marital status						
Single	192	18.47	1.67	44	15.69	3.32
Married or living with partner	522	56.72	2.59	150	54.55	3.99
Separated, divorced, or widowed	256	24.81	1.77	67	29.75	3.50
Educational attainment						
No HS degree/GED	238	22.57	2.00	90	34.11	3.06
HS degree/GED	256	25.68	2.06	59	21.53	2.80
>HS degree/GED	477	51.75	2.24	113	44.36	3.30
Employment status						
Employed	63	10.20	1.46	45	26.08	4.31
Retired and not currently employed	418	41.08	2.00	139	46.86	3.90
Unemployed	489	48.72	1.85	79	27.06	3.58
<i>Predisposing factors (vulnerable)</i>						
Place of birth						
Foreign born	935	95.08	1.25	256	97.83	0.94
USA born (including territories)	36	4.92	1.25	6	2.17	0.94
Years lived in USA (among foreign born)						
≥5	263	30.26	2.20	52	19.72	3.12
6–15	356	34.85	1.96	90	32.91	4.36
>15	352	34.89	2.69	122	47.37	5.07
SASH Language Preference subscale	970	1.40	0.026	262	1.33	0.05
SASH Ethnic Social Relations subscale	889	1.97	0.023	239	1.96	0.04
<i>Enabling factors</i>						
Health insurance						
Currently insured	338	40.11	2.91	143	67.87	3.81
Currently uninsured	416	40.44	2.47	66	18.70	2.37
Never been insured	211	19.45	1.78	50	13.43	2.88
Type of health insurance						
Medicaid	27	3.91	1.11	15	5.09	1.73
Medicare	166	19.68	1.93	83	41.94	3.84
Private	141	15.62	2.20	42	19.04	3.79
Other insurance	4	0.52	0.33	3	0.98	0.58
None	633	60.27	2.90	121	32.95	3.90
Vision insurance (separate from health)						
Yes	52	6.52	1.32	22	11.54	3.08
No	913	93.48	1.32	242	88.46	3.08

Continued

Table 1 Continued

	No diabetes (N=971)			Diabetes (N=264)		
	n	%/Mean	SE*	n	%/Mean	SE*
Household income						
<\$20 000	517	56.20	2.54	153	64.20	4.06
\$20 001–\$40 000	262	30.31	2.11	66	29.22	3.79
>\$40 000	84	13.50	1.91	14	6.58	2.50
Difficulty communicating with a healthcare provider in the past 12 months						
No	350	37.96	2.65	145	59.34	4.33
Yes	38	3.42	0.75	16	5.97	1.95
Did not see provider past 12 months	583	58.62	2.84	103	34.69	4.54
Could not get needed healthcare in the previous 12 months because of cost						
No	813	83.99	1.86	228	90.76	2.10
Yes	158	16.01	1.86	36	9.24	2.10
<i>Need factors</i>						
Mean SF-12 Physical Health Score	953	49.88	0.44	257	43.63	0.94
Mean SF-12 Mental Health Score	953	49.49	0.45	257	47.90	1.03
6-Item Neurocognitive Score (continuous)	805	5.46	0.03	244	5.33	0.07
Word fluency score (continuous)	799	18.65	0.35	241	16.75	0.50
Digital symbol score (continuous)	790	34.59	0.66	239	29.28	0.75
Self-reported chronic diseases						
None	474	48.16	2.05	41	14.61	2.64
One	382	38.83	1.91	74	24.28	2.94
Two or more	115	13.01	1.42	149	61.11	3.36
Smoking status						
Never	513	52.43	1.97	130	49.47	4.06
Former	227	22.66	1.75	85	35.44	3.46
Current	227	24.91	2.07	47	15.09	2.19
NIAAA risky alcohol use						
Non-drinker	335	39.69	2.17	116	57.37	4.39
Low-risk drinker	385	53.87	2.23	69	38.63	4.54
At-risk drinker	47	6.44	1.17	10	4.00	1.34
Meets 2008 physical activity guidelines						
No	420	43.41	1.79	136	56.59	3.42
Yes	550	56.59	1.79	126	43.41	3.42
HbA1C (continuous)	965	37.08	0.18	262	56.09	1.53
Self-reported visual impairment						
Excellent/good	493	53.23	2.06	147	58.13	4.43
Fair	391	37.42	2.03	90	32.60	4.04
Poor/very poor	86	9.34	1.18	26	9.27	1.96
NEI-VFQ composite score	971	86.62	0.77	264	84.05	1.07
<i>Ocular knowledge factors</i>						
Self-reported diabetes status at baseline examination						
No	961	98.91	0.40	117	41.34	3.39
Yes	9	1.09	0.40	145	58.66	3.39
General eye knowledge summary scale	971	6.88	0.06	264	6.92	0.12
Heard/seen something about eye health past 12 months from various sources						
No sources	292	29.96	1.89	68	27.67	3.26
One source	362	35.52	1.96	94	34.98	3.44
Two or more sources	317	34.52	2.28	100	37.36	3.53
Heard of diabetic retinopathy						
Yes	318	34.89	1.95	120	46.67	3.73
No	652	65.11	1.95	143	53.33	3.73

Ocular SOL, Ocular Study of Latinos; NEI-VFQ, National Eye Institute-Visual Functioning Questionnaire; SASH, Short Acculturation Score for Hispanics/Latinos; SE, standard error.

recommended by the healthcare provider because it is not possible to determine how many years a participant was living with undiagnosed diabetes, and the risk of diabetic retinopathy and increasingly severe, related complications

increases with length of time living with diabetes.<sup>2</sup> Kovarik *et al*<sup>36</sup> found that although hospitalized patients (inpatients) had a higher prevalence of diabetic retinopathy than outpatients and that transportation and physical disability

**Table 2** Logistic regression models to show predictors of dilated eye examination within the past 12 months from the Ocular SOL (2011–2013)

	<b>Model 1 OR (95% CI)</b>	<b>Model 2 OR (95% CI)</b>	<b>Model 3 OR (95% CI)</b>	<b>Model 4 OR (95% CI)</b>	<b>Model 5 OR (95% CI)</b>	<b>Final model OR (95% CI)</b>
<i>Predisposing factors (traditional)</i>						
Age group (years)						
40–54	REF	REF	REF	REF	REF	REF
55–64	0.95 (0.48 to 1.86)	0.85 (0.39 to 1.82)	0.94 (0.37 to 2.38)	0.63 (0.21 to 1.87)	0.79 (0.38 to 1.65)	0.82 (0.40 to 1.65)
65 and older	4.24 (1.90 to 9.46)	5.83 (2.51 to 13.54)	3.02 (1.27 to 7.16)	1.35 (0.43 to 4.29)	2.43 (1.09 to 5.39)	2.62 (1.22 to 5.60)
Gender						
Women	REF	REF	REF	REF	REF	REF
Men	1.34 (0.67 to 2.65)					
Hispanic Latino background						
Cuban	REF	REF	REF	REF	REF	REF
Central/South American	0.80 (0.43 to 1.49)					
Other	0.78 (0.18 to 3.34)					
Marital status						
Single	REF	REF	REF	REF	REF	REF
Married or living with partner	1.05 (0.37 to 3.01)					
Separated/divorced/widowed	0.91 (0.26 to 3.19)					
Educational attainment						
No high school degree/GED	REF	REF	REF	REF	REF	REF
High school degree/GED	0.33 (0.12 to 0.91)	0.31 (0.10 to 0.95)	0.43 (0.13 to 1.40)	0.42 (0.08 to 2.26)	0.31 (0.10 to 1.00)	0.30 (0.10 to 0.96)
Greater than a high school degree/GED	1.39 (0.63 to 3.05)	1.47 (0.70 to 3.09)	1.92 (0.87 to 4.23)	4.87 (1.04 to 22.79)	1.48 (0.71 to 3.11)	1.43 (0.69 to 2.98)
Employment status						
Employed	REF	REF	REF	REF	REF	REF
Retired, not currently employed	1.59 (0.57 to 4.40)					
Unemployed	1.32 (0.67 to 2.61)					
<i>Predisposing factors (vulnerable)</i>						
Place of birth						
Foreign born	REF	REF	REF	REF	REF	REF
USA born (including territories)		0.99 (0.08 to 12.05)				
Years lived in USA (if foreign born)						
≤5	REF	REF	REF	REF	REF	REF
6–15		0.76 (0.24 to 2.35)	1.16 (0.36 to 3.79)			
>15		1.78 (0.53 to 5.98)	1.77 (0.49 to 6.31)			
SASH Language subscale		1.49 (0.39 to 5.72)				
SASH Ethnic Social Relations subscale		1.23 (0.52 to 2.93)				
<i>Enabling factors</i>						
Health insurance						
Currently insured	REF	REF	REF	REF	REF	REF
Currently uninsured			0.49 (0.18 to 1.33)	0.27 (0.07 to 1.00)	0.37 (0.15 to 0.88)	0.34 (0.14 to 0.83)
Never been insured			0.37 (0.11 to 1.25)	0.11 (0.03 to 0.37)	0.21 (0.07 to 0.58)	0.19 (0.07 to 0.51)

Continued

Table 2 Continued

	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)	Model 5 OR (95% CI)	Final model OR (95% CI)
Vision insurance (not health)						
Yes	REF	REF	REF	REF	REF	REF
No			0.56 (0.18 to 1.72)			
Household income						
<\$20 000	REF	REF	REF	REF	REF	REF
\$20 001–\$40 000			0.81 (0.37 to 1.81)			
>\$40 000			0.96 (0.25 to 3.72)			
Difficulty communicating with a healthcare provider in the past 12 months						
Yes	REF	REF	REF	REF	REF	REF
No			0.71 (0.17 to 2.92)			
Did not see provider past 12 months			0.56 (0.15 to 2.12)			
Could not get needed healthcare in previous 12 months because of cost						
Yes	REF	REF	REF	REF	REF	REF
No			0.92 (0.32 to 2.71)			
<i>Need factors</i>						
Mean SF-12 Physical Health Score				0.99 (0.95 to 1.04)		
Mean SF-12 Mental Health Score				0.97 (0.92 to 1.02)		
6-Item Neurocognitive Score (continuous)				0.70 (0.37 to 1.33)		
Word fluency score (continuous)				0.98 (0.90 to 1.05)		
Digital symbol score (continuous)				0.98 (0.92 to 1.05)		
Self-reported chronic diseases						
None	REF	REF	REF	REF	REF	REF
One				3.42 (0.59 to 19.74)	0.82 (0.23 to 2.86)	
Two or more				3.34 (0.79 to 14.11)	1.63 (0.41 to 6.53)	
Smoking status						
Never	REF	REF	REF	REF	REF	REF
Former				1.27 (0.52 to 3.09)		
Current				1.63 (0.43 to 6.15)		
NIAAA risky alcohol use						
Non-drinker	REF	REF	REF	REF	REF	REF
Low-risk drinker				2.27 (0.75 to 6.89)		
At-risk drinker				1.00 (0.19 to 5.30)		
Meets 2008 physical activity guidelines						
Yes	REF	REF	REF	REF	REF	REF
No				1.56 (0.53 to 4.62)		
A1C (continuous)				1.00 (0.97 to 1.02)		
Self-reported visual impairment						

Continued

Table 2 Continued

	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)	Model 5 OR (95% CI)	Final model OR (95% CI)
Excellent/good	REF	REF	REF	REF	REF	REF
Fair				1.85 (0.62 to 5.51)		
Poor/very poor				2.33 (0.41 to 13.35)		
NEI-VFQ composite score				1.02 (0.98 to 1.06)		
Ocular knowledge factors						
Self-reported diabetes at baseline						
No	REF	REF	REF	REF	REF	REF
Yes					1.17 (0.47 to 2.92)	
General eye knowledge summary scale					0.99 (0.81 to 1.22)	
Heard/seen something about eye health past 12 months from various sources						
No sources	REF	REF	REF	REF	REF	REF
One source					1.66 (0.63 to 4.40)	
Two or more sources					3.10 (1.39 to 6.94)	
Heard of diabetic retinopathy						
No	REF	REF	REF	REF	REF	REF
Yes					0.82 (0.41 to 1.65)	

Ocular SOL, Ocular Study of Latinos; NEI-VFQ, National Eye Institute-Visual Functioning Questionnaire; SASH, Short Acculturation Score for Hispanics/Latinos.

were barriers to eye care, they were more aware of ocular complications from having diabetes.

Our findings also demonstrate that only 53.3% of Hispanics/Latinos living with diabetes in our study had heard of diabetic retinopathy, suggesting that more than half may not have knowledge of the blinding, yet preventable, nature of diabetes. A study by Munoz *et al*<sup>34</sup> found that Hispanics/Latinos who had uncontrolled diabetes were less knowledgeable about secondary problems, such as diabetic retinopathy. Similar to our findings, these investigators found that only half of those living with diabetes for longer than 12 months knew that diabetes could cause eye disease. Finally, we found no appreciable difference in general eye knowledge by diabetes status (table 1). That is, one would expect that those with a diabetes diagnosis would have a higher knowledge score for eye health than those without diabetes and suggests that this group needs further targeting to improve their knowledge of their disease.

In our study, 13.0% and 18.7% of Hispanics/Latinos living with diabetes never had health insurance or were currently uninsured, respectively (table 1). Several additional demographic factors related to a diabetes diagnosis were consistent in our study with previous studies,<sup>23 37</sup> including a greater proportion of Hispanics/Latinos with diabetes who were employed, currently insured, and had less than a high school degree or GED compared to those without diabetes.

### Multivariable modeling of adherence with retinopathy screening guidelines among Hispanics/Latinos living with diabetes

Multivariable sequential models identified only 4 out of 31 factors from Anderson's model and the Behavioral Model for Vulnerable Populations that were significant in predicting having a dilated eye examination in the past 12 months. We found age group to be associated with adherence to proper eye care for diabetes. Controlling for insurance status, Hispanics/Latinos with diabetes who were aged 65 years and older were more than 2.5 times likely to have a dilated eye examination within the past 12 months than those aged 40–54 years. In analysis of the entire HCHS/SOL cohort, Schneiderman *et al*<sup>6</sup> found that older Hispanics/Latinos were more likely to be aware of having diabetes ( $p=0.0011$ ), controlling for sex, education, years living in the USA, and Hispanic/Latino background. Similarly, in our analysis, having knowledge of diabetes may be the reason for older adults to be more adherent with the guidelines for dilated eye examination. Alternatively, it may be due to greater insurance coverage by Medicare in this older age group. Similarly, older age was associated with eye care in the past year in a sample of predominantly low income African-Americans.<sup>38</sup>

Health insurance status was strongly associated with having a dilated eye examination within the past year. Controlling for age and education, those currently uninsured were three times less likely to be adherent, while

those never insured were more than five times less likely to be adherent. Our findings strongly suggest that not having insurance is an enormous barrier to receiving needed eye care in Hispanic/Latinos; targeted programs to deliver screening access to those in need are warranted.

Hispanics/Latinos with diabetes who heard about eye health from two or more sources were more likely to follow the recommendations for dilated eye screening than those who could recall no sources. Other researchers have found that interventions designed to increase adherence to diabetic retinopathy screening were mostly successful especially when the patient was aware of the risk involved with such a diagnosis.<sup>39</sup> This raises the possibility that those who are aware of the secondary health problems associated with a diagnosis of diabetes may be paying closer attention to sources of information about eye health. The number of sources (or amount of exposure) is important, but so is the quality and accuracy of these sources of eye health information to increasing appropriate screening among those with diabetes. Weiss *et al*<sup>40</sup> found that when older African-Americans with diabetes underwent a behavioral intervention providing sources of information such as educational pamphlets, online information, and ophthalmology contact information, they were more likely to have a dilated eye examination within the following 6 months compared to those not receiving the intervention. Primary healthcare providers must be a key source of eye health information to their patients with diabetes, and they must also actively refer and encourage their patients to seek annual exams.

Hispanics/Latinos in our study who had a high school diploma or GED were *less* likely to have an eye examination than those without a high school degree, and this unexpected finding was consistent throughout all models. Although those with greater than high school education reported that they were more likely to have an eye examination, the finding did not reach statistical significance. Categorization of the education variable may be an important factor explaining how our findings fit into the general literature. In the Los Angeles Latino Eye Study (LALES) study, participants with diabetes not completing high school were less likely to adhere to annual dilated eye examinations compared to those with a high school degree and more.<sup>20</sup> In another LALES analysis of all study participants, in multivariable models while controlling for most of the same factors as in our study, compared to those Hispanics/Latinos of primarily Mexican heritage finishing grade 5 or less, only those with higher than high school education were more likely to have had at least one dilated eye examination in the past 12 months (OR 1.56, 95% CI 1.21 to 1.99).<sup>23</sup> Other investigators found that higher education, that is, high school degree and more, was non-significantly predictive of Hispanics/Latinos receiving a dilated eye examination within the past 2 years.<sup>34</sup> Potential explanations for our seemingly counterintuitive finding are not clear. However, one explanation is inherent in the data

collection of the baseline examination when participants were asked to indicate 'What was the highest grade/level of education achieved? If exact level is not listed, mark the closest equivalent'. There were three choices available: less than high school, high school or GED, or more than high school. Owing to the manner in which this question was asked, it is not possible to distinguish GED holders from those who earned a high school diploma. Previous research has indicated that those with a GED-only education have health status and health behavior patterns similar to non-high school rather than high school graduates.<sup>41</sup> Since these other investigators did not break down education as we did (ie, less than high school, high school or GED, greater than high school), comparing our findings to theirs is difficult; this education finding needs to be further investigated in other studies.

We had several limitations in this study including a relatively small sample of participants living with diabetes. With the exception of marital status and not seeing a provider in the past 12 months, our sample was not significantly different from the rest of the HCHS/SOL sample at the Miami site,<sup>25</sup> but we are unable to extrapolate these findings to all Hispanics/Latinos living in the USA as our sample was largely comprised of participants of Cuban and Central/South American heritage. We also did not have power to distinguish between these Hispanic/Latino heritage groups. However, this unique sample of Hispanics/Latinos of Cuban heritage with diabetes serves to fill a gap in the literature as a majority of similar studies have been conducted largely among Hispanics/Latinos of Mexican heritage.<sup>23 37</sup> Obtaining a dilated eye examination may require a referral from a doctor or healthcare organization, a practice variation that is outside of the control of the patient. The Ocular SOL study did not ask participants if they had difficulty obtaining any required referrals. Another important potential limitation is that accuracy of our self-reported dilated eye examination data in these Hispanic/Latino heritage groups is unknown. In fact, we could find no paper in the literature that documented the accuracy of self-reported eye examination in any Hispanic/Latino population group. Finally, owing to the cross-sectional design of our study, we can only speculate that viewing numerous eye health sources, for example, seeing advertisements for eye care on TV, in magazines, or on a billboard is influencing behavior to receive eye care. An alternate explanation for this association is that individuals who get an eye examination are simply more likely to recall having seen information relevant to ocular care. Interventions targeting Hispanic/Latino populations are needed to determine if greater information exposure actually leads to increased eye care utilization and which information sources are most effective at encouraging this behavior. When African-Americans with diabetes were given an educational intervention regarding the importance of eye care, the uptake of screening for diabetic retinopathy increased over the

following 6 months compared to African-Americans who did not receive this treatment.<sup>40</sup>

In summary, health promotion and education strategies that stress the importance of annual dilated eye examinations among Hispanics/Latinos with diabetes may affect a change in the number of Hispanics/Latinos who are examined, ultimately decreasing the burden of visual impairment and blindness secondary to diabetic retinopathy. Healthcare providers should play a key role in educating their patients with diabetes of the need for annual examinations. The critical role of health insurance in enhancing adherence with retinopathy screening guidelines cannot be overemphasized. Particularly vulnerable are those who have never had health insurance. Safety-net programs for this segment of the population should be considered a high priority.

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