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Original Research

The Relationship of a Diabetes Telehealth Eye Care Program to Standard Eye Care and Change in Diabetes Health Outcomes

STEPHANIE J. FONDA, Ph.D.,[1,2] SVEN-ERIK BURSELL, Ph.D.,[1,2] DREW G. LEWIS, B.A.,[3]
JEONIFER GARREN, M.P.H.,[1] KRISTEN HOCK, B.S.,[1]
and JERRY CAVALLERANO, O.D., Ph.D.[1]

ABSTRACT

Several studies suggest that telehealth eye care programs that combine retinal imaging, education, and some care management can improve patient adherence to annual, comprehensive eye examinations and follow-up treatments. Little is known, however, about whether such programs relate to other, more distal outcomes that affect diabetic eye disease, such as blood glucose control. This paper assesses the relationship of participation in a diabetes telehealth eye care program with standard, face-to-face eye care as well as improvements in other diabetes-related health outcomes. We conducted a retrospective study using data from electronic medical records of Joslin Diabetes Center (n = 13,752). The data span 2 years: baseline and follow-up. Subjects' eye care groups were no eye care, eye care outside of the clinic, standard eye care at the clinic, or participation in the Joslin Vision Network telehealth eye care program. We analyzed the relationship of participation in the telehealth eye care program at baseline to follow-up eye care groups and changes in hemoglobin A_{1c}, low density lipoprotein levels, and systolic blood pressure. The results show that participation in the telehealth eye care program was significantly correlated with whether subjects later obtained standard eye care, improvement in hemoglobin A_{1c}, and improvement in low density lipoprotein. Thus, telehealth eye care programs that incorporate evaluation, education, and care planning are related to use of recommended eye care and improvements in certain diabetes-related health outcomes. Such programs can address the many aspects of care necessary to reduce risk of vision loss due to diabetic retinopathy and other diabetes-related complications. Future research might test hypotheses suggested by sociological and psychological theories regarding causation between participation in a telehealth eye care program and other diabetes care.

INTRODUCTION

Diabetic retinopathy (DR) is a leading cause of new-onset blindness among working-aged Americans,[1] yet the risk can be greatly reduced by a combined approach to care including annual eye examinations for detection of DR, timely laser photocoagulation and vitrectomy surgery,[2,3] and maximized control of blood glucose, blood pressure, and blood

[1]Joslin Diabetes Center, Boston, Massachusetts.
[2]Harvard Medical School, Boston, Massachusetts.
[3]Estenda Solutions, Conshohocken, Pennsylvania.

lipids.[4–7] Unfortunately, many people with diabetes mellitus (DM) often do not get care that can reduce their risk. For example, only about 55% of Americans with DM get an annual, dilated eye exam,[8,9] one third do not get annual hemoglobin A_{1c} (A_{1c}) tests, and more than one third do not get blood lipid tests at least every 2 years.[10] Barriers to diabetes-related eye care include inadequate patient education or understanding about its importance,[11,12] poor access (e.g., long waiting times for appointments, transportation problems, high costs, and/or no availability of eye care specialists),[11,13] and physician nonadherence with "best practices."[14] Many of these same barriers can explain the suboptimal rates for other diabetes care as well.

Ocular telehealth relying on digital retinal imaging with remote evaluation of images by eye care specialists is now largely accepted as a method of evaluating for DR.[15] Previous research demonstrates that ocular telehealth can reduce barriers of costs and access to detection of retinal disease.[16,17] Recently diabetes telehealth eye care programs have emerged that incorporate major parts of the combined approach to care: digital-based imaging and evaluation; patient education on the need for diabetes-related eye care and good control of A_{1c}, blood pressure, and lipids; and care plans based on the patient's current risk and preferred practice patterns. Given the components of such diabetes telehealth eye care programs, can they increase the use of standard, face-to-face eye care and therapies as well as other (noneye) diabetes care necessary to lower the risks of DR among people with diabetes? There are only a few studies addressing the linkage between telehealth eye care programs and adherence to recommended treatment for diabetic eye disease[18] and annual, dilated, face-to-face eye examinations with clinicians.[19] To our knowledge, there are no prior studies addressing the linkage between telehealth eye care programs and diabetes-related health outcomes.

This study examines the relationship between participation in a telehealth eye care program with whether people with DM subsequently obtain standard eye care with a clinician and experience improvements in diabetes-related health outcomes over time that lower their risks of DR onset and progression.

MATERIALS AND METHODS

This study was conducted at the Joslin Diabetes Center (JDC), Boston, MA—an urban, tertiary care clinic. The JDC is the home of the Joslin Vision Network (JVN) telehealth eye care program, the focus of our examination. The JVN telehealth eye care program was developed by researchers at the JDC's Beetham Eye Institute.

The telehealth eye care program

The JVN telehealth eye care program has been described before.[20–22] Briefly, the JVN telehealth eye care program has three components. The first involves retinal imaging from specific retinal regions (in nonsimultaneous stereo pairs) to evaluate patients for level of DR, diabetic macula edema (DME), and nondiabetic eye disease. A commercially available nonmydriatic retinal imaging camera, together with a proprietary software program, is used to obtain and manage the retinal images. The images are then stored as Digital Imaging and Communications in Medicine (DICOM) Visible Light objects and can be transmitted to any computer that accepts DICOM files. The second component of the telehealth eye care program provides patient education on diabetic eye disease and the importance of annual retinal examinations, blood glucose control, and blood pressure management for preventing onset or progression of DR. The third component suggests a care plan that takes into account the patient's level of DR, nondiabetic eye disease, and systemic risk factors such as their blood glucose control, blood pressure levels, and comorbidities.

The JVN telehealth eye care program and programs modeled after it have been validated.[20–25] For diagnosis of DR and DME, JVN assessments agree substantially with mydriatic, 35 mm, seven-standard field Early Treatment Diabetic Retinopathy Study (ETDRS) protocol photography[23] and with dilated clinical examinations by retina specialists.[21] For diagnosis of nondiabetic eye disease among people with DM, JVN assessments agree substantially with dilated clinical examinations by retina specialists.[25] The JVN has also been shown to have better diagnostic and clinical outcomes at lower costs compared to conventional clinic-based eye examinations when used to detect sight-threatening proliferative DR in the Indian Health Service, the Department of Defense, and the Department of Veterans Affairs.[26]

Patient access to the telehealth eye care program

Patients have access to the JVN telehealth eye care program starting with their first encounter at the JDC. All new patients with scheduled appointments at JDC's Adult Diabetes Clinic are contacted by the JVN Patient Care Coordinator to schedule a telehealth eye care appointment as part of their first visit at Joslin, with the other examinations and tests that new patients receive. The telehealth eye care program provides open access, precluding the need for a definite appointment time.

Study design and subjects

This is a retrospective study using de-identified data from electronic medical records of patients of the JDC. The JDC Institutional Review Board reviewed and approved the study protocol.

The electronic medical records for this study spanned January 1, 2004 to December 31, 2005, with 2004 as the "baseline" year and 2005 as the "follow-up" year. From the patients who had one or more clinic encounters in the baseline year, we selected those who had a diagnosis of type 1 or type 2 DM, were at least 18 years of age, and were believed to be alive at the end of the follow-up year ($n = 13{,}752$).

Measures

Independent variables. The study includes the following variables representing the main possible eye care groups at baseline: (1) no eye care; (2) self-reported eye care outside of JDC and no eye care within JDC; (3) standard eye care at JDC with an optometrist or ophthalmologist; and (4) the telehealth eye care program. Patients were identified as having participated in the telehealth eye care program if they had an encounter with the JVN telehealth eye care program. Furthermore, the electronic medical records do not indicate whether the self-reported eye care outside of JDC was performed by an optometrist or ophthalmologist or included an examination for diabetes-related eye disease; hence, we categorized this group separately from the group that had eye care at JDC. We include all of the main eye care groups in the analyses to minimize selection bias that might be introduced by restricting the study sample to certain subjects.

Study outcomes. The study outcomes are (1) eye care status in the follow-up year (none, self-reported eye care outside of JDC and no eye care within JDC, standard eye care at JDC, telehealth eye care program); and (2) change in diabetes-related health outcomes, namely, A_{1c}, low density lipoprotein (LDL), and systolic blood pressure. For the outcome—eye care status in the follow-up year—the study includes all of the main eye care groups in the analyses to characterize subjects' eye care transitions between baseline and follow-up, such as from the telehealth eye care program to self-reported eye care outside of JDC or to standard eye care at JDC. Depending on when participation in the telehealth eye care program occurred (if it did occur), subjects should have had at least one eye examination, two or more A_{1c} tests, one or more lipid tests, and two or more blood pressure evaluations in the timeframe of this study.[27] Since subjects could have had multiple A_{1c}, lipid, and blood pressure tests in a year, the analyses used the last reported value per year for each subject. The last reported values per year for these measures are nearly identical to subjects' yearly averages.

Control variables include age (years), gender, duration of DM (0–5 years, 6–10 years, more than 10 years, or missing), and type of DM. The examination does not include race/ethnicity, because these data were not consistently recorded in the electronic medical records.

Statistical analyses

The statistical analyses have three parts. The first part compares the baseline characteristics of the four eye care groups and tests for significant differences using chi-square tests for categorical variables and analysis of variance for continuous variables.

The second part tests the relationship of participation in the telehealth eye care program in the baseline year to subjects' eye care status in the follow-up year, net of the effects of the control variables including age, gender, duration of DM, and type of DM. Because eye care status in the follow-up year (none, self-reported eye care outside of JDC and no eye care within JDC, standard eye care at JDC, telehealth eye care program) has four levels and is nominal rather than ordinal, the examination uses logistic regression for multinomial outcomes.[28] This type of analysis is similar to logistic regression for dichotomous outcomes; however, multinomial logistic regression estimates multiple generalized logits per subgroup. In these particular analyses, generalized logits are formed for the probability of self-reported eye care outside of JDC with respect to none, for the probability of standard eye care at JDC with respect to none, and for the probability of participation in the telehealth eye care program with respect to none.

The third part of the examination tests the relationship of participation in the telehealth eye care program to change in diabetes-related outcomes (i.e., A_{1c}, lipids, and blood pressure), net of the effects of the control variables. These analyses are limited to subjects who had the diabetes-related tests in both the baseline and follow-up years. Because the outcomes are continuous, the examination uses ordinary least-squares regression. The ordinary least-squares regression models include the baseline value for each outcome to adjust for the potential bias of regression to the mean. Inclusion of the baseline values in the statistical models makes the examination a conditional change analysis.[29]

All parts of the statistical analyses use SAS version 9.1 software (SAS Institute, Cary, North Carolina, United States).

RESULTS

Of the 13,752 subjects, 33% had no eye care at baseline, 23% self-reported having eye care outside of JDC, 35% had eye care at JDC, and 10% participated in the telehealth eye care program in the baseline year. The baseline characteristics of these individuals are shown in Table 1. Subjects who went through the telehealth eye care program were more likely to be younger, male, have type 2 DM, have a diagnosis of DM within 0–5 years, and have higher A_{1c} and LDL levels than subjects in the other eye care groups.

Diabetes-related eye care status

Twenty-three percent of subjects who participated in the telehealth eye care program at baseline transitioned into standard eye care at JDC during the follow-up year. This is a conservative report of transition rates because 35.9% had standard eye care at JDC after going through the program but *before* the follow-up year. The result of the telehealth eye care assessment may have required a sooner referral for a dilated eye examination by a retina spe-

TABLE 1. BASELINE (2004) CHARACTERISTICS OF THE STUDY SAMPLE OVERALL AND BY EYE CARE GROUP

		Eye Care Group at Baseline (2004)				
Variable	*Total (n = 13,752)*	*None (n = 4,491)*	*Self-reported, not at clinic (n = 3,181)*	*Standard, at clinic (n = 4,741)*	*Telehealth Eye Care Program (n = 1,339)*	p-*value*
Age (mean ± SD)	53.9 ± 16.7	52.5 ± 17.4	56.2 ± 16.2	54.9 ± 16.3	50.1 ± 15.6	<0.0001
Male (%)	51.7	53.1	50.9	50.1	54.4	0.005
Type 1 DM (%)	43.6	43.9	42.0	47.6	32.7	<0.0001
Duration of DM (%)						
0–5 years	7.8	8.2	5.6	5.3	20.2	<0.0001
6–10 years	12.0	11.9	14.3	9.6	15.3	
10 years	38.2	32.7	41.9	44.5	25.5	
Missing	42.0	47.2	38.2	40.6	38.9	
A_{1c} (mean ± SD)[a]	7.8 ± 1.5	7.8 ± 1.6	7.6 ± 1.4	7.8 ± 1.4	8.0 ± 1.9	<0.0001
LDL (mean ± SD)[b]	104.1 ± 30.7	105.5 ± 31.6	101.4 ± 29.1	102.9 ± 29.8	110.3 ± 33.9	<0.0001
Systolic BP (mean ± SD)[c]	125.4 ± 15.1	125.4 ± 15.2	126.0 ± 14.8	125.5 ± 15.3	123.4 ± 14.9	<0.0001

SD, standard deviation; DM, diabetes mellitus; LDL, low-density lipoprotein; BP, blood pressure.
[a] n = 10,133
[b] n = 8,694
[c] n = 10,594

cialist as part of the care plan that this program provides. By design, the statistical analyses do not address the relationship of the telehealth eye care program to care received immediately after participation, within the baseline year. Another 13.3% of telehealth eye care program participants transitioned into eye care outside of JDC during the follow-up year. Sixteen percent of subjects who had no eye care at baseline transitioned into standard eye care at JDC in the follow-up year and another 16.1% transitioned into eye care elsewhere.

Table 2 shows the results from the multinomial logistic regression analysis of follow-up eye care status. Baseline participation in the telehealth eye care program (vs. no eye care) increased the likelihood that subjects obtained standard eye care at JDC over time; i.e., the net relative risk of getting standard eye care at JDC was 1.71 times ($p < 0.0001$) higher for subjects who participated in the telehealth eye care program. The predicted probability for the "average" subject who participated in the telehealth eye care program was 40% versus 28% for the "average" subject who did not participate in the program. Subjects who self-reported getting eye care outside JDC or who received standard eye care at JDC in the baseline year were likely to obtain the same type of care in the follow-up year; e.g., the net relative risk of receiving standard eye care at JDC in the follow-up year was 11.36 times ($p < 0.0001$) higher for subjects who were in standard care at JDC at baseline. Baseline participation in the telehealth eye care program in the baseline year decreased the likelihood of participating in the program later (relative risk ratio = 0.11; $p < 0.0001$).

Change in diabetes-related outcomes

Table 3 displays the results from the conditional change analyses in diabetes-related outcomes. Fifty-five percent of subjects had A_{1c} tests, 43% had lipid tests, and 60% had blood pressure evaluations in both the baseline and follow-up years; these subjects are the analytic sample for this part of the examination. A coefficient <0 indicates that the subject's A_{1c}, LDL, or systolic blood pressure improved because it was lower at follow-up than at baseline.

Baseline telehealth eye care program participants were more likely to have an improvement in A_{1c} (coefficient = -0.22; $p < 0.0001$) and LDL levels (coefficient = 3.28; $p < 0.014$) than subjects who had no eye care at baseline. Similarly, subjects who self-reported having an eye examination outside JDC at baseline were more likely to have an improvement in A_{1c} (coefficient = -0.08; $p = 0.006$) and LDL levels (coefficient = -2.93; $p = 0.001$) compared with subjects who had no eye care at baseline. Subjects who had eye care at JDC also experienced an improvement in LDL levels (coefficient = -1.83; $p = 0.040$). Change in blood pressure level was unrelated to eye care group at the significance level of 0.05. Standardized regression coefficients (not shown) indicate that participation in the telehealth eye care program had a greater correlation with change in A_{1c} and LDL than either having had eye care at the clinic or self-reported eye care elsewhere.

DISCUSSION

This study investigated the relationship between participation in a telehealth eye care program with subsequent, standard eye care and improvements in A_{1c}, LDL, and systolic blood pressure over time. The results showed that participation in the telehealth eye care program corresponded positively with later receiving standard eye care. For subjects who had A_{1c}, lipid, and blood pressure tests, participation in the telehealth eye care program was associated with improvement in A_{1c} and LDL levels.

The results also showed that participants of the telehealth eye care program were less likely to participate in the program in the follow-up year. This pattern reflects the JVN telehealth eye care program's emphasis on moving people into standard eye care. Although the JVN has demonstrated reliability in providing follow-up retinal evaluations for persons who had no DR or very mild nonproliferative DR at the previous comprehensive retinal evaluation (within the past 11 months),[24] the JVN still stresses standard eye care based on the American Diabetes Association's recommendation that people with diabetes obtain a comprehensive eye exam with an optometrist or ophthal-

Table 2. Estimated Net Associations of Participation in a Telehealth Eye Care Program on Eye Care in the Follow-up Year (2005), from Multinomial Logistic Regression Analysis (n = 13,752)

	Self-reported, not at clinic		*Standard, at clinic*		*Telehealth Eye Care Program*	
Variable	*Relative risk ratio (95% CI)*	p-*value*	*Relative risk ratio (95% CI)*	p-*value*	*Relative risk ratio (95% CI)*	p-*value*
Age (years)	1.014 (1.010–1.017)	<0.0001	1.008 (1.005–1.011)	<0.0001	0.979 (0.968–0.990)	<0.0001
Male	0.926 (0.838–1.022)	0.128	0.948 (0.866–1.037)	0.244	1.833 (1.343–2.502)	<0.0001
Type 1 DM	1.410 (1.250–1.589)	<0.0001	1.229 (1.101–1.371)	<0.0001	0.517 (0.353–0.757)	0.001
Duration of DM 5 years	(reference)		(reference)		(reference)	
Duration of DM 6–10 years	1.918 (1.511–2.436)	<0.0001	1.217 (0.986–1.501)	0.067	1.477 (0.815–2.675)	0.198
Duration of DM >10 years	1.761 (1.415–2.192)	<0.0001	1.445 (1.204–1.735)	<0.0001	1.060 (0.597–1.881)	0.841
Duration of DM missing	1.349 (1.086–1.676)	0.007	1.138 (0.952–1.361)	0.157	1.029 (0.594–1.783)	0.918
Eye care at baseline (2004)						
None	(reference)		(reference)		(reference)	
Self-reported, not at clinic	3.803 (3.405–4.247)	<0.0001	0.591 (0.500–0.699)	<0.0001	2.146 (1.581–2.913)	<0.0001
Standard, at clinic	0.352 (0.285–0.435)	<0.0001	11.356 (10.216–12.622)	<0.0001	0.177 (0.077–0.405)	<0.0001
Telehealth Eye Care Program	0.975 (0.811–1.171)	0.785	1.708 (1.461–1.997)	<0.0001	0.105 (0.033–0.334)	<0.0001
Likelihood ratio Chi-square			6433.17			
Prob > Chi-square			<0.0001			
Degrees of Freedom			27			

CI, confidence interval; DM, diabetes mellitus.

Table 3. Estimated Net Associations of Participation in a Telehealth Eye Care Program on Change in A_{1C}, Low-Density Lipoprotein (LDL), and Systolic Blood Pressure, from Three Ordinary Least-Squares Regression Analyses

	A_{1c}[a]		LDL[b]		Systolic blood pressure[c]	
Variable	*Coefficient (95% CI)*	p-*value*	*Coefficient (95% CI)*	p-*value*	*Coefficient (95% CI)*	p-*value*
Intercept	1.988 (1.807–2.169)	<0.0001	68.798 (63.758–73.839)	<0.0001	62.503 (59.265–65.742)	<0.0001
Age (years)	−0.004 (−0.005–−0.002)	<0.0001	−0.240 (−0.289–−0.191)	<0.0001	0.198 (0.173–0.223)	<0.0001
Male	−0.033 (−0.076–0.011)	0.142	−2.514 (−3.831–−1.196)	0.000	−0.257 (−0.917–0.403)	0.445
Type 1 DM	0.059 (0.007–0.112)	0.027	−2.538 (−4.090–−0.987)	0.001	−0.401 (−1.189–0.388)	0.320
Duration of DM 5 years	(reference)		(reference)		(reference)	
Duration of DM 6–10 years	0.261 (0.153–0.368)	<0.0001	−0.657 (−3.930–2.616)	0.694	0.583 (−1.024–2.191)	0.477
Duration of DM >10 years	0.333 (0.236–0.431)	<0.0001	−1.295 (−4.250–1.659)	0.390	1.894 (0.452–3.336)	0.010
Duration of DM missing	0.327 (0.230–0.423)	<0.0001	−1.374 (−4.308–1.559)	0.359	1.606 (0.175–3.038)	0.028
Baseline A_{1c}	0.725 (0.709–0.741)	<0.0001	—	—	—	—
Baseline LDL	—	—	0.469 (0.447–0.491)	<0.0001	—	—
Baseline systolic blood pressure	—	—	—	—	0.439 (0.416–0.462)	<0.0001
Eye care at baseline (2004)						
None	(reference)		(reference)		(reference)	
Self-reported, not at clinic	−0.084 (−0.144–−0.024)	0.006	−2.934 (−4.733–−1.134)	0.001	−0.637 (−1.537–0.263)	0.165
Standard, at clinic	−0.024 (−0.081–0.034)	0.424	−1.829 (−3.570–−0.087)	0.040	−0.822 (−1.695–0.052)	0.065
Telehealth Eye Care Program	−0.215 (−0.301–−0.128)	<0.0001	−3.284 (−5.896–−0.673)	0.014	−0.153 (−1.426–1.120)	0.814
R^2	0.54		0.26		0.23	

CI, confidence interval; DM, diabetes mellitus.
[a]n = 7,625.
[b]n = 5,942.
[c]n = 8,253.

mologist annually or every 2–3 years in the context of "normal" examination findings.[27]

The study also found that already being in a standard eye care program was correlated with subsequent adherence to standard eye care. Future research might address whether people who go through the telehealth eye care program and then go into standard eye care will be more adherent than other groups with their standard eye care program. Future research might also examine whether program participants who have normal eye examinations findings and are encouraged to remain with the program between comprehensive eye examinations choose to do so. Additionally, expanded recognition of validated telemedicine programs to substitute for annual retinal evaluation for DR under appropriate circumstances will expand the use of such programs for DR surveillance.

There are several reasons to expect a relationship between telehealth eye care programs and diabetes-related eye care specifically and diabetes care in general. One is previous research. An observational study in the Indian Health Service demonstrated that adding such a program to existing care increased surveillance rates for DR by 50% and follow-up laser treatments by 51% in 5 years.[18] A randomized controlled trial at a Veterans Affairs medical center showed that people who were randomized to a telehealth eye care program at baseline were significantly more likely to obtain a complete eye examination with pupil dilation 1 year later compared with people randomized to receive "usual eye care".[19] Clearly, the telehealth eye care programs removed barriers, prepared, and/or motivated people for the next steps in their eye care. These two programs—both of which are modeled after the JVN telehealth eye care program—educate participants about the value and benefits of care and/or they offer a relatively convenient, accessible "foot-in-the-door," making it more likely that people will adhere to clinical guidelines-based standards of care.[30]

Another reason to expect such a relationship is that education or self-management training[31] and care management[32] have been shown to impact lifestyle and behavior beneficially. Again, both education and care plans are important components of the JVN telehealth eye care program. In a study by Cavallerano and associates, almost all patients who went through the JVN telehealth eye care program reported improved understanding of diabetes-related eye disease and care afterwards.[24] If participants learn from the telehealth eye care program, we can reasonably expect them to be better prepared to make adjustments in self-management. These adjustments would then be evident in such outcomes as follow-up eye care, A_{1c} levels, and lipid levels.

Yet another explanation is that patients who opt to participate in a telehealth eye care program may be predisposed to address their diabetes care proactively. This predisposition would then be apparent in their subsequent diabetes care patterns and its outcomes. This latter explanation suggests that participation in a telehealth eye care program does not cause later use of diabetes care and its outcomes but is itself a consequence of other factors. It is likely that the relationship we observed between participation in the telehealth eye care program and diabetes care and outcomes is bidirectional. Future research might disentangle causation so that telehealth eye care programs could be tailored to address the readiness of participants.

Several features of this study limit our ability to make general inferences to the overall population of people with DM. First, the study used data from a tertiary care setting. Patients in this setting tend to be highly motivated and educated or may be experiencing complications of their disease. The differences reported here between participants of the telehealth eye care program and people with no eye care might be greater in a primary care or community health setting, where the most motivated people might elect to participate in the telehealth eye care program and/or where the educational component of the program might have greater impact. Conversely, the differences might be smaller in a setting where patients do not have the full range of diabetes care services available to them in the same building, so participants of the telehealth eye care program are less able to obtain subsequent care. Second, all parts of the telehealth eye care program that we studied occur within the specialty clinic. Program participants in this particular setting have the same experience as participants in remote and/or primary care settings, but they might perceive the experience differently because of the relative convenience of follow-up care.

The retrospective study design, while typically not considered the best method for examining associations, has several merits: primarily that the data show naturally occurring behaviors among clinic patients because they were not altering their behaviors in response to being in a research study on eye care. The study design also used all clinic data available that met the purposefully minimal inclusion criteria. Consequently, we have a representative view of people with DM who attended an urban diabetes clinic at least once in the baseline year. Not all of the patients received all of their diabetes care at the clinic. Although the patients of this clinic tend to be motivated, we believe there is some variation within the study sample. Finally, the retrospective design allowed us to use several years of data and to delineate the temporal ordering of eye and diabetes care. Understanding the timing of events is helpful for generating hypotheses about causation.

In summary, the JVN telehealth eye care program that combines evaluation, education, and care planning is related to use of other diabetes care—namely, standard eye care—and with improvements in diabetes-related health outcomes. Thus, appropriately designed and validated telemedicine eye care programs can address the many aspects of care necessary to reduce vision loss and other complications.

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Address reprint requests to:
Stephanie Fonda, Ph.D.
Joslin Diabetes Center
One Joslin Place
Boston, MA 02215

E-mail: fondasj@gmail.com