Changes in Incidence of Diabetes Mellitus–Related Eye Disease Among US Elderly Persons, 1994-2005

Frank A. Sloan, PhD; Daniel Belsky, BA; David Ruiz Jr, BS; Paul Lee, MD, JD

Objectives: To determine if diabetic eye disease has changed over time among older Americans and to explore possibilities for observed change.

Methods: We performed a longitudinal analysis of nationally representative Medicare data, the Medicare 5% sample, collected from January 1, 1991, through December 31, 2004, using standard claims data algorithms and cross-sectional analysis of the Medicare Current Beneficiary Survey.

Results: Compared with Medicare beneficiaries first diagnosed with diabetes mellitus in 1994, those first diagnosed with diabetes in 1999 and in 2003 showed lower rates of background and proliferative diabetic retinopathy within 1 year after diagnosis and during 6 years of follow-up among the 1999 cohort. Six-year rates of surgical procedures for retinopathy were lower among beneficiaries in the 1999 cohort than in the 1994 cohort, and rates of glucose, lipid, and cholesterol monitoring were higher. In addition, hypertension was diagnosed more frequently among the 1999 cohort during 6 years. Data from the Medicare Current Beneficiary Survey showed higher rates of antihypertensive drug use among persons diagnosed with diabetes in 1999 compared with 1994.

Conclusions: Decreases in rates of diabetic retinopathy among persons newly diagnosed with diabetes enrolled in Medicare from 1994 to 2004 and concurrent improvements in primary care for diabetes suggest that better primary care has had an effect on the Medicare population, despite increasing rates of other adverse outcomes.

Arch Ophthalmol. 2008;126(11):1548-1553

Author Affiliations:
Departments of Economics (Dr Sloan and Messrs Belsky and Ruiz) and Ophthalmology (Dr Lee), Duke University School of Medicine, Durham, North Carolina.

LIMITED EVIDENCE IS AVAILABLE on longitudinal changes in rates of diabetic retinopathy (DR) among persons with type 2 diabetes mellitus.[1,2] There is reason to expect some improvement in eye-related outcomes of diabetes since 1990. Studies[3-9] have demonstrated the importance of glucose control and hypertension management in reducing adverse outcomes of diabetes mellitus. Results of important randomized controlled trials, such as the United Kingdom Prospective Diabetes Study, the Diabetes Control and Complications Trial, and the Appropriate Blood Pressure Control in Diabetes Trial, indicate better glycemic and hypertension control result in reduced rates in the development of diabetic eye disease, particularly DR.[9-14]

Clinical experience suggests primary care for persons with diabetes has improved after the dissemination of these findings.[15] Indeed, rates of glucose control monitoring in the Medicare population improved during the 1990s.[16]

This study used claims data from Medicare to assess change in longitudinal rates of diabetes-related eye disease in beneficiaries first diagnosed with diabetes in 1994, 1999, and 2003. We conducted further analyses with data from this sample and the Medicare Current Beneficiary Survey (MCBS) to assess change in rates of surgical treatment for diabetes-related eye disease and glucose monitoring and hypertension management among persons diagnosed with diabetes and hypertension during the same period.

METHODS

DATA COLLECTION

Data came from January 1, 1991, through December 31, 2004, Medicare 5% claims for inpatient, outpatient, Part B, and durable medical equipment, which contain data on service dates, diagnoses (*International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*][17]), and procedures (*Current Procedural Terminology*). Data on diagnoses, procedures, and service dates were used to measure adverse outcomes rates. Durable medical equipment claims files contained Healthcare Common Procedure Coding System codes used to identify beneficiaries using low vision aids and

dialysis equipment. Other Medicare administrative data provided information on demographic characteristics and dates of death. Data were linked by a unique identifier, permitting construction of longitudinal, person-specific data.

Supplemental data from the 1994 and 1999 MCBS were used to provide drug use information for Medicare beneficiaries unavailable in the claims data. The MCBS is a rotating panel of current Medicare beneficiaries that comprises claims data in addition to self-reported information, including prescription drug use. Participants remain in the MCBS for 4 years. Reinterview of the same participants allows researchers to track changes in consumption of health care services and in the health of individual participants for several years. Medicare claims data on the same individuals are available for the time period during which interview data are available. Participants were encouraged to bring the drugs to the MCBS interview to allow interviewers to verify self-reports of drug use.

SAMPLE SELECTION

Individuals were classified as being diagnosed with diabetes based on having at least 2 Medicare Part B claims or at least 1 inpatient claim with a diabetes diagnosis code (*ICD-9-CM* code 250.xx). We selected 3 distinct cohorts of persons newly diagnosed with diabetes in 1994, 1999, and 2003. We searched all claims from 1991 through the cohort year to construct cohorts for 1994, 1999, and 2003. We eliminated all individuals with a diabetes diagnosis before the cohort year. We then limited each of the cohort samples to persons 65 years and older for at least 6 months before the person's first diabetes diagnosis and younger than 96 years as of December 31 of the cohort year. We also excluded individuals who did not survive through July 1 of the cohort year and those who were enrolled for more than 6 months of the base year in a Medicare risk plan (health maintenance organization). Our final samples were 33 164 for the 1994, 31 722 for the 1999, and 40 058 for the 2003 diabetes cohort. By construction, there was no overlap of individuals among these 3 cohorts.

ANALYTIC METHODS

Using data from the Medicare 5% samples, individuals in the 1994 and 1999 diabetes cohorts were followed up from entry into a cohort through December 31, 1999, and December 31, 2004, respectively. The 2003 cohort was followed up from the date of first diagnosis in 2003 through December 31, 2003.

Rates of key diabetes-related eye diseases, including DR in general, background DR (BDR), proliferative DR (PDR), macular edema, rubeosis iridis (new blood vessels on the iris), and vitreous hemorrhage were calculated using established coding algorithms.[16] For comparison, rates of cardiovascular, cerebrovascular, renal, and lower extremity adverse outcomes of diabetes were also assessed.

Persons in the 1994 and 1999 cohorts with any diabetes-related eye disease were placed into 3 groups: persons with any diabetes-related eye disease and 2 mutually exclusive subgroups, persons with BDR and persons with PDR. Persons who transitioned from BDR to PDR were placed in the PDR group. Rates of surgical interventions within these diagnostic categories were ascertained to investigate whether rates of more severe manifestations of disease may have decreased from more aggressive surgical treatment of less severe manifestations of disease, with type of surgery varying by disease (**Table 1**). The same procedures were used for BDR and other diabetes-related eye diseases. A different set of procedures was used for PDR.

To examine whether observed differences in longitudinal rates of diabetes-related eye disease reflected patterns in primary care for diabetes, rates of hypertension, visits to optom-

Table 1. *ICD-9-CM*, *CPT*, HCPCS, and Physician Specialty Codes Used to Identify Diagnoses, Procedures, and Medical Equipment in Claims Data

Claim	Codes
Diagnoses	
Diabetes	250.xx
Diabetic retinopathy	362.xx
Background diabetic retinopathy	362.01
Proliferative diabetic retinopathy	362.02
Cystoid macular edema	362.53, 362.83
Rubeosis iridis	379.23
Cardiovascular adverse outcomes	398.91, 402.01, 402.11, 402.91, 404.01, 404.11, 404.91, 410.xx-414.xx, 428.0-428.4, 428.9
Cerebrovascular adverse outcomes	430.xx-436.xx, 785.9
Renal adverse outcomes	404.12, 404.13, 404.92, 404.93, 403.01, 403.11, 403.91, 581.8x, 585, 586, 791.x, 39.27, 39.42, 39.43, 39.49, 39.50, 39.53, 39.93, 39.94, 50340, 50360, 50365, 90921, 90935, 90937, 90940, 90989, 90993, 90997, 90999, 93990, V42.0, V45.1, V56.0, V56.8
Lower extremity adverse outcomes	040.0, 250.7, 355.8, 355.9, 358.1, 440.21-440.24, 443.9, 681.xx, 682.xx, 707.1-707.9, 713.5, 729.5, 730.0, 730.1, 731.8, 782, 785.4, 84.1x, 86.28, 11000, 11011, 11040-11042, 27290, 27295, 27590-27592, 27594-27596, 27598, 27880-27882, 27884, 27886, 27888, 28800, 28805, 28810, 28820, 28825
Hypertension	401.xx
Procedures and durable medical equipment	
Surgical interventions for all diabetes-related eye disease: destruction of localized lesion of retina, choroid	67208, 67210, 67220
Surgical interventions for proliferative diabetic retinopathy: vitrectomy; repair, prophylaxis of retinal detachment; destruction of localized lesion of retina with implanted radiation source; destruction of extensive or progressive retinopathy	67036-67040, 67101-67112, 67141-67145, 67227, 67228
Hemoglobin A_{1c} tests	82985, 83036
Lipid and cholesterol tests	80061, 82465, 83715-83719, 83721, 84478
Urinalysis, microalbumin, and proteinuria tests	81000-81003, 81005, 82040, 82042-82044, 84155
Glucose monitoring device	E0607, E2100, E2101
Physician specialty codes	
Optometrist claims	48
Ophthalmologist claims	18

Abbreviations: CPT, *Current Procedural Terminology*; HCPCS, Healthcare Common Procedure Coding System; *ICD-9-CM*, *International Classification of Diseases, Ninth Revision, Clinical Modification*.

etrists and ophthalmologists, diabetes monitoring procedures,[16] and claims for glucose monitoring devices were calculated. Codes for diagnoses, procedures, durable medical equipment, and physician specialty are listed in Table 1.

Diabetes-related eye diseases were considered incident on the date the diagnosis was entered on a claim and remained prevalent until death or through December 31 of a cohort's final study year. First-year incidence rates were calculated from enrollment in the cohort to December 31 of the same year. Six-year prevalence rates were calculated from enrollment in cohorts through year 6 in persons still alive. Six-year cumulative incidence similarly reflected the total number of individuals in the cohort who were ever diagnosed with a given adverse outcome from enrollment in the cohort through year 6 but also included persons who died during follow-up but were recorded as having the diagnosis before death.

Diagnosed diabetes was identified in the MCBS sample using the same algorithm applied to the Medicare 5% claims data, although no attempt was made to limit this sample to new diagnoses since the beneficiaries were only included for 4 years and Medicare claims data were only available during the time the beneficiaries participated in the MCBS. Rates of use of antihypertensive drugs[18] were then calculated separately for persons diagnosed with diabetes and hypertension in the MCBS in 1994 and 1999. We calculated rates for individuals who reported taking at least 1 medication of any type at the time of their interview, 1192 of 2006 participants with a diagnosis of diabetes and hypertension in 1994, and 1462 of 2154 in 1999. We excluded individuals with no recorded medication use because such individuals may not have reported medication use to the MCBS.

Table 2. Sample Characteristics at Baseline for 1994, 1999, and 2003 Cohorts in the Medicare 5% Sample[a]

Characteristic	1994 (n=33 164)	1999 (n=31 722)	2003 (n=40 058)
Mean age, y	74.4	74.8[b]	74.6[b]
Male sex	41.5	43.5[b]	45.1[b]
Race			
White	83.2	83.2	83.1
Black	11.5	10.3[b]	10.5[b]
Hispanic	1.3	1.9[b]	2.3[b]
Asian	0.6	1.2[b]	2.2[b]
Other or race missing	3.4	3.5	2.0[b]

[a] Except for age, all variables are percentages.
[b] $P<.01$ compared with values for the 1994 cohort.

RESULTS

The number of persons newly diagnosed with diabetes increased substantially from 1994 to 2003 (**Table 2**). Rates of diabetes-related eye disease in the year after diagnosis of diabetes decreased from 51 cases per 1000 persons in 1994 to 45 cases per 1000 persons in 1999 ($P<.001$) (**Table 3**). Although not a large decrease, the opposite pattern was observed for other diabetes-related adverse outcomes (**Table 4**). Rates of renal adverse outcomes nearly doubled ($P<.001$), whereas rates of cerebrovascular and lower extremity adverse outcomes also increased substantially ($P<.001$). For the 2003

Table 3. Diabetes Mellitus–Related Eye Disease in 3 Cohorts of Persons Newly Diagnosed With Diabetes in the Medicare 5% Sample (per 1000 Persons)

	1-Year Incidence			6-Year Prevalence		6-Year Cumulative Incidence	
	1994 (n=33 164)	1999 (n=31 722)	2003 (n=40 058)	1994 (n=19 806)	1999 (n=21 356)	1994 (n=33 164)	1999 (n=31 722)
Any diabetes-related eye disease	51	45[a]	47	200	176[a]	163	150[a]
Background diabetic retinopathy	30	25[a]	25[a]	137	112[a]	109	91[a]
Macular edema	11	10	11	55	49[b]	43	39[c]
Proliferative diabetic retinopathy	8	6[b]	5[a]	31	24[a]	26	20[a]
Rubeosis iridis	0	1	1	3	3	3	3
Vitreous hemorrhage	4	4	4	17	18	14	15

[a] $P<.001$ compared with values for the 1994 cohort.
[b] $P<.01$.
[c] $P<.05$.

Table 4. Other Adverse Outcomes in 3 Cohorts of Persons Newly Diagnosed With Diabetes Mellitus in the Medicare 5% Sample (per 1000 Persons)

	1-Year Incidence			6-Year Prevalence		6-Year Cumulative Incidence	
Adverse Outcome	1994 (n=33 164)	1999 (n=31 722)	2003 (n=40 058)	1994 (n=19 806)	1999 (n=21 356)	1994 (n=33 164)	1999 (n=31 722)
Cardiovascular	295	316[a]	298	547	552	569	593[a]
Cerebrovascular	131	148[a]	152[a]	347	366[a]	347	377[a]
Renal	54	81[a]	106[a]	169	225[a]	176	242[a]
Lower extremity	266	326[a]	363[a]	667	721[a]	613	696[a]

[a] $P<.001$ compared with values for the 1994 cohort.

cohort, rates of cardiovascular adverse outcomes in the year after diagnosis of diabetes did not significantly differ from those for 1994.

At 6 years of follow-up, changes were more pronounced; whereas 6-year cumulative incidence of diabetes-related eye disease was 13 persons per 1000 lower in the 1999 cohort relative to the 1994 cohort ($P<.001$), rates of all other adverse outcome categories ranged from 24 to 83 persons per 1000 higher in the 1999 cohort ($P<.001$). Decreases in rates of diabetes-related eye disease reflected falling rates of BDR and PDR. No change was seen in rates of rubeosis iridis or vitreous hemorrhage; rates of macular edema decreased slightly.

Many potential reasons exist for changes in the rates of DR. These reasons include the following: (1) more aggressive surgical treatment involving patients with a BDR diagnosis to prevent occurrence of PDR, (2) improved rates of adherence to guidelines for diabetes monitoring and thus better glycemic control and lower rates of vascular complications, and (3) higher rates of use of antihypertensive drugs and thus presumably better blood pressure control.

First, similar to the decrease among beneficiaries diagnosed with any diabetes-related eye disease (from 201 per 1000 persons in 1994 to 138 per 1000 persons in 1999; $P<.001$), in the subgroup diagnosed with BDR, there was a decrease from 259 per 1000 persons with surgical interventions in the 1994 cohort to a rate of 179 per 1000 for the 1999 cohort during the 6 years of follow-up ($P<.001$). A decrease occurred in the rates of surgery for those diagnosed with PDR (from 525 per 1000 persons in 1994 to 469 per 1000 persons in 1999; $P=.03$).

Second, significant improvements were seen in the 6-year cumulative incidence of diabetes monitoring in the 1999 cohort compared with the 1994 cohort, although rates remained low (**Table 5**). Although those in the 1999 cohort were only slightly more likely to receive at least 1 of a battery of diabetes management screens ($P=.004$) than were their 1994 counterparts, there was a 16% increase in the proportion of beneficiaries with a claim for a hemoglobin A_{1c} test during 6 years of follow-up ($P<.001$). Also, the rate of claims for glucose monitors during 6 years of follow-up nearly doubled ($P<.001$) from the 1994 to the 1999 cohort, although less than 20% of beneficiaries diagnosed with diabetes in 1999 had claims for monitors through 2005. Small but statistically significant increases were seen between the 1994 and 1999 cohorts in the proportion of beneficiaries with at least 1 claim by both ophthalmologists and optometrists.

Third, hypertension was diagnosed much more frequently in the 1999 than in the 1994 cohort (6-year incidence: 690 vs 599 per 1000 persons; $P<.001$; data not shown). Medical management of hypertension also became more aggressive over time. In the MCBS, 858 persons per 1000 beneficiaries diagnosed with diabetes and hypertension reported taking at least 1 antihypertensive medication in 1999, an increase from 803 per 1000 in 1994 ($P<.001$). Rates were higher in both years among those with a diabetes-related eye disease diagnosis but still higher in 1999 (872 per 1000 persons) than in 1994 (865 per 1000). Persons diagnosed with BDR or PDR did not experience a statistically significant change (875 in 1994 and 878 in 1999 for BDR and 880 in 1994 and 860 in 1999 for PDR), although few persons in the MCBS had such a diagnosis, limiting statistical power.

Table 5. Use of Diabetes Monitoring Procedures in 2 Cohorts of Persons Newly Diagnosed With Diabetes in the Medicare 5% Sample (6-Year Cumulative Incidence per 1000 Persons)

Procedures	1994	1999
Any screening procedure	806	814[a]
Hemoglobin A_{1c} test	462	538[b]
Lipid and cholesterol test	575	621[b]
Urinalysis, microalbumin, proteinuria test	668	665
Glucose meter	94	171[b]
Visit to ophthalmologist	439	452[b]
Visit to optometrist	169	187[b]
Sample	33 164	31 722

[a] $P<.01$.
[b] $P<.001$ compared with values for the 1994 cohort.

COMMENT

Between 1994 and 2005, rates of diabetic retinopathy decreased among Medicare beneficiaries newly diagnosed with diabetes, both in the first year after diagnosis and during the 6 years of follow-up. By contrast, rates of other adverse outcomes increased. We cannot fully explain these contrasting trends. However, we did investigate several factors that might have contributed to the decreases in rates of DR in general and PDR in particular. Initially, we speculated that lower rates might have been the product of more aggressive surgical therapy. However, rates of surgical therapy actually decreased during the study period.

We then examined the possibility of improved monitoring among patients diagnosed with diabetes, which would be consistent with lower rates of PDR onset. First, eye care use rates increased during the study period. Second, glucose monitoring increased substantially in claims for tests and home monitoring devices. These results extend previous findings of improved glucose monitoring during the 1990s.[16,19,20] Rates of diagnosis and treatment of hypertension among Medicare beneficiaries diagnosed with diabetes increased. By addressing the key underlying causes of vascular complications of diabetes and the monitoring of eye disease, these improved care patterns may indeed be linked to lower rates of retinopathy.

The discrepancy between diabetes-related eye disease and other diabetes-related complications may also reflect differential changes in rates of monitoring for some other complications, especially lower extremity monitoring,[21] which were much lower than eye assessments in the early 1990s and thus increased much more than eye assessments. As such, the discrepancy may be a function of better ascertainment of complications other than for the eye.

A final potential reason is greater diagnostic sensitivity in other disease areas, such as renal insufficiency. Changes in awareness may have led to lower thresholds for diagnosis, particularly when paired with new evidence suggesting effective treatment for such conditions can prevent later morbidity and mortality (as with

angiotensin-converting enzyme inhibitors for renal insufficiency).

Brown et al[22] reported rates of DR specific to the duration of diabetes and made the connection to improved primary care. The investigators derived diabetes duration–specific rates of DR from medical records of 6993 persons with type 2 diabetes enrolled in the Kaiser Permanente Northwest (KPNW) health maintenance organization in 1997-1998. Of those who underwent a retinal examination at 1 year after diagnosis, 2.63%, 0.45%, and 0.74% were diagnosed with BDR, macular edema, and PDR, respectively. These rates are comparable to those we report. At 6 years of follow-up, rates of BDR, macular edema, and PDR were 13.25%, 1.31%, and 0.93%, respectively. Rates for BDR are comparable to those reported herein; however, rates of macular edema and PDR are nearly half those reported in this study. The mean age in the KPNW sample with diabetes (58.8) was 15 years younger than in our sample. Moreover, differences between claims data and medical records and between our nationally representative sample and the region- and insurance-specific KPNW sample may explain the lower rates observed for PDR and macular edema in the study by Brown et al. Because all persons in the KPNW sample were identified in 1997-1998, the 1- and 6-year rates were computed for populations diagnosed with diabetes at different times (1996-1997 and 1991-1992, respectively).

Brown and colleagues characterized their findings as an improvement over rates reported in the Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR)[23] 20 years earlier for BDR but not for PDR. They argued this improvement, at least partly, was due to superior management of diabetes in the KPNW to the WESDR population. There are a number of concerns with comparing these 2 studies, including differences in sample composition and diagnostic sensitivity, but it suggests improvement from the late 1970s to the late 1990s in onset of DR among persons diagnosed with diabetes. Results reported in our study partly reinforce and extend the finding of Brown et al of improved eye-related outcomes for persons diagnosed with diabetes into the 21st century in a nationally representative sample of older adults. Furthermore, by tracking rates of eye care, glucose monitoring, and hypertension management among Medicare beneficiaries diagnosed with diabetes, we provide evidence of improvements in primary care for diabetes among the population experiencing decreasing rates of DR.

Our study has several important strengths. First, it used longitudinal data from a large, nationally representative sample of older Americans to assess rates of disease and treatment. Second, longitudinal follow-up of 2 large cohorts of persons newly diagnosed with diabetes in a single database permit monitoring changes in health status more reliably than is possible with cross-sectional data or cross-study comparisons. Third, by including drug use data from the MCBS, also a nationally representative sample of the Medicare population, we could more closely track treatment of hypertension than is possible using claims data alone.

We acknowledge several study limitations. First, the introduction of new criteria for diagnosing diabetes in 1997 lowered the threshold fasting glucose level for diagnosis,[24,25] resulting in diagnosis of diabetes at an earlier stage in the disease process.[26] Thus, beneficiaries in the 1999 and 2003 diabetes cohorts may have had their conditions diagnosed earlier in the disease process than in the 1994 cohort. Because the risk of retinopathy increases with duration of diabetes,[23] some of the reduction in rates observed in this study may have reflected earlier ascertainment of diabetes rather than reduced incidence and progression of DR.

Second, diagnoses of diabetes and adverse outcomes were based on diagnosis and procedure codes from Medicare claims data designed for administrative rather than research purposes. Medicare claims data are highly specific in identifying diabetes and its adverse outcomes, but such data are insensitive, that is, often fail to capture diabetes when it is present. Having data from multiple years is helpful for improving sensitivity.[27] In addition, our claims data–derived DR rates among persons newly diagnosed with diabetes are comparable to clinical findings reported from the Diabetes Prevention Program,[28] which identified individuals with fasting plasma glucose levels just below American Diabetes Association–defined thresholds between 1996 and 1999, and monitored fasting plasma glucose levels at 6-month intervals to track the development of diabetes. At a mean follow-up of 5.6 years, prevalence of DR was assessed with fundus photography. Of those persons who had developed diabetes, prevalence of DR was 12.6%, which was comparable to 6-year rates for the 1994 and 1999 cohorts in our study.

Third, study outcomes can be ascertained only if patients see a physician. Failure to visit physicians at recommended intervals may lead to an underestimate of the rates of adverse outcomes. Low rates of adherence to diabetes guidelines have been documented.[20,29-31] Fourth, although a 6-year follow-up after the initial diagnosis of diabetes represents an improvement over most prior epidemiologic studies, a longer follow-up may have revealed different trends.

Finally, we excluded enrollees in Medicare risk plans. On average, enrollees in such plans tend to be healthier than those who remain in Medicare fee-for-service plans.[32] Although the second limitation may lead to an understatement of the true rates of diabetes and its adverse effects, the final limitation goes in the other direction.

In conclusion, rates of DR are decreasing among the US elderly persons, whereas indicators of primary care for diabetes, specifically improved use of eye care, monitoring of glucose levels and blood pressure, and treatment of hypertension, appear to be improving. Yet rates of other adverse outcomes related to diabetes have increased. Some evidence suggests DR may be especially sensitive to the control of glucose levels and blood pressure.[4,9] Thus, rates of diabetes-related eye disease may serve as an early indicator for improvements in primary care for diabetes. Further research is required to verify a link between improved primary care for diabetes in the Medicare population and reduced rates of specific adverse outcomes and to determine whether gains observed for DR will eventually be seen for other adverse outcomes related to diabetes.

Submitted for Publication: October 1, 2007; final revision received March 7, 2008; accepted March 13, 2008.
Correspondence: Frank A. Sloan, PhD, Campus Box 90253, 114 Rubenstein Hall, Center for Health Policy, Duke University, Durham, NC 27708 (fsloan@duke.edu).
Financial Disclosure: None reported.
Funding/Support: Partial support for this research came from the National Institute on Aging grant 2R37-AG-17473-05A1.

REFERENCES

1. Klein R. Has the frequency of proliferative diabetic retinopathy declined in the U.S.? *Diabetes Care*. 2003;26(9):2691-2692.
2. Sloan FA, Bethel MA, Ruiz D, et al. The growing burden of diabetes mellitus in the US elderly population [published correction appears in *Arch Intern Med*. 2008;168(8):860]. *Arch Intern Med*. 2008;168(2):192-199.
3. Epstein M, Sowers JR. Diabetes mellitus and hypertension. *Hypertension*. 1992; 19(5):403-418.
4. Klein R, Klein BEK. Relation of glycemic control to diabetic complications and health outcomes. *Diabetes Care*. 1998;21(suppl 3):C39-C43.
5. Lewis EJ, Hunsicker LG, Bain RP, et al. The effect of angiotensin-converting enzyme-inhibition on diabetic nephropathy. *N Engl J Med*. 1993;329(20):1456-1462.
6. Parving HH. Impact of blood-pressure and antihypertensive treatment on incipient and overt nephropathy, retinopathy, and endothelial permeability in diabetes-mellitus. *Diabetes Care*. 1991;14(3):260-269.
7. Snow V, Weiss KB, Mottur-Pilson C. The evidence base for tight blood pressure control in the management of type 2 diabetes mellitus. *Ann Intern Med*. 2003; 138(7):587-592.
8. UK Prospective Diabetes Study Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet*. 1998;352(9131): 837-853.
9. UK Prospective Diabetes Study Group. Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38. *BMJ*. 1998;317(7160):703-713.
10. Diabetes Control and Complications Trial Study Group. The relationship of glycemic exposure (HbA_{1c}) to the risk of development and progression of retinopathy in the Diabetes Control and Complications Trial. *Diabetes*. 1995;44(8):968-983.
11. Estacio RO, Gifford N, Jefers BW, Schrier R. Effect of blood pressure control on diabetic microvascular complications in patients with hypertension and type 2 diabetes. *Diabetes Care*. 2000;23(suppl 2):B54-B64.
12. Kohner EM, Aldington SJ, Stratton IM, et al. Diabetic retinopathy at diagnosis of non-insulin-dependent diabetes mellitus and associated risk factors. *Arch Ophthalmol*. 1998;116(3):297-303.
13. Stratton IM, Kohner EM, Aldington SJ, et al. UKPDS 50: risk factors for incidence and progression of retinopathy in type 2 diabetes over 6 years from diagnosis. *Diabetologia*. 2001;44(2):156-163.
14. Matthews DR, Stratton IM, Aldington SJ, Holman RR, Kohner EM; UK Prospective Diabetes Study Group. Risks of progression of retinopathy and vision loss related to tight blood pressure control in type 2 diabetes mellitus, UKPDS 69. *Arch Ophthalmol*. 2004;122(11):1631-1640.
15. Kempen JH, O'Colmain BJ, Leske MC, et al; Eye Disease Prevalence Research Group. The prevalence of diabetic retinopathy among adults in the United States. *Arch Ophthalmol*. 2004;122(4):552-563.
16. Sloan FA, Bethel MA, Lee PP, Brown DS, Feingloss MN. Adherence to guidelines and its effects on hospitalizations with complications of type 2 diabetes. *Rev Diabet Stud*. 2004;1(1):29-38.
17. World Health Organization. *International Classification of Diseases, Ninth Revision (ICD-9)*. Geneva, Switzerland: World Health Organization; 1977.
18. Lance LL, Lacy CH, Goldman MP, Armstrong LL, eds. *Quick Look Drug Book*. Philadelphia, PA: Lippincott Williams & Wilkins; 2006.
19. McClellan WM, Millman L, Presley R, Couzins J, Flander WD. Improved diabetes care by primary care physicians: results of a group-randomized evaluation of the Medicare Health Care Quality Improvement Program (HCQIP). *J Clin Epidemiol*. 2003;56(12):1210-1217.
20. McGlynn EA, Asch SM, Adams J, et al. The quality of health care delivered to adults in the United States. *N Engl J Med*. 2003;348(26):2635-2645.
21. Peters AL, Legorreta AP, Ossorio RC, et al. Quality of outpatient care provided to diabetic patients: a health maintenance organization experience. *Diabetes Care*. 1996;19(6):601-606.
22. Brown JB, Pedula KL, Summer KH. Diabetic retinopathy: contemporary prevalence in a well-controlled population. *Diabetes Care*. 2003;26(9):2637-2642.
23. Klein R, Klein BE, Moss SE, et al. The Wisconsin Epidemiologic Study of Diabetic Retinopathy, III: prevalence and risk of diabetic retinopathy when age at diagnosis is 30 or more years. *Arch Ophthalmol*. 1984;102(4):527-532.
24. Barr AG, Nathan DM, Meigs JB, Singer DE. Tests of glycemia for the diagnosis of type 2 diabetes mellitus. *Ann Intern Med*. 2002;137:E263-E272.
25. The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care*. 1997;20(12):1859-1862.
26. Dinneen SF, Maldonado D, Leibson CL, et al. Effects of changing diagnostic criteria in the risk of developing diabetes. *Diabetes Care*. 1998;21(9):1408-1413.
27. Hebert PL, Geiss LS, Tierney EF, Engelgau MM, Yawn P, McBean AM. Identifying persons with diabetes using Medicare claims data. *Am J Med Qual*. 1999; 14(6):270-277.
28. Diabetes Prevention Program Research Group. The prevalence of retinopathy in impaired glucose tolerance and recent-onset diabetes in the Diabetes Prevention Program. *Diabet Med*. 2007;24(2):137-144.
29. Kell SH, Drass J, Bausell R, Thomas KA, Osborn MA, Cohdes D. Measures of disease control in Medicare beneficiaries with diabetes mellitus. *J Am Geriatr Soc*. 1999;47(4):417-422.
30. Saaddine JB, Engelau MM, Beckles GL, Gregg EW, Thompson TJ, Narayan KMV. A diabetes report card for the United States: quality of care in the 1990s. *Ann Intern Med*. 2002;136(8):565-574.
31. Lee PP, Feldman ZW, Ostermann J, Brown DS, Sloan FA. Longitudinal rates of annual eye examinations of persons with diabetes and chronic eye diseases. *Ophthalmology*. 2003;110(10):1952-1959.
32. Morgan RO, Virnig BA, DeVito CA, Persily NA. The Medicare-HMO revolving door: the healthy go in and the sick go out. *N Engl J Med*. 1997;337(3):169-175.