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Diabetes Mellitus Care Provided by Nurse Practitioners vs Primary Care Physicians

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Abstract

Objectives—To compare processes and cost of care of older adults with diabetes mellitus cared for by nurse practitioners (NPs) with processes and cost of those cared for by primary care physicians (PCPs).

Design—Retrospective cohort study.

Setting—Primary care in communities.

Participants—Individuals with a diagnosis of diabetes mellitus in 2009 who received all their primary care from NPs or PCPs were selected from a national sample of Medicare beneficiaries (N = 64,354).

Measurements—Propensity score matching within each state was used to compare these two cohorts with regard to rate of eye examinations, low-density lipoprotein cholesterol (LDL-C) and glycosylated hemoglobin (HbA1C) testing, nephropathy monitoring, specialist consultation, and Medicare costs. The two groups were also compared regarding medication adherence and use of statins, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers (for individuals with a diagnosis of hypertension), and potentially inappropriate medications (PIMs).

Results—Nurse practitioners and PCPs had similar rates of LDL-C testing (odds ratio (OR) = 1.01, 95% confidence interval (CI) = 0.94–1.09) and nephropathy monitoring (OR = 1.05, 95% CI = 0.98–1.03), but NPs had lower rates of eye examinations (OR = 0.89, 95% CI = 0.84–0.93) and HbA1C testing (OR = 0.88, 95% CI = 0.79–0.98). NPs were more likely to have consulted

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cardiologists (OR = 1.29, 95% CI = 1.21–1.37), endocrinologists (OR = 1.64, 95% CI = 1.48–1.82), and nephrologists (OR = 1.90, 95% CI = 1.67–2.17) and more likely to have prescribed PIMs (OR = 1.07, 95% CI = 1.01–1.12). There was no statistically significant difference in adjusted Medicare spending between the two groups ($P = .56$).

Conclusion—Nurse practitioners were similar to PCPs or slightly lower in their rates of diabetes mellitus guideline–concordant care. NPs used specialist consultations more often but had similar overall costs of care to PCPs.

Keywords

nurse practitioner; diabetes mellitus; primary care; Medicare

An increasing number of individuals living with diabetes mellitus receive their primary care from non-physician clinicians. This trend is in part due to a decreasing number of primary care physicians (PCPs), a growing rural–urban disparity in physician distribution, and rising healthcare costs.¹ In view of these changes, it is important to examine whether there are differences in the processes and outcomes of healthcare delivery between physicians and nurse practitioners (NPs) because they undergo different training. Older adults with diabetes mellitus may be particularly difficult to manage. Age-related changes in pharmacokinetics, along with their higher rate of comorbid diseases and receipt of concomitant medications, place older adults at substantially greater risk of complications from diabetes mellitus, polypharmacy, and adverse drug events.^{2,3} Having access to primary care has been shown to improve adherence to American Diabetes Association diabetes mellitus guidelines for optimal care.⁴ No nationally representative studies have compared processes of care provided to older adults with diabetes mellitus by NPs and processes of care provided by PCPs.

Findings from past studies comparing quality of care delivered by NPs and physicians have been mixed. A recent meta-analysis of 24 randomized controlled trials (RCTs) with a total of 38,974 participants of all ages seeking care for all conditions reported that NP care was associated with higher overall survival and lower hospitalization rates for subgroups of participants, with conflicting findings on costs of care.⁵ Another systematic review and meta-analysis of 11 RCTs ($N = 30,247$) comparing NP with PCP care found no statistically significant differences in diastolic blood pressure, total cholesterol, or glycosylated hemoglobin (HbA1c).⁶

Several factors may account for the mixed findings from studies comparing NPs with physicians. Most of the trials had small sample sizes, with 10 of 11 RCTs having fewer than 200 participants per group and a high dropout rate. Only two RCTs were conducted in the United States. Participants and clinicians were clustered in geographically selected healthcare settings, systems, and practices.^{6,7} The generalizability of these findings to adults aged 65 and older in the United States is limited because most of the studies were based on data from predominantly younger subjects and from clinics affiliated with academic hospitals or Veterans Affairs clinics.⁸ To address this knowledge gap, the current study of a large, nationally representative cohort of older adults with diabetes mellitus examined the differences in the processes and cost of care provided by NPs and PCPs. It was hypothesized

that individuals with diabetes mellitus cared for by NPs would receive care similar to that of those cared for by PCPs but at a lower cost.

Methods

Establishment of the Study Cohorts

First, all Medicare beneficiaries with diabetes mellitus in 2009 were identified from the Centers for Medicare and Medicaid Services (CMS) Chronic Disease Data Warehouse (CCDW).⁹ Next, to select the NP cohort, all Medicare beneficiaries who received all of their primary care from NPs in 2009 were identified by selecting individuals with billing records for two or more outpatient evaluation and management (E&M) services by NPs and no outpatient E&M services from PCPs (general practitioner, family physician, general internist, geriatrician). Next, to select the physician cohort, individuals cared for by PCPs were identified using a 5% national sample of Medicare data. These individuals had at least two outpatient E&M services from PCPs and no outpatient E&M services from NPs in 2009. For both groups, individuals younger than 66; those with incomplete enrollment in Medicare Parts A, B, and D in 2008 and 2009; and those with enrollment based on original entitlement of disability or end-stage renal disease were excluded. Individuals who were covered by health maintenance organizations (HMOs) any time in 2008 and 2009 and those who stayed in a nursing home in 2009 were also excluded. The study cohort was limited to those who were taking any medication for diabetes mellitus in 2009.

Measurements

Information on participant age, sex, and race was obtained from Medicare enrollment files. A Medicaid eligibility indicator in the enrollment file was used as a proxy for low income. The Elixhauser comorbidity measures¹⁰ were generated from inpatient facility (Medicare Provider Analysis and Review files), outpatient facility (Outpatient Standard Analytical Files), and professional claims (Carrier files) in 2008. Each comorbidity was added separately as a covariate in the analyses. Complications of diabetes mellitus and uncontrolled diabetes mellitus were identified using *International Classification of Diseases, Ninth Revision* (ICD-9) codes (Appendix 1). The size of residential area was categorized using Rural-Urban Continuum Codes that distinguish metropolitan counties according to size and nonmetropolitan counties according to degree of urbanization and proximity to metropolitan areas.¹¹ State regulations on NP practice were classified into five categories from least to most restricted.^{12,13}

Study Outcomes

For processes of care, the Healthcare Effectiveness Data and Information Set (HEDIS) diabetes mellitus comprehensive care measures were adapted to assess annual eye examinations, LDL-C screening, HbA1C tests, and nephropathy monitoring, based on billed claims following HEDIS specifications.¹⁴ Receipt of examinations and tests was assessed regardless of who provided them (NP, PCP or some other provider). The frequency of provider visits and the use of specialist consultations was also evaluated. The Modified Modified Continuity Index (MMCI) was used to measure continuity of care.¹⁵ A higher

MMCI indicates better care continuity, which has been shown to be associated with better health outcomes and patient satisfaction in primary care practice.¹⁶

Measures in medication management endorsed by the National Quality Forum were selected.¹⁷ The use of statins was examined for all participants and the use of angiotensin-converting enzyme inhibitors (ACEIs) or angiotensin receptor blockers (ARBs) for participants with a diagnosis of hypertension. The diabetes mellitus medication possession ratio (MPR), a measure of medication adherence, was also examined. Measures of medication safety examined use of potentially inappropriate medications (PIMs) and use of antimicrobials known to have possible adverse interactions with sulfonylureas.^{18–20} The Beers criteria 2003 list of inappropriate medications in older adults was used to define PIMs¹⁸ and the antimicrobials (including fluconazole, sulfamethoxazole, metronidazole, moxifloxacin, ciprofloxacin, clarithromycin and levofloxacin) were identified from published studies.^{19,20}

Finally, Medicare costs in 2009 were estimated according to the Medicare paid amount in the Medicare Provider Analysis and Review files, Outpatient Standard Analytical Files, and Carrier files, following the payment calculation worksheets provided by the Research Data Assistance Center.

Statistical Analyses

The nonpooling approach of propensity score analysis was used to assess differences in processes of care between individuals cared for by NPs and PCPs.²¹ In these analyses, the likelihood that a participant would be cared for by an NP was calculated from a logistic regression model that incorporated the participant characteristics listed in Table 1 for each state. This approach controlled for the effect of state regulations intrinsically by balancing state-level characteristics that affect receiving care from NPs. Participants in the PCP group were matched to those in the NP group based on state-specific propensity scores. A 1:1 matching algorithm, without replacement, was adopted based on the nearest Mahalanobis metric within the calipers of width equal to 0.10 of the standard deviation of the logit of the nonpooling propensity score.^{22,23} Conditional logistic models were used for binary outcomes and general linear mixed models for continuous outcomes. A two-part conditional model that included a logit model in the first part (which estimated the percentage of participants with any Medicare costs) and a log gamma model in the second part (which estimated the average costs in those participants) was used to estimate differences in Medicare costs in 2009 dollars.²⁴

Overall, 87.0% of participants from the NP group and 26.0% of those from the PCP group in the unmatched study cohort met the criteria for the main analyses. The unmatched study cohort was also analyzed using a multi-variable logistic regression model and a general linear model to study the average differences between the two groups. All analyses were performed using SAS version 9.3 (SAS Institute, Inc., Cary, NC). All statistical tests were two-sided, with $P < .05$ considered to be statistically significant.

Results

The study cohort included 14,811 Medicare beneficiaries with diabetes mellitus who received primary care from NPs and 49,543 from PCPs. Table 1 shows the characteristics of these individuals stratified according to provider type (NP, PCP). Before nonpooling propensity score matching, participants in the NP group were more likely to be female, younger, and impoverished and to reside in nonurban areas and in states with fewer restrictions on the scope of NP practice. They were less likely to be minorities and had fewer comorbidities, complications of diabetes mellitus, hospitalizations, and provider visits in the previous year than those in the PCP group. After nonpooling propensity score matching, participants in both groups were well balanced regarding age, sex, race, Medicaid eligibility, complications of diabetes mellitus, and uncontrolled diabetes mellitus, but participants in the NP group had fewer comorbidities, fewer primary care provider visits, and fewer hospitalizations in the previous year.

Table 2 shows the processes of care according to provider type. The unadjusted and adjusted results were calculated for each measure in unmatched and matched study cohorts. For the matched analyses, participants in the NP group were less likely to have an eye examination (odds ratio (OR) = 0.89, 95% confidence interval (CI) = 0.84–0.93) or HbA1C test (OR = 0.88, 95% CI = 0.79–0.98). The odds of receiving an LDL-C test (OR = 1.01, 95% CI = 0.94–1.09) or nephropathy monitoring (OR = 1.05, 95% CI = 0.98–1.03) were not significantly different between the two groups.

Participants in the NP group had a similar number of provider visits (9.0 ± 6.5) as those in the PCP group (9.2 ± 6.3) ($P = .19$) and slightly lower continuity of care (0.72 ± 0.21 vs 0.75 ± 0.20 , $P < .001$) but were more likely to receive specialist consultations for cardiologists (OR = 1.29, 95% CI = 1.21–1.37), endocrinologists (OR = 1.64, 95% CI = 1.48–1.82), and nephrologists (OR = 1.90, 95% CI = 1.67–2.17).

Table 3 shows diabetes mellitus medication management according to provider type. The unadjusted and adjusted results were determined for each measure in unmatched and matched study cohorts. For the matched analyses, participants in the NP group had slightly lower adherence to diabetes mellitus medication (MPR 73.7 ± 23.0 vs 74.8 ± 22.2 , $P < .001$) and were less likely to be prescribed statins (OR = 0.94, 95% CI = 0.89–0.99). Participants in the NP (31.3%) and PCP (30.6%) groups had a high rate of exposure to PIMs, although NP participants were slightly more likely to be prescribed PIMs (OR = 1.07, 95% CI = 1.01–1.12). The two groups did not differ significantly in prescribing ACEIs or ARBs for participants with hypertension or in prescribing antimicrobials known to have possible adverse drug interactions with sulfonylureas.

Table 4 compares Medicare spending for participants cared for by NPs and PCPs. Spending was also stratified according to type of service (e.g., professional charge, hospitalization). For the matched analysis, the adjusted Medicare spending was similar between participants cared for by NPs and PCPs ($P = .56$). The costs for primary care professional services and inpatient care were significantly lower for the NP group ($P < .001$), but the outpatient facility costs were significantly higher ($P < .001$). The higher outpatient facility costs were

from charges for rural hospitals, freestanding clinics, laboratory tests, cardiology tests, and medications.

Discussion

Other than LDL-C screening, the findings on the rate of older individuals with diabetes mellitus receiving recommended processes of care were close to provider recognition program criteria or the national benchmark for health plan accreditation of the National Committee for Quality Assurance (eye examination, 60%; nephropathy monitoring, 80%; HbA1c test, 94%; LDL-C screening, 93%).^{25,26} Similarly, the rate of adherence to diabetes mellitus medications (MPR) was approximately 75%, which was somewhat below the target of 80% reported by the National Quality Forum 2010 report for individuals with diabetes mellitus aged 18–75.²⁷ Participants receiving care from NPs were less likely than those receiving care from PCPs to have undergone eye examinations and HbA1c testing but as likely to have a lipid test and nephropathy monitoring. Findings from past studies have been mixed, with some showing NPs having rates of eye examinations and tests equivalent to or higher than those of PCPs, whereas others showed the opposite.^{4–7,28} One study⁷ comparing practices with NPs with physician-only practices found that practices with NPs were more likely to assess HbA1c and lipids. Another study²⁸ also showed that NPs ordered HbA1c tests and urinalysis more often than physicians. It is not clear whether differences in processes of care between NPs and PCPs affect outcomes such as emergency department and urgent care visits.

It was also found that participants cared for by NPs were more likely to have been referred to cardiologists, endocrinologists, and nephrologists than participants cared for by PCPs. The higher use of consulting and outpatient facilities by participants cared for by NPs is consistent with past studies,^{1,29} although a randomized trial comparing NP with PCP quality of care showed that individuals who saw NPs and physicians had similar numbers of hospitalizations and outpatient visits for primary care, specialty care, and emergency and urgent care.³⁰ A study³¹ showed that care received in a nurses-led clinic under the supervision of a diabetologist resulted in better diabetes mellitus control outcomes. The more-frequent specialist consultations associated with NP care may reflect a process necessary, in this provider group, to access the expertise and skills of physicians. Higher proportions of participants cared for by NPs experienced renal failure and pulmonary circulation disease. The frequent specialist consultations suggest that NPs recognize limitations in their training when caring for medically complex individuals with multiple comorbidities. It is important that state regulations allow and encourage NPs to make referrals to specialist consultants independently. This is consistent with the Institute of Medicine recommendation on liberalizing state laws regulating the practice of NPs in the 2010 report *The Future of Nursing*.³²

The rate of use of PIMs was close to that in a previous study.³³ Some of these medications prolong hypoglycemia in individuals with diabetes mellitus. Other medications on the Beers list could be used for common comorbidities associated with diabetes mellitus, such as depression and hypertension. Safe alternatives for these medications exist. Individuals with diabetes mellitus are at high risk of falls, orthostatic hypotension, gastrointestinal autonomic

dysfunction, and other diabetes mellitus–related complications. Many of the Beers PIMs increase the risks of these complications in elderly adults.³⁴ The current study showed a slightly higher rate of use of PIMs in participants cared for by NPs. Although the difference was small, the effect on individuals receiving these medications could be severe. An analysis of prescription data from the National Ambulatory Medical Care Survey database of individuals seen by NPs, physician assistants, and physicians showed that NPs had the highest mean number of prescriptions written per primary care visit for individuals in rural areas.³⁵ The involvement of specialists can increase the risk of polypharmacy and potential adverse drug events.

The findings of similar cost of care between individuals cared for by NPs and PCPs are consistent with past studies.^{8,36,37} A Cochrane meta-analysis showed that participants receiving care from NPs had longer clinic visits and higher frequency of return visits, with no difference in cost.⁸ The longer consultation time and greater number of clinic visits associated with NP care may be necessary for older adults with diabetes mellitus, given that this group requires time to coordinate care and visits with various consultants (e.g., podiatry and ophthalmology); carefully monitor complications and comorbidities; manage complex drug regimens; and address social, psychological, and functional concerns.

The study has several limitations. First, NPs may deliver care to healthier, less medically complex individuals than PCPs, but comparing results from unmatched analyses shows that nonpooling propensity score matching reduced the differences between the two groups on several measurements for disease and medication management. Selection bias may explain the lower rate of eye examinations, HbA1c tests, and statin prescriptions in the NP group, although if NPs care for less medically complex individuals needing simpler medication regimens, the bias may be in the direction of underestimating the use of PIMs. Second, to reduce heterogeneity in the study population between NPs and PCPs, only individuals taking diabetes mellitus medication were included, not those controlled using diet alone. Third, the cost estimation did not include costs associated with home health care, durable equipment, or medication. Fourth, because there was no access to laboratory data, it was not possible to assess the degree to which diabetes mellitus was adequately controlled in the two groups completely. Fifth, only the pattern of care for which claims are generated was examined. Other care patterns, such as foot care or dietary advice, which is generally included in routine care, cannot be assessed. Sixth, the cross-sectional study design limited the ability to examine temporal patterns of the study variables. Further longitudinal study will help to characterize the differences in care delivery between NPs and PCPs and the effect of these differences on outcomes. Last, many participants receiving care from NPs also received care from PCPs,¹³ but this group was excluded from the analyses. Their results may be different. It also could not be distinguished whether NPs practiced in exclusive NP clinics (e.g., rural health clinics or retail clinics) or collaborative practices.

In conclusion, overall delivery of diabetes mellitus care was similar for NPs and PCPs. Both groups had high rates of prescribing of PIMs and medications with potential interactions. These rates underscore the need to design and implement more-effective medical and advanced nursing education programs to improve the appropriateness and safety of prescribing by primary care providers of older adults living with diabetes mellitus. Future

studies are needed to evaluate the cost-effectiveness, the reasons for frequent use of specialist consultation, and the necessity of outpatient facility charges. This information will help further clarify the differences in processes and cost of care between the two groups. In view of the growing role of NPs in the United States, further population-based studies assessing quality and outcomes of NP and PCP care are needed to guide reform of healthcare policy, delineate the scope of practice of different primary care providers, and develop age-appropriate clinical practice guidelines.

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Appendix 1

Definition of Complications of Diabetes Mellitus and Uncontrolled Diabetes Mellitus

Diagnostic Category	International Classification of Diseases, Ninth Revision, Clinical Modification Codes	Description
Complications of diabetes mellitus	249.4X, 249.5X, 249.6X, 249.8X, 249.9X	Secondary diabetes mellitus with renal manifestations, ophthalmic manifestations, neurologic manifestations, other specified manifestations and unspecified manifestations
	250.4X, 250.5X, 250.6X, 250.8X, 250.9X	Diabetes mellitus with renal manifestations, ophthalmic manifestations, neurologic manifestations, other manifestations and unspecified complication
	357.2, 362.01, 362.02, 362.03, 362.04, 362.05, 362.06, 366.41	Polyneuropathy in diabetes mellitus, background diabetic retinopathy, proliferative diabetic retinopathy, nonproliferative diabetic retinopathy (not otherwise specified), mild nonproliferative diabetic retinopathy, moderate nonproliferative diabetic retinopathy, severe nonproliferative diabetic retinopathy and diabetic cataract
Uncontrolled diabetes mellitus	249.01, 249.11, 249.21, 249.31, 249.41, 249.51, 249.61, 249.71, 249.81, 249.91	Secondary diabetes mellitus without mention of complication (uncontrolled); secondary diabetes mellitus with ketoacidosis (uncontrolled), hyperosmolarity (uncontrolled), other coma (uncontrolled), renal manifestations (uncontrolled), ophthalmic manifestations (uncontrolled), neurologic manifestations (uncontrolled), peripheral circulatory disorders (uncontrolled), other specified manifestations (uncontrolled) and unspecified complication (uncontrolled)
	250.02, 250.03, 250.12, 250.13, 250.22, 250.23, 250.32, 250.33, 250.42, 250.43, 250.52, 250.53, 250.62, 250.63, 250.72, 250.73, 250.82, 250.83, 250.92, 250.93	Diabetes mellitus without complication type II or unspecified type uncontrolled, diabetes mellitus without complication type I uncontrolled; diabetes mellitus with ketoacidosis type II or unspecified type uncontrolled, ketoacidosis type I uncontrolled, hyperosmolarity type II or unspecified type uncontrolled, hyperosmolarity type I uncontrolled, other coma type II or unspecified type uncontrolled, other coma type I uncontrolled, renal manifestations II or unspecified type uncontrolled, renal

Diagnostic Category	International Classification of Diseases, Ninth Revision, Clinical Modification Codes	Description
		manifestations I uncontrolled, ophthalmic manifestations type II or unspecified type uncontrolled, ophthalmic manifestations type I uncontrolled, neurologic manifestations type II or unspecified type uncontrolled, neurologic manifestations type I uncontrolled, peripheral circulatory disorders type II or unspecified type uncontrolled, peripheral circulatory disorders type I uncontrolled, unspecified complication type II or unspecified type uncontrolled and unspecified complication type I uncontrolled

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Table 1
Characteristics of Participants with Diabetes Mellitus Stratified According to Whether They Received Primary Care from Nurse Practitioners (NPs) or Primary Care Physicians (PCPs)

Characteristic	Before Matching			After Matching ^a		
	NP, n = 14,811	PCP, n = 49,543	P-Value	NP, n = 12,882	PCP, n = 12,882	P-Value
Age, mean ± SD	76.2 ± 6.2	77.6 ± 6.5	<.001	76.4 ± 6.2	76.5 ± 6.2	.11
Sex, %						
Male	32.2	33.9	<.001	32.6	32.9	.59
Female	67.8	66.1		67.4	67.1	
Race, %						
Non-Hispanic white	80.5	74.1	<.001	80.7	80.2	.70
Black	10.2	9.7		10.3	10.5	
Hispanic	6.2	9.5		6.4	6.7	
Other	3.1	6.7		2.6	2.6	
Medicaid eligibility, %						
Yes	32.1	28.1	<.001	29.3	29.7	.53
No	67.9	71.9		70.7	70.3	
Number of provider visits in prior year, mean ± SD	8.5 ± 6.5	10.2 ± 7.7	<.001	8.5 ± 6.4	8.7 ± 6.1	.02
Comorbidities, %						
Congestive heart failure	9.5	10.2	.01	8.9	9.5	.08
Valve disease	4.2	5.4	<.001	3.8	4.0	.27
Pulmonary circulation disease	1.5	1.3	.03	1.5	1.2	.12

Characteristic	Before Matching				After Matching ^d			
	NP, n = 14,811	PCP, n = 49,543	P-Value	NP, n = 12,882	PCP, n = 12,882	P-Value	NP, n = 12,882	P-Value
Peripheral vascular disease	8.7	11.0	<.001	8.4	8.6		8.6	.45
Hypertension	76.9	81.2	<.001	76.9	79.2		79.2	<.001
Paralysis	0.8	0.9	.06	0.7	0.8		0.8	.25
Neurological disorder	3.3	3.9	<.001	2.9	3.7		3.7	<.001
Chronic pulmonary disease	11.6	12.0	.17	11.1	11.4		11.4	.41
Hypothyroidism	12.3	14.0	<.001	11.7	13.0		13.0	.001
Renal failure	10.1	9.3	.004	9.5	8.3		8.3	<.001
Liver disease	0.9	1.0	.21	0.8	0.8		0.8	.83
Peptic ulcer	0.04	0.04	.99	0.03	0.04		0.04	>.99
Acquired immunodeficiency syndrome	0.07	0.04	.08	0.08	0.05		0.05	.45
Lymphoma	0.9	0.6	<.001	0.9	0.6		0.6	.001
Metastatic cancer	0.7	0.6	.03	0.7	0.5		0.5	.11
Solid tumor with or without metastasis	7.0	7.8	.003	7.0	6.4		6.4	.04
Rheumatoid arthritis	2.0	2.8	<.001	1.8	2.3		2.3	.003
Coagulopathy	1.6	1.8	.10	1.6	1.3		1.3	.12
Obesity	4.6	4.1	.02	4.2	4.2		4.2	.93
Weight loss	1.2	1.3	.74	1.2	1.1		1.1	.91
Fluid and electrolyte disorders	7.3	8.1	.002	6.8	7.6		7.6	.01
Chronic blood loss anemia	0.6	1.0	<.001	0.5	0.8		0.8	.001
Deficiency anemia	14.4	17.8	<.001	13.8	14.7		14.7	.03

Characteristic	Before Matching			After Matching ^d		
	NP, n = 14,811	PCP, n = 49,543	P-Value	NP, n = 12,882	PCP, n = 12,882	P-Value
Alcohol abuse	0.2	0.2	.10	0.2	0.2	.89
Drug abuse	0.1	0.1	.41	0.1	0.1	.70
Psychosis	1.9	2.3	.002	1.9	2.2	.08
Depression	4.2	3.7	.006	3.8	3.8	.90
Number of comorbidities, mean $\pm$ SD	1.9 $\pm$ 1.6	2.0 $\pm$ 1.6	<.001	1.8 $\pm$ 1.5	1.9 $\pm$ 1.6	.001
Complications of diabetes mellitus, %						
Yes	37.7	39.1	.003	37.0	38.0	.13
No	62.3	60.9		63.0	62.0	
Uncontrolled diabetes mellitus, %						
Yes	41.0	39.2	<.001	39.3	40.0	.25
No	59.0	60.8		60.7	60.0	
Number of hospitalizations in prior year, %						
0	80.0	78.2	<.001	81.0	79.4	.002
1	13.3	14.5		12.9	13.5	
2	4.1	4.6		3.8	4.3	
3	2.6	2.7		2.3	2.8	
Location, %						
Metropolitan	52.3	79.5	<.001	57.6	57.4	.84
Nonmetropolitan urban	39.9	18.5		37.0	37.3	
Rural	7.8	2.0		5.4	5.3	

Characteristic	Before Matching			After Matching ^a		
	NP, n = 14,811	PCP, n = 49,543	P-Value	NP, n = 12,882	PCP, n = 12,882	P-Value
State regulations on NP, %						
1 (least restrictive)	15.9	7.9	<.001	14.2	14.2	>.99
2	15.3	15.8		16.2	16.2	
3	30.0	29.1		26.8	26.8	
4	22.8	24.9		25.1	25.1	
5 (most restrictive)	16.0	22.3		17.7	17.7	

SD = standard deviation.

Groups of participants with primary care from NP or PCP were compared using *t*-test and chi-square test for any difference where appropriate.

^aNonpooling propensity score matching within a state was implemented.

Differences in Processes of Care Between Nurse Practitioners (NPs) and Primary Care Physicians (PCPs)**Table 2**

Process of Care	Before Matching			After Matching ^d		
	NP, n = 14,811	PCP, n = 49,543	OR (95% CI) ^b	NP, n = 12,882	PCP, n = 12,882	OR (95% CI) ^c
Diabetes mellitus care (%)						
Eye examination	57.1	61.7	0.89 (0.85–0.92)	57.3	60.2	0.89 (0.84–0.93)
Lipid test	84.7	85.9	0.97 (0.91–1.02)	85.3	85.1	1.01 (0.94–1.09)
Glycosylated hemoglobin test	92.6	93.3	0.90 (0.84–0.97)	92.9	93.8	0.88 (0.79–0.98)
Monitoring nephropathy	84.9	85.4	1.06 (1.01–1.13)	84.7	84.4	1.05 (0.98–1.03)
Specialist consultation (%)						
Endocrinologist	9.7	8.1	1.63 (1.52–1.75)	10.1	6.6	1.64 (1.48–1.82)
Cardiologist	32.0	32.2	1.26 (1.20–1.32)	32.4	28.3	1.29 (1.21–1.37)
Nephrologist	9.7	6.3	1.97 (1.82–2.14)	9.5	5.4	1.90 (1.67–2.17)
Number of provider visits						
Mean ± SD	9.0 ± 6.5	10.5 ± 7.6	–0.21 (–0.30 to –0.11)	9.0 ± 6.5	9.2 ± 6.3	–0.08 (–0.19–0.03)
Median (IQR)	7(5–11)	9 (5–13)		7(5–11)	8 (5–12)	
Continuity of care (range 0–1) ^d						
Mean ± SD	0.72 ± 0.21	0.75 ± 0.19	–0.031 (–0.035 to –0.027)	0.72 ± 0.21	0.75 ± 0.20	–0.029 (–0.034 to –0.024)
Median (IQR)	0.72 (0.58–0.88)	0.76 (0.63–0.88)		0.72 (0.59–0.88)	0.76 (0.63–0.90)	

OR = odds ratio; CI = confidence interval; SD = standard deviation; IQR = interquartile range.

^aNonpooling propensity score matching within a state was implemented.

^bMultivariable analyses were adjusted for age, sex, race, Medicaid eligibility, provider visits in prior year, comorbidities, complications of diabetes mellitus, uncontrolled diabetes mellitus, hospitalization in prior year, urban or rural residential area, and state NP regulation.

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^c Conditional logistic regression was adjusted for clustering within states for residential areas, comorbidity, provider visits, and hospitalization in prior year. Only comorbidity measures that were significantly different between two groups after matching were adjusted.

^d The Modified Modified Continuity Index is based on the number of providers and number of visits. It measures the dispersion of care among providers. Index values range from 0 (each visit made to a different physician) to 1 (all visits made to a single physician).

Table 3
Differences in Medication Management Between Nurse Practitioners (NPs) and Primary Care Physicians (PCPs)

Medication Management	Before Matching			After Matching ^d		
	NP, n = 14,811	PCP, n = 49,543	OR (95% CI) ^b	NP, n = 12,882	PCP, n = 12,882	OR (95% CI) ^c
Diabetes mellitus medication possession ratio						
Mean ± SD	73.7 ± 22.9	74.2 ± 22.6	-1.01 (-1.45 to -0.58)	73.7 ± 23.0	74.8 ± 22.2	-1.08 (-1.62 to -0.54)
Median (interquartile range)	83.3 (63.3–90.7)	83.0 (64.7–90.7)		83.3 (63.3–90.7)	83.6 (65.8–90.7)	
Use of statin (%)	66.7	68.2	0.96 (0.92–1.00)	66.9	68.3	0.94 (0.89–0.99)
Angiotensin-converting enzyme inhibitor or angiotensin receptor blocker, % ^d	71.5	71.4	1.00 (0.96–1.05)	71.6	71.4	1.00 (0.93–1.07)
Use of PIM, % ^e	32.1	30.1	1.08 (1.03–1.12)	31.3	30.6	1.07 (1.01–1.12)
Use of antimicrobial known to have adverse drug interaction with sulfonyleurea, % ^f	26.8	25.3	1.11 (1.04–1.18)	26.2	24.8	1.07 (0.95–1.21)

OR = odds ratio; CI = confidence interval.

^aNonpooling propensity score matching within a state was implemented.^bMultivariable analyses were adjusted for age, sex, race, Medicaid eligibility, provider visits in prior year, comorbidity measures, complications of diabetes mellitus, uncontrolled diabetes mellitus, hospitalization in prior year, rural vs urban residential area, and state NP regulation.^cConditional logistic regression was adjusted for clustering within states of residential areas, comorbidity, provider visits, and hospitalization in prior year. Only comorbidity measures that were significantly different between two groups after matching were adjusted.^dThe corresponding results were produced in participants with hypertension.^eUse of potentially inappropriate medication (PIM) was based on the Beers criteria, which include medications and drug-disease combination with a high risk-benefit ratio for older adults.^fThese analyses were performed only with participants receiving sulfonyleureas.

Table 4
Difference in Medical Cost Between Participants Cared for by Nurse Practitioners (NPs)
and Primary Care Physicians (PCPs)

	Before Matching		After Matching ^a	
	NP, n = 14,811	PCP, n = 49,543	NP, n = 12,882	PCP, n = 12,882
Type of Service	Medical Cost, \$ (95% Confidence Interval)			
Professional services				
Primary care	425 (420–431)	583 (578–587)	418 (407–429)	578 (562–594)
Specialists	1,564 (1,534–1,595)	1,505 (1,490–1,520)	1,428 (1,377–1,481)	1,355 (1,306–1,405)
Other	567 (556–577)	611 (606–617)	515 (501–530)	540 (525–555)
Outpatient facilities	1,539 (1,503–1,575)	1,192 (1,177–1,208)	1,551 (1,492–1,613)	1,253 (1,204–1,304)
Hospitalization	2,648 (2,566–2,733)	2,762 (2,720–2,806)	2,543 (2,434–2,656)	2,796 (2,685–2,912)
Other facilities	607 (574–643)	606 (587–625)	639 (599–682)	718 (675–765)
Total costs	7,183 (7,039–7,323)	7,088 (7,013–7,165)	6,864 (6,634–7,103)	6,965 (6,731–7,208)

Adjusted medical cost was estimated from a two-part gamma model controlling for age, sex, race, Medicaid eligibility, provider visits in prior year, comorbidity measures, complications of diabetes mellitus, uncontrolled diabetes mellitus, hospitalization in prior year, rural vs urban residential area, and state NP regulation.

^aNonpooling propensity score matching within a state was implemented.