Annals of Internal Medicine ORIGINAL RESEARCH

Intermediate Diabetes Outcomes in Patients Managed by Physicians, Nurse Practitioners, or Physician Assistants

A Cohort Study

George L. Jackson, PhD, MHA; Valerie A. Smith, DrPH; David Edelman, MD, MHS; Sandra L. Woolson, MPH; Cristina C. Hendrix, DNS, GNP-BC; Christine M. Everett, PhD, MPH, PA-C; Theodore S. Berkowitz, MS; Brandolyn S. White, MPH; and Perri A. Morgan, PhD, PA-C

Background: Primary care provided by nurse practitioners (NPs) and physician assistants (PAs) has been proposed as a solution to expected workforce shortages.

Objective: To examine potential differences in intermediate diabetes outcomes among patients of physician, NP, and PA primary care providers (PCPs).

Design: Cohort study using data from the U.S. Department of Veterans Affairs (VA) electronic health record.

Setting: 568 VA primary care facilities.

Patients: 368 481 adult patients with diabetes treated pharmaceutically.

Measurements: The relationship between the profession of the PCP (the provider the patient visited most often in 2012) and both continuous and dichotomous control of hemoglobin A_{1c} (HbA_{1c}), systolic blood pressure (SBP), and low-density lipoprotein cholesterol (LDL-C) was examined on the basis of the mean of measurements in 2013. Inverse probability of PCP type was used to balance cohort characteristics. Hierarchical linear mixed models and logistic regression models were used to analyze continuous and dichotomous outcomes, respectively.

Results: The PCPs were physicians (n = 3487), NPs (n = 1445), and PAs (n = 443) for 74.9%, 18.2%, and 6.9% of patients, respectively. The difference in HbA_{1c} values compared with physicians was −0.05% (95% CI, −0.07% to −0.02%) for NPs and 0.01% (CI, −0.02% to 0.04%) for PAs. For SBP, the difference was −0.08 mm Hg (CI, −0.34 to 0.18 mm Hg) for NPs and 0.02 mm Hg (CI, −0.42 to 0.38 mm Hg) for PAs. For LDL-C, the difference was 0.01 mmol/L (CI, 0.00 to 0.03 mmol/L) (0.57 mg/dL [CI, 0.03 to 1.11 mg/dL]) for NPs and 0.03 mmol/L (CI, 0.01 to 0.05 mmol/L) (1.08 mg/dL [CI, 0.25 to 1.91 mg/dL]) for PAs. None of these differences were clinically significant.

Limitation: Most VA patients are men who receive treatment in a staff-model health care system.

Conclusion: No clinically significant variation was found among the 3 PCP types with regard to diabetes outcomes, suggesting that similar chronic illness outcomes may be achieved by physicians, NPs, and PAs.

Primary Funding Source: VA Health Services Research and Development.

Ann Intern Med. 2018;169:825-835. doi:10.7326/M17-1987 **Annals.org**
For author affiliations, see end of text.
This article was published at Annals.org on 20 November 2018.

Almost a third of adults who say they have a regular health care provider visit a physician assistant (PA) or advanced practice nurse, such as a nurse practitioner (NP), at least once each year (1), and almost half of U.S. patients with diabetes see an NP or a PA for some part of their care (2). Approximately a third of primary care visits in both the U.S. Department of Veterans Affairs (VA) health care system and community health centers are with NPs or PAs (3, 4). The role of nonphysician primary care providers (PCPs) continues to expand (5, 6). However, concerns have long been expressed as to whether the outcomes achieved by NPs and PAs are equivalent to those of physicians (7–10). Further, few studies have compared chronic illness outcomes of primary care provided by PAs versus NPs or physicians (11, 12).

The purpose of this study was to examine whether intermediate diabetes outcomes differ among physician, NP, and PA PCPs. Our study improved on previous methods by accounting for case-mix differences in medical and social complexity among patients of each provider type, using a national sample, requiring a period of continuous primary care long enough for a PCP to reasonably affect outcomes (2 years), analyzing outcomes over 1 year (rather than isolated visits), assessing NPs and PAs as separate provider groups, using electronic health record (EHR) data to accurately identify the type of provider actually seeing patients (rather than relying on assigned provider status), and evaluating PAs and NPs in the PCP (as opposed to a supplemental) role.

Methods

This study used nationwide administrative data from the VA-EHR. It was approved by the Durham VA Medical Center's Institutional Review Board (Durham, North Carolina).

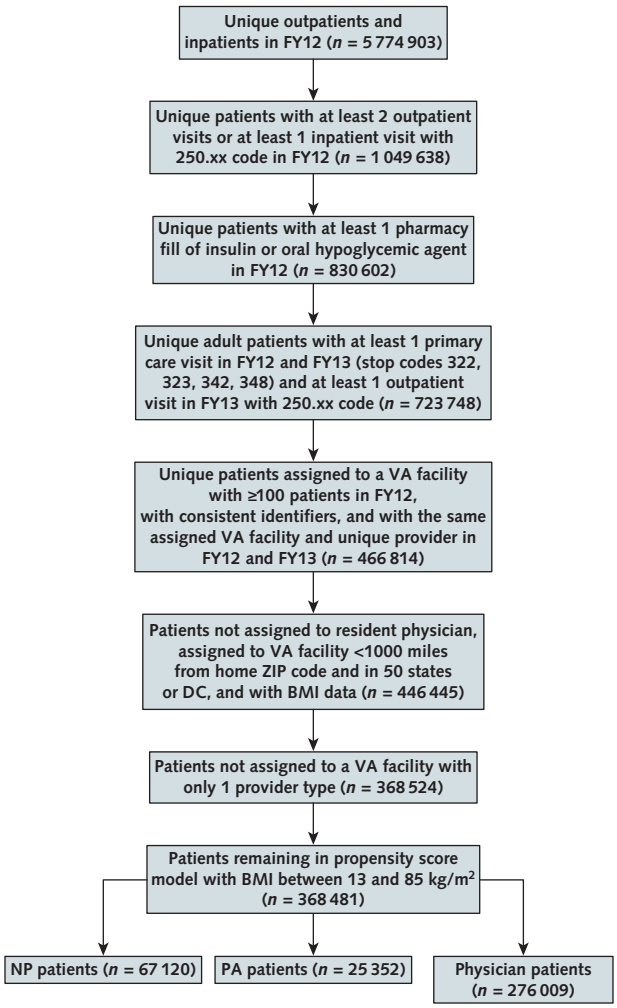
Data Sources and Sample Construction

Construction of the cohort used for this study is summarized in the Figure, including the number of pa-

See also:

Editorial comment 875
Summary for Patients I-16

Figure. Cohort construction.



BMI = body mass index; DC = District of Columbia; FY12 = fiscal year 2012; FY13 = fiscal year 2013; NP = nurse practitioner; PA = physician assistant; VA = U.S. Department of Veterans Affairs.

tients included and excluded at each stage of the process. Our sample consisted of adults (aged ≥18 years) with pharmaceutically treated prevalent diabetes who were seen at VA primary care clinics. Patients must have had a diabetes diagnosis (International Classification of Diseases, Ninth Revision, Clinical Modification codes 250.xx) associated with at least 1 VA inpatient admission or at least 2 VA outpatient visits in fiscal year 2012 (FY12) and a filled prescription for insulin or an oral hyperglycemic agent (see **Appendix Table 1** [available at Annals.org] for specific codes) in the same year. They must have had at least 1 VA primary care visit in FY12, identified by VA administrative codes indicating a primary care clinic (see **Appendix Table 1** for specific codes). Persons were excluded if they did not also have an outpatient visit with a diabetes diagnosis in fiscal year 2013 (FY13; 1 October 2012 to 30 September 2013).

Each patient was assigned a "home" VA facility, which was the clinic most frequently visited for primary care in FY12. For a patient to remain in the cohort, his or her home VA facility had to have at least 100 eligible veterans with diabetes in FY12. The same procedure was used to determine the patient's home clinic and PCP in FY13. To ensure consistency in the patient–provider relationship, we excluded veterans whose PCP assignment changed between FY12 and FY13. Patients who most frequently saw a physician resident were ineligible for the study because of the dual responsibility of care held by both the resident and attending physician. We also excluded veterans whose home VA facility was more than 1000 miles from their home ZIP code or was not in 1 of the 50 states or the District of Columbia. We did not include patients with inconsistent identifiers in the VA Corporate Data Warehouse or those without information on body mass index (BMI). Finally, we examined only patients from VA facilities where at least 2 PCP types practiced. This restriction was necessary because the positivity assumption of propensity score weighting would not be met if patients could have seen only a physician because their home VA facility had only physician PCPs. Therefore, it would have been statistically inappropriate to include practices with only 1 type of PCP (13).

Provider Type

The provider most often visited at a patient's home VA primary care clinic in FY12 was considered to be his or her PCP. The provider type (that is, physician, NP, or PA) for each PCP was determined on the basis of his or her profession code maintained by the VA.

Outcome

We examined the association between provider type and the outcomes of continuous level and dichotomous control of hemoglobin A_{1c} (HbA_{1c}), systolic blood pressure (SBP), and low-density lipoprotein cholesterol (LDL-C) on the basis of mean values in FY13. Because serious acute illness may produce nonrepresentative blood pressure readings, measures obtained within 1 day before or after an inpatient hospital stay were excluded. Continuous outcomes included the mean of all outpatient HbA_{1c}, SBP, and LDL-C measurements in FY13. Control outcome definitions were based on clinical practice guidelines in place in 2013, including mean HbA_{1c} concentration less than 7.0%, mean SBP less than 130 mm Hg (14), and mean LDL-C level below 2.59 mmol/L (100 mg/dL) (15). Systolic blood pressure was used as the outcome for blood pressure because its association with cardiovascular disease risk is greater than that of diastolic blood pressure, making it more appropriate for establishing a priori definitions of clinical significance (16–18).

Statistical Analysis

All statistical analyses were performed by using SAS, version 9.4 (SAS Institute). To address the possibility that characteristics of patients seen by physicians, NPs, and PAs might differ, we used inverse probability of PCP-type weighting (that is, inverse probability of "treatment" weighting), whereby the weights were the inverse of the propensity score computed for the probability of the patient having the type of provider he or she was observed to have (19). The propensity scores

Table 1. Unweighted Sample Characteristics for FY12*

Characteristic	PCP Type, %†			Differences Between PCP Types		
	NP (*n* = 67 120)	PA (*n* = 25 352)	Physician (*n* = 276 009)	Physician vs. NP	Physician vs. PA	PA vs. NP
Patient						
Male	95.0	97.2	97.0	11.5	−0.8	10.8
Age group						
<40 y	1.1	1.0	0.9	−1.8	−1.1	−0.6
40–<65 y	50.8	49.8	51.4	1.2	3.2	−2.0
65–<80 y	38.5	39.4	38.4	−0.2	−2.0	1.8
≥80 y	9.6	9.8	9.3	−1.0	−1.7	0.7
Mean age (SD), *y*	65.2 (10.2)	65.5 (10.0)	65.2 (10.0)	−0.3	−2.9	2.5
Race						
White	72.3	74.7	69.9	−5.2	−10.5	5.4
American Indian/Alaska Native	0.7	0.8	0.7	−0.1	−0.8	0.7
Asian American	0.4	0.3	0.6	1.8	3.5	−2.0
Black/African American	17.4	15.5	19.5	5.3	10.0	−5.0
Native Hawaiian/other Pacific Islander	0.9	0.9	1.2	2.4	2.4	0
Missing or unknown	8.3	7.8	8.2	−0.2	1.5	−1.7
Hispanic ethnicity	3.8	3.6	4.8	4.7	5.7	−1.1
Marital status						
Currently married	59.3	61.7	59.7	0.9	−4.0	4.9
Never married	11.4	9.8	11.1	−1.1	3.9	−5.0
Previously married	29.0	28.3	29.0	−0.1	1.5	−1.6
Unknown	0.3	0.2	0.3	−0.7	1.3	−2.0
Homeless at any time during the year	1.9	1.4	1.8	−0.2	3.0	−3.2
Copay status						
Must pay copay	19.4	20.1	17.2	−5.8	−7.8	1.8
No copay because of disability	52.3	52.6	55.2	5.8	5.1	0.7
No copay because of low income	26.6	25.9	26.3	−0.7	0.9	−1.5
Unknown	1.7	1.3	1.4	−3.0	0.2	−3.0
Mental health diagnosis						
Mood disorder	24.4	23.2	24.0	−1.0	1.9	−2.9
Posttraumatic stress disorder	14.0	13.5	14.4	1.3	2.7	−1.5
Dementia	2.7	2.9	3.2	2.5	1.5	1.1
Substance use disorder	7.8	6.5	7.8	−0.3	4.7	−5.0
Other	6.2	5.8	6.0	−0.9	0.7	−1.7
DCG risk score category						
<0.5	51.8	53.1	49.6	−4.4	−7.0	2.6
0.5–<1.0	17.4	16.3	16.9	−1.5	1.4	−2.9
1.0–<1.5	12.9	12.6	12.9	0.2	0.9	−0.7
1.5–<2.0	6.6	6.8	7.3	2.6	1.8	0.8
2.0–<2.5	3.7	3.9	4.3	2.6	2.1	0.6
≥2.5	7.6	7.2	9.1	5.4	6.4	−1.1
Mean DCG risk score (SD)	0.9 (1.2)	0.9 (1.2)	1.0 (1.4)	7.0	7.6	−0.8
Distance from a VA primary care clinic						
<5 mi	25.3	23.9	22.7	−6.4	−2.9	−3.4
5–<25 mi	50.1	48.6	52.2	4.1	7.1	−3.1
25–<50 mi	16.2	18.7	16.6	1.2	−5.6	6.8
≥50 mi	7.2	8.2	7.9	2.6	−1.3	4.0
Missing	1.1	0.6	0.7	−5.5	1.1	−5.8
Mean distance from VA primary care clinic (SD), *mi*	19.2 (35.1)	21.2 (39.0)	20.3 (39.1)	3.0	−2.1	5.5
Baseline BMI						
<18.5 kg/m^2	0.2	0.2	0.2	1.0	1.4	−0.4
18.5–<25.0 kg/m^2	9.0	8.7	9.3	1.2	2.2	−1.0
25.0–<30.0 kg/m^2	29.1	29.2	29.3	0.5	0.2	0.3
30.0–<35.0 kg/m^2	31.8	32.0	31.3	−1.1	−1.6	0.6
35.0–<40.0 kg/m^2	18.0	17.9	18.1	0.1	0.4	−0.3
≥40.0 kg/m^2	12.0	12.0	11.8	−0.6	−0.7	0
Mean BMI (SD), *kg/m^2*	32.5 (6.4)	32.5 (6.4)	32.4 (6.5)	−1.1	−1.5	0.4
Mean visits in which the patient was assigned as having seen a provider (SD), %	77.0 (25.1)	77.9 (24.7)	75.3 (25.8)	−6.4	−10.0	3.7

Continued on following page

Table 1–Continued

Characteristic	PCP Type, %†			Differences Between PCP Types		
	NP (*n* = 67 120)	PA (*n* = 25 352)	Physician (*n* = 276 009)	Physician vs. NP	Physician vs. PA	PA vs. NP
Facility						
Endocrinology/specialty diabetes services available‡	41.4	43.8	55.2	27.7	22.8	4.9
RUCA status§						
Metropolitan area core (largest urban areas)	74.7	67.2	77.5	6.9	24.5	−16.8
Metropolitan area core–remaining levels	8.5	16.4	12.2	11.7	−12.6	25.8
Micropolitan area core	12.3	13.1	7.8	−15.9	−19.5	2.7
Small town or rural area	4.6	3.2	2.5	−12.8	−5.0	−6.7
Region						
Northeast	22.1	22.9	14.8	−19.7	−22.4	2.0
West	21.2	12.3	17.0	−11.0	12.7	−22.9
Midwest	28.0	26.8	23.8	−9.7	−6.9	−2.7
South	28.7	38.0	44.3	32.0	12.8	20.1
Diabetes control in FY12						
Mean HbA_{1c} level (SD), %	7.6 (1.5)	7.6 (1.4)	7.6 (1.5)	2.7	0.6	2.1
Mean SBP (SD), *mm Hg*	132.9 (13.0)	132.8 (12.9)	133.1 (13.2)	2.2	2.9	−0.8
Mean LDL-C level (SD), *mg/dL*‖	87.2 (29.9)	87.0 (29.7)	85.8 (29.6)	−4.8	−4.2	−0.7
Patients with control of HbA_{1c} levels	39.6	37.8	38.4	−2.5	1.3	−3.8
Patients with control of SBP	41.4	41.4	40.6	−1.7	−1.7	0
Patients with control of LDL-C levels	72.1	72.0	73.8	3.8	4.2	−0.3

BMI = body mass index; DCG = diagnostic cost group; FY12 = fiscal year 2012; HbA_{1c} = hemoglobin A_{1c}; LDL-C = low-density lipoprotein cholesterol; NP = nurse practitioner; PA = physician assistant; PCP = primary care provider; RUCA = rural–urban commuting area; SBP = systolic blood pressure; VA = U.S. Department of Veterans Affairs.

* The continuous variables for age, distance from a VA medical center, DCG risk score, and BMI and unweighted variables on diabetes control in FY12 were not included as variables in the propensity score model but are included here for descriptive purposes. Percentages may not sum to 100 due to rounding.

† Unless otherwise indicated.

‡ Indicates that a facility had ≥500 VA encounter/stop codes for endocrinology and/or specialty diabetes services from any patient in FY12.

§ Designation of rural and urban areas represents a combination of the 10 RUCA codes, which are described at http://depts.washington.edu/uwruca/ruca-codes.php. *Metropolitan area core* corresponds to code 1, *metropolitan area core–remaining levels* corresponds to codes 2 and 3, *micropolitan area core* corresponds to codes 4–6, and *small town or rural area* corresponds to codes 7–10.

‖ To convert LDL-C values from mg/dL to mmol/L, multiply by 0.0259.

were computed from 3 separate logistic regression models to predict each provider type versus another (SAS PROC LOGISTIC). Each model had the same covariates, including demographic characteristics, social complexity measures, health status, access to services, and facility practice patterns. Demographic characteristics included sex, age, race, and ethnicity. Social complexity measures included marital status, homelessness, and mental health diagnoses. Health status was measured by using the prospective diagnostic cost group (DCG) score calculated by the VA, as well as the patient's BMI. The DCG scale was originally designed to predict cost of care but has been validated to measure medical complexity within the VA population (20, 21). The algorithm uses demographic and diagnostic information to assign each patient a DCG score, normed so that the average Medicare patient has a score equal to 1 (22). Body mass index was calculated on the basis of height and weight data from the EHR (see **Appendix Table 1** for details). Access-to-services measures included copay status, travel distance to the VA health center, availability of specialized diabetes services at the VA clinic (proxy for facility complexity and highly correlated with facility size), rurality of the VA clinic based on the ZIP code version of the Rural Urban Community Area codes (23), and the U.S. region where the clinic was located. To account for potential differences in continuity of care among patients with physician, NP, or PA PCPs, our propensity score model included a variable representing the proportion of visits patients made to their assigned PCP. Because our previous work found that PCP assignment was not associated with state scope-of-practice regulations, we did not include a variable for scope of practice in our propensity score model (24).

All patient-level variables were obtained from VA-EHR data from FY12. To assess the balance of patient characteristics among groups (that is, physicians, NPs, and PAs), we evaluated standardized mean differences (PROC FREQ). The standardized mean difference is the difference in means or proportions divided by their pooled SE, then multiplied by 100. Imbalance typically is defined as an absolute value greater than 10 (19).

Weighted hierarchical linear mixed models with 2 independent random intercepts to account for clustering by both VA facility and PCP were used to analyze the association between PCP type and continuous outcomes (PROC MIXED). These models were coupled with empirical "sandwich" SEs to account for sampling variability in estimating the weights. Logistic regression models fit with generalized estimating equations and an exchangeable correlation structure and empirical SEs to account for within-facility clustering were fit to examine the association between PCP type and dichot-

Table 2. Inverse Probability of Treatment-Weighted Sample Characteristics for FY12*

Characteristic	PCP Type, %†			Standardized Differences Between PCP Types		
	NP (*n* = 67 120)	PA (*n* = 25 352)	Physician (*n* = 276 009)	Physician vs. NP	Physician vs. PA	PA vs. NP
Patient						
Male	96.6	96.7	96.7	0.3	−0.3	0.6
Age group						
<40 y	0.9	0.9	0.9	0.3	0	0.3
40–<65 y	51.0	50.8	51.2	0.3	0.7	−0.4
65–<80 y	38.6	38.8	38.5	−0.1	−0.6	0.5
≥80 y	9.5	9.4	9.4	−0.4	−0.1	−0.2
Mean age (SD), *y*	65.2 (23.4)	65.2 (38.3)	65.2 (11.6)	−0.1	0.2	−0.1
Race						
White	70.8	70.8	70.7	−0.1	−0.3	0.1
American Indian/Alaska Native	0.8	0.7	0.7	−0.5	−0.1	−0.4
Asian American	0.5	0.5	0.5	−0.2	0	−0.2
Black/African American	18.7	18.9	18.8	0.3	−0.1	0.4
Native Hawaiian/other Pacific Islander	1.1	1.1	1.1	0.3	0.3	−0.1
Missing or unknown	8.2	8.0	8.2	0	0.5	−0.6
Hispanic ethnicity	4.3	4.6	4.5	1.3	−0.2	1.6
Marital status						
Currently married	59.5	59.9	59.7	0.4	−0.2	0.6
Never married	11.1	11.0	11.0	−0.1	0.3	−0.4
Previously married	29.1	28.9	28.9	−0.3	0.1	−0.4
Unknown	0.3	0.3	0.3	−0.1	0	0
Homeless at any time during the year	1.8	1.8	1.8	0.1	0.4	−0.3
Copay status						
Must pay copay	18.0	17.7	17.8	−0.5	0.3	−0.7
No copay because of disability	54.1	54.5	54.5	0.6	−0.2	0.8
No copay because of low income	26.4	26.3	26.3	−0.2	−0.1	−0.2
Unknown	1.5	1.4	1.4	−0.4	0.1	−0.4
Mental health diagnosis						
Mood disorder	23.8	24.0	24.0	0.4	0.1	0.3
Posttraumatic stress disorder	14.2	14.3	14.3	0.2	−0.3	0.4
Dementia	3.1	3.1	3.1	−0.3	0	−0.3
Substance use disorder	7.7	7.7	7.7	0.1	0	0
Other	6.1	6.0	6.0	−0.5	−0.2	−0.3
DCG risk score category						
<0.5	50.2	50.1	50.2	0.1	0.3	−0.2
0.5–<1.0	16.9	16.8	16.9	−0.1	0.4	−0.5
1.0–<1.5	13.0	13.0	12.9	−0.2	−0.3	0
1.5–<2.0	7.1	7.1	7.1	0.1	0	0.1
2.0–2.5	4.2	4.2	4.1	−0.1	−0.3	0.2
≥2.5	8.6	8.8	8.7	0.2	−0.5	0.7
Mean DCG risk score (SD)	1.0 (3.0)	1.0 (5.1)	1.0 (1.6)	0.7	−0.1	0.4
Distance from VA primary care clinic						
<5 mi	23.9	23.0	23.2	−1.6	0.6	−2.1
5–<25 mi	50.5	51.5	51.5	1.9	−0.1	2.0
25–50 mi	16.7	16.7	16.7	0.2	0.1	0.1
≥50 mi	8.2	8.0	7.8	−1.3	−0.9	−0.4
Missing	0.7	0.7	0.7	−0.1	0	−0.1
Mean distance from a VA primary care clinic (SD), *mi*	20.0 (82.7)	20.6 (146.1)	20.3 (45.4)	0.5	−0.6	0.6
Baseline BMI						
<18.5 kg/m^2	0.2	0.2	0.2	−0.1	0	0
18.5–<25.0 kg/m^2	9.3	9.2	9.2	−0.2	0	−0.2
25.0–<30.0 kg/m^2	29.3	29.2	29.3	−0.1	0	−0.1
30.0–<35.0 kg/m^2	31.5	31.4	31.4	−0.2	0	−0.1
35.0–<40.0 kg/m^2	17.9	18.1	18.0	0.3	−0.1	0.5
≥40.0 kg/m^2	11.8	11.8	11.8	0.2	0.2	0
Mean BMI (SD), *kg/m^2*	32.4 (14.9)	32.5 (24.6)	32.5 (7.5)	0.4	0.1	0.2
Mean visits in which the patient was assigned as having seen a provider (SD), %	76.2 (59.0)	75.6 (96.6)	75.8 (29.7)	−1.0	0.5	−0.8

Continued on following page

Table 2–Continued

Characteristic	PCP Type, %†			Standardized Differences Between PCP Types		
	NP (*n* = 67 120)	PA (*n* = 25 352)	Physician (*n* = 276 009)	Physician vs. NP	Physician vs. PA	PA vs. NP
Facility						
Endocrinology/specialty diabetes services available‡	50.4	52.4	51.8	2.8	−1.2	4.0
RUCA status§						
Metropolitan area core (largest urban areas)	75.8	76.3	76.3	1.1	0	1.2
Metropolitan area core–remaining levels	12.3	11.6	11.8	−1.4	0.9	−2.2
Micropolitan area core	9.2	9.2	9.0	−0.8	−0.6	−0.1
Small town or rural area	2.7	3.0	2.9	1.1	−0.5	1.6
Region						
Northeast	17.1	16.1	16.7	−1.1	1.8	−2.8
West	17.9	17.5	17.5	−1.1	−0.2	−0.9
Midwest	24.9	25.1	24.8	−0.2	−0.6	0.4
South	40.1	41.3	41.0	1.8	−0.7	2.5
Diabetes control in FY12						
Mean HbA_{1c} level (SD), %	7.6 (3.4)	7.6 (5.6)	7.6 (1.7)	1.8	−0.2	1.0
Mean SBP (SD), *mm Hg*	133.0 (30.3)	132.9 (49.4)	133.1 (15.3)	0.8	1.1	−0.2
Mean LDL-C level (SD), *mg/dL*‖	86.7 (69.7)	87.2 (114.8)	85.9 (34.2)	−1.8	−2.8	0.6
Patients with control of HbA_{1c} levels	39.6	37.9	38.4	−1.7	0.7	−1.3
Patients with control of SBP	41.1	41.2	40.7	−0.5	−0.6	0.1
Patients with control of LDL-C levels	72.5	71.6	73.7	1.8	3.0	−0.7

BMI = body mass index; DCG = diagnostic cost group; FY12 = fiscal year 2012; HbA_{1c} = hemoglobin A_{1c}; LDL-C = low-density lipoprotein cholesterol; NP = nurse practitioner; PA = physician assistant; PCP = primary care provider; RUCA = rural–urban commuting area; SBP = systolic blood pressure; VA = U.S. Department of Veterans Affairs.
* The continuous variables for age, distance from a VA medical center, DCG risk score, and BMI, and diabetes control in FY12 were not included as variables in the propensity score model but are included here for descriptive purposes. Percentages may not sum to 100 due to rounding.
† Unless otherwise indicated.
‡ Indicates that a facility had ≥500 VA encounter/stop codes for endocrinology and/or specialty diabetes services from any patient in FY12.
§ Designation of rural and urban areas represents a combination of the 10 RUCA codes, which are described at http://depts.washington.edu/uwruca/ruca-codes.php. *Metropolitan area core* corresponds to code 1, *metropolitan area core–remaining levels* corresponds to codes 2 and 3, *micropolitan area core* corresponds to codes 4–6, and *small town or rural area* corresponds to codes 7–10.
‖ To convert LDL-C values from mg/dL to mmol/L, multiply by 0.0259.

omous control outcomes (PROC GENMOD). To interpret the results, we set a priori thresholds for clinical significance of observed differences of 0.3% for HbA_{1c} concentration, 3.0 mm Hg for SBP, and 0.13 mmol/L (5.0 mg/dL) for LDL-C level, and a 20% difference in odds (for example, an odds ratio of 1.2) for differences in outcome control. This was done because the large number of patients in the sample may have led us to find differences that were statistically but not clinically significant. For additional interpretability, we estimated additive differences in proportions for the control outcomes by using estimated differences in probabilities from PROC GENMOD. Corresponding 95% CIs were estimated by using 1000 bootstrapped samples and obtaining the 2.5th and 97.5th percentiles of the estimated differences among the bootstrapped estimates.

To address the possibility that differences in the mix of PCPs by site and outcomes may have led to confounding by site, we stratified the analysis of continuous outcomes by site. This was done to ascertain whether the median treatment effect across sites remained essentially zero and to determine the number of sites with "near-

Table 3. Model-Estimated Means and Percentages of Patients Meeting Definitions of Intermediate Outcome Control in FY13, by PCP Type*

PCP Type	HbA_{1c}†			SBP‡		
	Patients With Measurements, *n*	Estimated Mean Level (95% CI), %	Patients With Control (95% CI), %	Patients With Measurements, *n*	Estimated Mean (95% CI), *mm Hg*	Patients With Control (95% CI), %
NP	63 246	7.53 (7.51–7.56)	40.04 (39.16–40.92)	66 442	133.03 (132.72–133.34)	36.07 (35.02–37.13)
PA	23 789	7.59 (7.56–7.62)	38.43 (37.39–39.48)	25 147	133.09 (132.66–133.51)	36.29 (34.89–37.71)
Physician	263 209	7.58 (7.56–7.61)	38.67 (38.14–39.20)	274 873	133.11 (132.74–133.47)	35.81 (35.11–36.51)

FY13 = fiscal year 2013; HbA_{1c} = hemoglobin A_{1c}; LDL-C = low-density lipoprotein cholesterol; NP = nurse practitioner; PA = physician assistant; PCP = primary care provider; SBP = systolic blood pressure.
* Weighted means and weighted percentages of patients with control of intermediate outcomes are based on modeled estimates.
† Data on outcomes were missing for 18 237 patients.
‡ Data on outcomes were missing for 2019 patients.
§ Data on outcomes were missing for 42 247 patients.
‖ To convert LDL-C values from mg/dL to mmol/L, multiply by 0.0259.

zero" effects. For outlier sites—defined as those with observed treatment effects in the lowest or highest fifth percentile—we examined whether the numbers of both providers and patients differed at sites where anomalies were seen. In particular, stratified results were calculated by running the described models on data from each site separately. Because the sample size was too constrained within sites to estimate a site-specific propensity score by using the large number of covariates in our original specification, we examined the stratified results by using models weighted from our original analysis weights, as well as unweighted models, to assess the potential for unaddressed site-level confounding (PROC MIXED and PROC GENMOD).

Finally, to address the possibility that results may have reflected differences in the percentages of NP, PA, and physician patients comanaged by endocrinologists, we compared the weighted average percentages of NP, PA, and physician patients who received endocrinology or specialized diabetes services, setting a 10–percentage point difference as an a priori threshold for clinical significance. In addition, to examine the robustness of the results among patients with various levels of clinical complexity, we conducted 2 sensitivity analyses. These analyses dichotomized patients by health status (DCG scores >2.0 and ≤2.0) and complexity of diabetes medication regimen (receiving and not receiving insulin). We computed SEs for the sensitivity analyses using maximum likelihood model–based SEs because of runtime constraints.

Role of the Funding Source

The funding source had no role in the design or conduct of the study; the collection, management, analysis, or interpretation of the data; or the preparation, review, or approval of the manuscript.

RESULTS

The sample included 368 481 patients from 568 VA primary care facilities. The PCPs were physicians (n = 3487), NPs (n = 1445), and PAs (n = 443) for 74.9% (n = 276 009), 18.2% (n = 67 120), and 6.9% (n = 25 352) of patients, respectively. In 2013, patients of NPs, PAs, and physicians had a mean of 4.1 (SD, 3.6), 4.1 (SD, 3.5), and 4.0 (SD, 3.6) primary care visits, respectively. On average, 75.8% of primary care visits were with the identified PCP. Information on the number of visits and intermediate outcome measurements obtained, by PCP type, may be found in **Appendix Table 2** (available at Annals.org).

Mirroring the VA patient population, 96.7% of patients were men and the mean age was 65.2 years (SD, 10.0). Most patients were white (70.7%) or African American (18.8%), and 4.5% were Hispanic.

Minor unweighted baseline differences were found (that is, before propensity score weights were applied) among patients assigned to physicians, NPs, and PAs (**Table 1**). Women were more likely to have NP PCPs, with 95% of NP patients being male, compared with 97% of physician and PA patients. Patients of physician PCPs had modestly higher unweighted DCG scores (mean, 1.00 [SD, 1.37]) than patients of NPs (mean, 0.90 [SD, 1.23]) and PAs (mean, 0.89 [SD, 1.25]), but baseline BMI values were similar across PCP types.

The balance among patient characteristics after inverse probability of treatment weighting was applied is shown in **Table 2**. Our weighted sample was exceptionally well balanced. No standardized differences were greater than 4.0, and the vast majority were less than 1, including those for key characteristics of sex, age, race, ethnicity, copay status, DCG score, and BMI. We examined the distribution of propensity scores (inverse of weights for the PCP types) and found overlap (data not shown).

Table 3 contains the weighted mean HbA_{1c}, SBP, and LDL-C values and percentages of patients with HbA_{1c}, SBP, and LDL-C control, by PCP type, for FY13. **Table 4** shows the differences in mean HbA_{1c}, SBP, and LDL-C values and the degree of guideline-concordant control among patients with physician, NP, and PA PCPs. Although some differences were statistically significant, we estimated no differences across PCP types that met our a priori definitions of clinical significance. Compared with values for physicians, model-estimated HbA_{1c} differences were −0.05% (95% CI, −0.07% to −0.02%) for NPs and 0.01% (CI, −0.02% to 0.04%) for PAs, SBP differences were −0.08 mm Hg (CI, −0.34 to 0.18 mm Hg) for NPs and 0.02 mm Hg (CI, −0.42 to 0.38 mm Hg) for PAs, and LDL-C differences were 0.01 mmol/L (CI, 0.00 to 0.03 mmol/L) (0.57 mg/dL [CI, 0.03 to 1.11 mg/dL]) for NPs and 0.03 mmol/L (CI, 0.01 to 0.05 mmol/L) (1.08 mg/dL [CI, 0.25 to 1.91 mg/dL]) for PAs. No clinically significant differences were found in the odds for control of the 3 dichotomous intermediate diabetes outcomes or for simultaneous control of all 3 intermediate outcomes, which had an odds ratio of 1.04 (CI, 0.99 to 1.09) for NPs versus physicians and 0.98 (CI, 0.91 to 1.04) for PAs versus physicians. Results indicating no clinically important differences held on examination of patients with DCG scores above 2.0 and of 2.0 or below and patients receiving and not receiving insulin (**Appendix Tables 3** and **4**, available at Annals.org).

***Table 3*–Continued**

LDL-C§		
Patients With Measurements, *n*	**Estimated Mean Level (95% CI), *mg/dL*‖**	**Patients With Control (95% CI), %**
59 037	85.47 (84.72–86.21)	74.13 (73.11–75.12)
22 151	85.97 (84.99–86.95)	73.23 (72.02–74.40)
245 046	84.89 (84.16–85.63)	75.15 (74.53–75.75)

Table 4. Model-Estimated Differences in FY13 for Intermediate Diabetes Outcomes*

Outcome	NPs vs. Physicians	PAs vs. Physicians	PAs vs. NPs
Continuous difference in means of intermediate outcomes (95% CI)			
HbA_{1c} level, %	−0.05 (−0.07 to −0.02)	0.01 (−0.02 to 0.04)	0.06 (0.02 to 0.09)
SBP, *mm Hg*	−0.08 (−0.34 to 0.18)	0.02 (−0.42 to 0.38)	0.06 (−0.35 to 0.48)
LDL-C level, *mg/dL*†	0.57 (0.03 to 1.11)	1.08 (0.25 to 1.91)	0.50 (−0.39 to 1.40)
Odds ratio for differences in intermediate outcome control (95% CI)			
HbA_{1c} level <7%	1.06 (1.02 to 1.10)	0.99 (0.95 to 1.04)	0.93 (0.88 to 0.99)
SBP <130 mm Hg	1.02 (0.98 to 1.07)	1.04 (0.98 to 1.10)	1.02 (0.95 to 1.09)
LDL-C level <100 mg/dL†	0.95 (0.90 to 0.99)	0.90 (0.85 to 0.96)	0.95 (0.89 to 1.03)
Simultaneous control of intermediate outcomes	1.04 (0.99 to 1.09)	0.98 (0.91 to 1.04)	0.94 (0.87 to 1.02)
Additive difference in intermediate outcome control (95% CI), *percentage points*			
HbA_{1c} level <7%	1.36 (0.51 to 2.24)	−0.24 (−1.39 to 0.83)	−1.61 (−2.91 to −0.34)
SBP <130 mm Hg	0.37 (−0.44 to 1.60)	−0.24 (−0.34 to 2.40)	−0.61 (−0.34 to 2.10)
LDL-C level <100 mg/dL†	−1.02 (−2.02 to −0.11)	−1.92 (−3.03 to −0.86)	−0.90 (−2.22 to 0.49)
Simultaneous control of intermediate outcomes	0.37 (−0.18 to 0.94)	−0.24 (−0.96 to 0.45)	−0.61 (−1.48 to 0.24)

FY13 = fiscal year 2013; HbA_{1c} = hemoglobin A_{1c}; LDL-C = low-density lipoprotein cholesterol; NP = nurse practitioner; PA = physician assistant; SBP = systolic blood pressure; VA = U.S. Department of Veterans Affairs.
* Continuous outcomes were estimated by using linear mixed models with provider- and VA site–level random intercepts paired with empirical sandwich SEs. Binary control outcomes were estimated by using a logistic regression model fit with generalized estimating equations, with clustering by VA site and empirical sandwich SEs. All models incorporated inverse probability of provider assignment weights and included provider type as the only covariate in the model.
† To convert LDL-C values from mg/dL to mmol/L, multiply by 0.0259.

The comparison of outcomes for PAs versus NPs (reference group) yielded similar results, with no clinically significant differences (Table 4). Differences in model-estimated mean intermediate outcomes for PAs versus NPs were 0.06% (CI, 0.02% to 0.09%) for HbA_{1c} concentration, 0.06 mm Hg (CI, −0.35 to 0.48 mm Hg) for SBP, and 0.01 mmol/L (CI, 0.01 to 0.04 mmol/L) (0.50 mg/dL [CI, −0.39 to 1.40 mg/dL]) for LDL-C level. No clinically significant differences were found in control of intermediate outcomes, including simultaneous control (odds ratio, 0.94 [CI, 0.87 to 1.02]). Results indicating no clinically important differences held on examination of patients with DCG scores above 2.0 and of 2.0 or below and patients receiving and not receiving insulin (Appendix Tables 3 and 4).

We observed no clinically significant difference in the weighted average proportions of NP, PA, and physician patients with diabetes who used endocrinology or specialty diabetes services—8.5%, 9.8%, and 9.2%, respectively—during the year outcomes were calculated.

Finally, analysis of potential confounding by site or location related to staff-mix variations indicated that such confounding was unlikely. The median treatment effect difference over all sites between any 2 provider types remained essentially zero (HbA_{1c} concentration, −0.04%; SBP, 0.01 mm Hg; and LDL-C level, 0.01 mmol/L [0.38 mg/dL]). In addition, most sites had near-zero effects of provider type. However, a few nonsystematic outlier sites had larger effects equally in both directions (for example, physician outcomes were better than PA outcomes, and vice versa). We found that these clinics, on average, saw fewer patients with diabetes. Further, these centers frequently had only 1 provider of a given PCP type, typically an NP or a PA. Therefore, results from these outlying sites seem to have been driven largely by the behavior of a single provider. Taken together, stratified results do not suggest confounding but seem to reflect the natural variation one would expect to observe in provider behavior. The average effect among providers, including after stratification by site—and within site for many locations—was still essentially the same with regard to these clinical outcomes.

DISCUSSION

Using diabetes as a model, we investigated whether patients with NPs or PAs as their PCPs had chronic illness outcomes different from patients seen by physicians. We did not observe clinically significant differences in intermediate diabetes outcomes or the control of those outcomes among patients with NP, PA, or physician PCPs. These results held when we examined only patients with medical complexity, specifically those receiving insulin or with poorer health status (DCG score >2.0). Further, we found no meaningful difference in the percentage of NP, PA, and physician patients who also were using endocrinology or specialty diabetes services.

The present study addressed key methodologic challenges that might affect conclusions regarding outcome differences based on provider type. First, we used data from the VA-EHR (25, 26), which identifies the provider or clinician who actually conducts in-person encounters and connects that record to a code indicating the profession of that person. Other data sources often underestimate NP and PA care. Medicare data, for example, may present a biased underrepresentation of care by NPs and PAs, because a substantial number of these providers bill for Medicare services "incident to" their supervising physicians. In other words, services are provided by an NP or a PA but charged under the collaborating physician's billing number to take advantage of reimbursement rules,

meaning that PA or NP involvement cannot be identified. A survey of NPs found that among those who worked with physicians, 29% billed all their services and 24% billed some of their services incident to physician care (27).

Unlike studies examining PCP assignment and outcomes simultaneously, we limited our analysis to patients who had a PCP consistently for 2 years (by using visit-level data) so that the PCP would have cared for the patient long enough to affect outcomes. In addition, we based our calculation of outcomes on an entire follow-up year, as opposed to information gathered at a single visit or from a limited number of observations, and analyzed data at the patient level as opposed to the facility level (28, 29).

The present study examined outcomes among more than 368 000 patients in more than 560 clinical settings across the United States. High-quality clinical trials found that NPs and physicians provide primary care with equivalent outcomes (30–35). However, most of those studies had small patient samples and compared care provided by a small number of physicians and NPs in very limited settings. Although the trials had the advantage of randomization, the lack of differences they found in outcomes may reflect something unique about the specific clinicians or organizations involved. In addition, the role of NPs and PAs in different settings may vary widely. Although the VA represents a national health care system, the organization, quality, and processes of care, including the use and precise roles of NPs and PAs (3, 29, 36), differ among its locations (37–39). Finally, our statistical analysis was designed to reduce the potential for results being affected by different types of providers seeing patients with different characteristics (by using propensity score techniques), to account for clustering due to several patients being seen within the same clinics and by the same providers (by using hierarchical analyses), and to explicitly recognize that the large number of patients in the study might lead to statistically significant results with little practical importance (by using a priori definitions of clinical significance).

The study had limitations and considerations that should be noted. First, VA patients are predominantly male and are older and sicker than the general population (40). Although it seems unlikely that differences among provider types would be greater in systems serving younger, healthier patients, we cannot rule this out. In addition, although we based patient and provider characteristics on 1 year and looked at outcomes the next year, diabetes cases in the present study were prevalent and not incident, and we do not have long-term information regarding disease trajectory in our study patients. Third, despite available evidence suggesting that NPs consult with their collaborating physicians relatively rarely in the VA primary care setting (41), we cannot rule out off-the-record consultation of physicians by NPs or PAs as a mitigating factor in quality-of-care differences between these providers and physician PCPs. Fourth, compared with many health care systems in the United States, the VA makes greater use of strategies that may diminish disparities in provider care quality, such as patient-centered medical homes, team-based care involving staff other than the PCP, comprehensive EHRs, and extensive quality monitoring. However, private health care systems are adopting these approaches (42–44), further increasing study generalizability. The possibility exists that greater use of such strategies as patient-centered medical homes may be associated with enhanced orientation and residency programs for NPs and PAs compared with other health systems. Finally, we did not have access to information on the demographic or work history characteristics of providers included in this analysis. However, the large number of providers and locations of care represented in this study reduced the potential for differences in provider demographics that would reduce the generalizability of results.

In conclusion, we found no clinically significant differences in intermediate diabetes outcomes. As a result, this study provides further evidence that using NPs and PAs as PCPs may represent a mechanism for expanding access to primary care while maintaining quality standards.

From Durham Veterans Affairs Health Care System and Duke University, Durham, North Carolina (G.L.J., V.A.S., D.E., C.C.H.); Durham Veterans Affairs Health Care System, Durham, North Carolina (S.L.W., T.S.B., B.S.W.); and Duke University, Durham, North Carolina (C.M.E., P.A.M.).

Disclaimer: The views expressed in this article are those of the authors and do not reflect the position or policy of the VA or the U.S. government.

Grant Support: Funding was provided through a peer-reviewed grant (IIR 13-063) from the VA Health Services Research and Development (HSR&D) Service. This work was also supported by the Center of Innovation for Health Services Research in Primary Care (CIN 13-410) at Durham VA Medical Center.

Disclosures: Drs. Jackson and Edelman report grants from the VA during the conduct of the study. Authors not named here have disclosed no conflicts of interest. Disclosures can also be viewed at www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M17-1987.

Reproducible Research Statement: *Study protocol:* Available from Dr. Jackson (e-mail, george.jackson3@va.gov). *Statistical code:* Information on the statistical code that could not lead to identification of individual patients is available from Dr. Jackson upon consultation with study statisticians. *Data set:* The data set, with information obtained from national VA databases originating in the VA-EHR, is not available. Use of underlying national VA databases is subject to VA rules and regulations. Further information relating to specific national VA data sets used for this study is available from Dr. Jackson upon consultation with study statisticians.

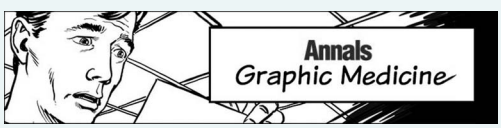
Corresponding Author: George L. Jackson, PhD, MHA, Durham VA Medical Center, HSR&D Service (152), 508 Fulton Street, Durham, NC 27705; e-mail, george.l.jackson@duke.edu.

Current author addresses and author contributions are available at Annals.org.

References

1. **Everett CM, Morgan P, Jackson GL.** Primary care physician assistant and advance practice nurses roles: patient healthcare utilization, unmet need, and satisfaction. Healthc (Amst). 2016;4:327-33. [PMID: 27451337] doi:10.1016/j.hjdsi.2016.03.005
2. **Druss BG, Marcus SC, Olfson M, Tanielian T, Pincus HA.** Trends in care by nonphysician clinicians in the United States. N Engl J Med. 2003;348:130-7. [PMID: 12519924]
3. **Morgan PA, Abbott DH, McNeil RB, Fisher DA.** Characteristics of primary care office visits to nurse practitioners, physician assistants and physicians in United States Veterans Health Administration facilities, 2005 to 2010: a retrospective cross-sectional analysis. Hum Resour Health. 2012;10:42. [PMID: 23148792] doi:10.1186/1478-4491-10-42
4. **Morgan P, Everett C, Hing E.** Nurse practitioners, physician assistants, and physicians in community health centers, 2006-2010. Healthc (Amst). 2015;3:102-7. [PMID: 26179731] doi:10.1016/j.hjdsi.2014.06.002
5. **Barnes H, Richards MR, McHugh MD, Martsolf G.** Rural and nonrural primary care physician practices increasingly rely on nurse practitioners. Health Aff (Millwood). 2018;37:908-14. [PMID: 29863933] doi:10.1377/hlthaff.2017.1158
6. **Martsolf GR, Barnes H, Richards MR, Ray KN, Brom HM, McHugh MD.** Employment of advanced practice clinicians in physician practices. JAMA Intern Med. 2018;178:988-90. [PMID: 29710094] doi:10.1001/jamainternmed.2018.1515
7. **Sox HC Jr.** Quality of patient care by nurse practitioners and physician's assistants: a ten-year perspective. Ann Intern Med. 1979;91:459-68. [PMID: 38721]
8. Physician assistants and nurse practitioners. American College of Physicians. Ann Intern Med. 1994;121:714-6. [PMID: 7944083]
9. **Donelan K, DesRoches CM, Dittus RS, Buerhaus P.** Perspectives of physicians and nurse practitioners on primary care practice. N Engl J Med. 2013;368:1898-906. [PMID: 23675658] doi:10.1056/NEJMsa1212938
10. **Rich EC.** Advanced practice clinicians and physicians in primary care: still more questions than answers. Ann Intern Med. 2016;165:290-1. [PMID: 27322738] doi:10.7326/M16-1326
11. **Hooker RS, Everett CM.** The contributions of physician assistants in primary care systems. Health Soc Care Community. 2012;20:20-31. [PMID: 21851446] doi:10.1111/j.1365-2524.2011.01021.x
12. **Halter M, Drennan V, Chattopadhyay K, Carneiro W, Yiallouros J, de Lusignan S, et al.** The contribution of physician assistants in primary care: a systematic review. BMC Health Serv Res. 2013;13:223. [PMID: 23773235] doi:10.1186/1472-6963-13-223
13. **Hernán MA, Robins JM.** Estimating causal effects from epidemiological data. J Epidemiol Community Health. 2006;60:578-86. [PMID: 16790829]
14. **Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, et al; National Heart, Lung, and Blood Institute Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.** The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. JAMA. 2003;289:2560-72. [PMID: 12748199]
15. Executive summary: standards of medical care in diabetes–2013. Diabetes Care. 2013;36 Suppl 1:S4-10. [PMID: 23264424] doi:10.2337/dc13-S004
16. **Lloyd-Jones DM, Evans JC, Larson MG, O'Donnell CJ, Roccella EJ, Levy D.** Differential control of systolic and diastolic blood pressure: factors associated with lack of blood pressure control in the community. Hypertension. 2000;36:594-9. [PMID: 11040241]
17. **Lewington S, Clarke R, Qizilbash N, Peto R, Collins R; Prospective Studies Collaboration.** Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet. 2002;360:1903-13. [PMID: 12493255]
18. **Strandberg TE, Pitkala K.** What is the most important component of blood pressure: systolic, diastolic or pulse pressure? Curr Opin Nephrol Hypertens. 2003;12:293-7. [PMID: 12698068]
19. **Austin PC.** An introduction to propensity score methods for reducing the effects of confounding in observational studies. Multivariate Behav Res. 2011;46:399-424. [PMID: 21818162]
20. **Maciejewski ML, Liu CF, Derleth A, McDonell M, Anderson S, Fihn SD.** The performance of administrative and self-reported measures for risk adjustment of Veterans Affairs expenditures. Health Serv Res. 2005;40:887-904. [PMID: 15960696]
21. **Ellis RP, Ash A.** Refinements to the diagnostic cost group (DCG) model. Inquiry. 1995;32:418-29. [PMID: 8567079]
22. **Ash A, Porell F, Gruenberg L, Sawitz E, Beiser A.** Adjusting Medicare capitation payments using prior hospitalization data. Health Care Financ Rev. 1989;10:17-29. [PMID: 10313277]
23. **U.S. Department of Agriculture.** 2010 Rural–Urban Commuting Area (RUCA) codes. Updated 12 October 2016. Accessed at www.ers.usda.gov/data-products/rural-urban-commuting-area-codes/documentation.aspx on 26 October 2018.
24. **Morgan P, Everett CM, Smith VA, Woolson S, Edelman D, Hendrix CC, et al.** Factors associated with having a physician, nurse practitioner, or physician assistant as primary care provider for veterans with diabetes mellitus. Inquiry. 2017;54:46958017712762. [PMID: 28617196] doi:10.1177/0046958017712762
25. **Brown SH, Lincoln MJ, Groen PJ, Kolodner RM.** VistA–U.S. Department of Veterans Affairs national-scale HIS. Int J Med Inform. 2003;69:135-56. [PMID: 12810119]
26. **Jackson GL, Krein SL, Alverson DC, Darkins AW, Gunnar W, Harada ND, et al.** Defining core issues in utilizing information technology to improve access: evaluation and research agenda. J Gen Intern Med. 2011;26 Suppl 2:623-7. [PMID: 21989613] doi:10.1007/s11606-011-1789-3
27. **Buerhaus PI, DesRoches CM, Dittus R, Donelan K.** Practice characteristics of primary care nurse practitioners and physicians. Nurs Outlook. 2015;63:144-53. [PMID: 25261383] doi:10.1016/j.outlook.2014.08.008
28. **Virani SS, Akeroyd JM, Ramsey DJ, Chan WJ, Frazier L, Nasir K, et al.** Comparative effectiveness of outpatient cardiovascular disease and diabetes care delivery between advanced practice providers and physician providers in primary care: implications for care under the Affordable Care Act. Am Heart J. 2016;181:74-82. [PMID: 27823696] doi:10.1016/j.ahj.2016.07.020
29. **Jackson GL, Lee SY, Edelman D, Weinberger M, Yano EM.** Employment of mid-level providers in primary care and control of diabetes. Prim Care Diabetes. 2011;5:25-31. [PMID: 20980212] doi:10.1016/j.pcd.2010.09.005
30. **Spitzer WO, Sackett DL, Sibley JC, Roberts RS, Gent M, Kergin DJ, et al.** The Burlington randomized trial of the nurse practitioner. N Engl J Med. 1974;290:251-6. [PMID: 4808929]
31. **Mundinger MO, Kane RL, Lenz ER, Totten AM, Tsai WY, Cleary PD, et al.** Primary care outcomes in patients treated by nurse practitioners or physicians: a randomized trial. JAMA. 2000;283:59-68. [PMID: 10632281]
32. **Lenz ER, Mundinger MO, Kane RL, Hopkins SC, Lin SX.** Primary care outcomes in patients treated by nurse practitioners or physicians: two-year follow-up. Med Care Res Rev. 2004;61:332-51. [PMID: 15358970]
33. **Horrocks S, Anderson E, Salisbury C.** Systematic review of whether nurse practitioners working in primary care can provide equivalent care to doctors. BMJ. 2002;324:819-23. [PMID: 11934775]
34. **Laurant M, Harmsen M, Wollersheim H, Grol R, Faber M, Sibbald B.** The impact of nonphysician clinicians: do they improve the quality and cost-effectiveness of health care services? Med Care Res Rev. 2009;66:36S-89S. [PMID: 19880672] doi:10.1177/1077558709346277

35. **Newhouse RP, Stanik-Hutt J, White KM, Johantgen M, Bass EB, Zangaro G, et al.** Advanced practice nurse outcomes 1990-2008: a systematic review. Nurs Econ. 2011;29:230-50. [PMID: 22372080]
36. **Moran EA, Basa E, Gao J, Woodmansee D, Almenoff PL, Hooker RS.** PA and NP productivity in the Veterans Health Administration. JAAPA. 2016;29:1-6. [PMID: 27351641] doi:10.1097/01.JAA.0000484311.96684.0c
37. **Jackson GL, Yano EM, Edelman D, Krein SL, Ibrahim MA, Carey TS, et al.** Veterans Affairs primary care organizational characteristics associated with better diabetes control. Am J Manag Care. 2005;11:225-37. [PMID: 15839183]
38. **Yano EM, Simon BF, Lanto AB, Rubenstein LV.** The evolution of changes in primary care delivery underlying the Veterans Health Administration's quality transformation. Am J Public Health. 2007;97:2151-9. [PMID: 17971540]
39. **Bryson CL, Au DH, Maciejewski ML, Piette JD, Fihn SD, Jackson GL, et al.** Wide clinic-level variation in adherence to oral diabetes medications in the VA. J Gen Intern Med. 2013;28:698-705. [PMID: 23371383] doi:10.1007/s11606-012-2331-y
40. **Haibach JP, Haibach MA, Hall KS, Masheb RM, Little MA, Shepardson RL, et al.** Military and veteran health behavior research and practice: challenges and opportunities. J Behav Med. 2017;40:175-93. [PMID: 27678001] doi:10.1007/s10865-016-9794-y
41. **Fletcher CE, Copeland LA, Lowery JC, Reeves PJ.** Nurse practitioners as primary care providers within the VA. Mil Med. 2011;176:791-7. [PMID: 22128721]
42. **Jackson GL, Powers BJ, Chatterjee R, Bettger JP, Kemper AR, Hasselblad V, et al.** The patient centered medical home. A systematic review. Ann Intern Med. 2013;158:169-78. [PMID: 24779044]
43. **Shortell SM, Wu FM, Lewis VA, Colla CH, Fisher ES.** A taxonomy of accountable care organizations for policy and practice. Health Serv Res. 2014;49:1883-99. [PMID: 25251146] doi:10.1111/1475-6773.12234
44. **Press MJ, Rajkumar R, Conway PH.** Medicare's new bundled payments: design, strategy, and evolution. JAMA. 2016;315:131-2. [PMID: 26720889] doi:10.1001/jama.2015.18161



Annals Graphic Medicine brings together original graphic narratives, comics, animation/video, and other creative forms by those who provide or receive health care. They address medically relevant topics—be they poignant, thought-provoking, or just plain entertaining.

Annals Graphic Medicine is a Web-only feature at annals.org. Visit www.annals.org/graphicmedicine to see the most recent piece and to sign up to be alerted when new ones are released.

Have an artistic flair? Submit your work to *Annals* Graphic Medicine by following the "Submit a Manuscript" link at www.annals.org.

Current Author Addresses: Dr. Jackson: Durham VA Medical Center, HSR&D Service (152), 508 Fulton Street, Durham, NC 27705.
Drs. Smith and Edelman, Ms. Woolson, Mr. Berkowitz, and Ms. White: Durham VA Medical Center, Center for Health Services Research in Primary Care (152), 508 Fulton Street, Durham, NC 27705.
Dr. Hendrix: Duke University School of Nursing, 307 Trent Drive, Durham, NC 27710.
Drs. Everett and Morgan: DUMC 104780, Duke University Medical Center, Durham, NC 27710.

Author Contributions: Conception and design: G.L. Jackson, V.A. Smith, D. Edelman, C.C. Hendrix, C.M. Everett, P.A. Morgan.
Analysis and interpretation of the data: G.L. Jackson, V.A. Smith, D. Edelman, S.L. Woolson, C.C. Hendrix, C.M. Everett, T.S. Berkowitz, P.A. Morgan.
Drafting of the article: G.L. Jackson, V.A. Smith, D. Edelman, S.L. Woolson, C.C. Hendrix, C.M. Everett.
Critical revision for important intellectual content: V.A. Smith, D. Edelman, C.C. Hendrix, C.M. Everett, P.A. Morgan.
Final approval of the article: G.L. Jackson, V.A. Smith, D. Edelman, S.L. Woolson, C.C. Hendrix, C.M. Everett, T.S. Berkowitz, B.S. White, P.A. Morgan.
Provision of study materials or patients: B.S. White.
Statistical expertise: V.A. Smith, T.S. Berkowitz.
Obtaining of funding: G.L. Jackson, D. Edelman, P.A. Morgan.
Administrative, technical, or logistic support: G.L. Jackson, S.L. Woolson, C.C. Hendrix, B.S. White.
Collection and assembly of data: S.L. Woolson, T.S. Berkowitz, P.A. Morgan.

Appendix Table 1. VA Administrative Information Used to Identify Diabetes Medication, Primary Care Encounter Location, and Primary Care Provider Type, and to Calculate BMI

VA Administrative Code or Data	Description of Code
VA drug class codes used to define filled prescriptions for oral hyperglycemic agents or insulin	
VA drug class HS501	Insulin
VA drug class HS502	Oral hyperglycemic agents
VA administrative codes/stop codes used to identify primary care encounters	
VA stop code 322	Comprehensive women's primary care
VA stop code 323	Primary care medicine
VA stop code 342	Family practice
VA stop code 348	Primary care shared appointment
VA provider codes used to classify provider types	
VA provider codes 070500 to 070507, 100600 to 100618	Nurse practitioners
VA provider codes 100000 to 100200	Physician assistants
VA provider codes 110000 to 111200, 111500 to 115400, 115700 to 118343, 160100 to 160102, 180100 to 183402	Physicians
Calculating BMI	
Height: Use the most frequently recorded in FY12, if available. If not available, use the modal height in FY13. If no mode in either year, then assign as missing.	Algorithm for assigning height (assumed to be in inches): Allowable range, 48-84 inches
Weight: Use the value that is closest to 1 October 2012 in the 30 days prior if available. If not available, then use the value that is closest to 1 October 2012 in the 30 days after. If not available, then use the value that is closest to 1 October 2012 in the 1 year prior. If none of the above is available, then code as missing.	Algorithm for assigning weight (assumed to be in pounds): Allowable range, 50-700 pounds
BMI calculated after cleaning height and weight data.	Use only the BMI measures within the acceptable range of 13-85 kg/m^2

BMI = body mass index; FY12 = fiscal year 2012; FY13 = fiscal year 2013; VA = U.S. Department of Veterans Affairs.

Appendix Table 2. Primary Care Encounters and Outcome Measurements in the Year of the Outcome Assessment (FY13)

Variable	All Providers	NPs	PAs	Physicians
Mean total primary care visits to any provider (SD), *n*	4.0 (3.6)	4.1 (3.6)	4.1 (3.5)	4.0 (3.6)
Mean primary care visits with the PCP designated in the present study (SD), %	75.8 (25.6)	77.0 (25.1)	77.9 (24.7)	75.3 (25.8)
Mean HbA_{1c} observations used in the present study (SD), *n*	2.1 (1.2)	2.1 (1.7)	2.2 (1.2)	2.1 (1.2)
Mean SBP observations used in the present study (SD), *n*	7.3 (11.7)	7.0 (11.0)	7.1 (11.4)	7.3 (11.9)
Mean LDL-C observations used in the present study (SD), *n*	1.7 (1.0)	1.7 (1.0)	1.7 (1.0)	1.6 (1.0)

FY13 = fiscal year 2013; HbA_{1c} = hemoglobin A_{1c}; LDL-C = low-density lipoprotein cholesterol; NP = nurse practitioner; PA = physician assistant; PCP = primary care provider; SBP = systolic blood pressure.

Appendix Table 3. Stratified Model-Estimated Differences in Intermediate Diabetes Outcomes for Veterans With DCG Scores ≤2 and >2*

Outcome	NPs vs. Physicians	PAs vs. Physicians	PAs vs. NPs
DCG score ≤2.0†			
Continuous difference in means of intermediate outcomes (95% CI)			
HbA_{1c}, *%*	−0.05 (−0.07 to −0.03)	0.00 (−0.03 to 0.02)	0.05 (0.02 to 0.08)
SBP, *mm Hg*	−0.24 (−0.44 to −0.04)	−0.24 (−0.51 to 0.03)	0.00 (−0.30 to 0.31)
LDL-C, *mg/dL*§	0.98 (0.53 to 1.44)	1.76 (1.15 to 2.37)	0.78 (0.10 to 1.46)
Differences in odds of intermediate outcome control: odds ratio (95% CI)			
HbA_{1c} <7%	1.08 (1.03 to 1.11)	1.01 (0.96 to 1.05)	0.94 (0.89 to 0.99)
SBP <130 mm Hg	1.02 (0.98 to 1.07)	1.04 (0.98 to 1.10)	1.01 (0.94 to 1.09)
LDL-C <100 mg/dL§	0.95 (0.90 to 0.99)	0.90 (0.84 to 0.95)	0.94 (0.88 to 1.02)
Simultaneous control of intermediate outcomes	1.04 (0.98 to 1.09)	0.98 (0.91 to 1.05)	0.94 (0.87 to 1.02)
Additive difference in intermediate outcome control (95% CI), *percentage points*			
HbA_{1c} <7%	1.63 (0.77 to 2.54)	0.12 (−1.08 to 1.24)	−1.52 (−2.85 to −0.22)
SBP <130 mm Hg	0.59 (−0.42 to 1.66)	0.88 (−0.47 to 2.39)	0.29 (−1.40 to 2.07)
LDL-C <100 mg/dL§	−1.02 (−2.00 to −0.12)	−2.13 (−3.30 to −1.03)	−1.11 (−2.48 to 0.27)
Simultaneous control of intermediate outcomes	0.39 (−0.20 to 0.96)	−0.23 (−0.98 to 0.50)	−0.62 (−1.48 to 0.29)
DCG score >2.0‡			
Continuous difference in means of intermediate outcomes (95% CI)			
HbA_{1c}, *%*	0.00 (−0.05 to 0.04)	0.04 (−0.01 to 0.10)	0.05 (−0.01 to 0.11)
SBP, *mm Hg*	−0.38 (−0.79 to 0.03)	−0.25 (−0.74 to 0.25)	0.13 (−0.41 to 0.68)
LDL-C, *mg/dL*§	1.00 (−0.01 to 2.01)	1.83 (0.57 to 3.08)	0.82 (−0.56 to 2.20)
Differences in odds of intermediate outcome control: odds ratio (95% CI)			
HbA_{1c} <7%	0.98 (0.92 to 1.05)	0.89 (0.81 to 0.98)	0.91 (0.82 to 1.02)
SBP <130 mm Hg	1.01 (0.95 to 1.08)	1.06 (0.98 to 1.16)	1.05 (0.95 to 1.16)
LDL-C <100 mg/dL§	0.94 (0.86 to 1.03)	0.97 (0.89 to 1.05)	1.02 (0.91 to 1.15)
Simultaneous control of intermediate outcomes	1.03 (0.95 to 1.13)	0.97 (0.85 to 1.11)	0.94 (0.81 to 1.10)
Additive difference in intermediate outcome control (95% CI), *percentage points*			
HbA_{1c} <7%	−0.48 (−2.06 to 1.10)	−2.66 (−4.68 to −0.54)	−2.19 (−4.77 to 0.33)
SBP <130 mm Hg	0.30 (−1.19 to 1.92)	1.50 (−0.62 to 3.68)	1.20 (−1.27 to 3.68)
LDL-C <100 mg/dL§	−1.06 (−2.60 to 0.50)	−0.62 (−2.16 to 1.01)	0.44 (−1.64 to 2.50)
Simultaneous control of intermediate outcomes	0.36 (−0.62 to 1.41)	−0.31 (−1.65 to 1.06)	−0.67 (−2.16 to 0.92)

DCG = diagnostic cost group; HbA_{1c} = hemoglobin A_{1c}; LDL-C = low-density lipoprotein cholesterol; NP = nurse practitioner; PA = physician assistant; SBP = systolic blood pressure; VA = U.S. Department of Veterans Affairs.

* Differences in continuous outcomes were estimated by using linear mixed models with provider- and VA site-level random intercepts. Binary control outcomes were estimated by using a logistic regression model fit with generalized estimating equations, with clustering by VA site. All models incorporated inverse probability of provider assignment weights and included provider type as the only covariate in the models.

† Number of patients with a DCG score ≤2.0: 239 168, 59 540, and 22 537 with physician, NP, and PA providers, respectively.

‡ Number of patients with a DCG score >2.0: 36 841, 7580, and 2815 with physician, NP, and PA providers, respectively.

§ To convert LDL-C values from mg/dL to mmol/L, multiply by 0.0259.

Appendix Table 4. Stratified Model-Estimated Differences in Intermediate Diabetes Outcomes for Veterans Not Receiving and Receiving Insulin*

Outcome	NPs vs. Physicians	PAs vs. Physicians	PAs vs. NPs
Not receiving insulin†			
Continuous difference in means of intermediate outcomes (95% CI)			
HbA_{1c}, *%*	−0.06 (−0.08 to −0.04)	0.00 (−0.03 to 0.03)	0.06 (0.03 to 0.12)
SBP, *mm Hg*	−0.40 (−0.63 to −0.18)	−0.12 (−0.41 to 0.18)	0.29 (−0.04 to 0.61)
LDL-C, *mg/dL*§	1.07 (0.56 to 1.59)	1.77 (1.10 to 2.45)	0.70 (−0.05 to 1.45)
Differences in odds of intermediate outcome control: odds ratio (95% CI)			
HbA_{1c} <7%	1.09 (1.05 to 1.13)	1.00 (0.95 to 1.06)	0.92 (0.86 to 0.98)
SBP <130 mm Hg	1.02 (0.97 to 1.06)	1.02 (0.96 to 1.09)	1.00 (0.93 to 1.08)
LDL-C <100 mg/dL§	0.93 (0.89 to 0.97)	0.89 (0.83 to 0.95)	0.96 (0.88 to 1.03)
Simultaneous control of intermediate outcomes	1.04 (0.99 to 1.09)	0.98 (0.91 to 1.06)	0.94 (0.86 to 1.03)
Additive difference in intermediate outcome control (95% CI), *percentage points*			
HbA_{1c} <7%	2.12 (1.07 to 3.16)	0.10 (−1.41 to 1.35)	−2.02 (−3.62 to −0.48)
SBP <130 mm Hg	0.87 (−0.20 to 2.04)	1.04 (−0.50 to 2.64)	0.18 (−1.71 to 2.00)
LDL-C <100 mg/dL§	−1.42 (−2.38 to 0.45)	−2.31 (−3.72 to −1.00)	−0.89 (−2.55 to 0.63)
Simultaneous control of intermediate outcomes	0.54 (−0.23 to 1.27)	−0.27 (−1.33 to 0.70)	−0.81 (−2.02 to 0.37)
Receiving insulin‡			
Continuous difference in means of intermediate outcomes (95% CI)			
HbA_{1c}, *%*	−0.02 (−0.04 to 0.01)	0.04 (0.01 to 0.08)	0.06 (0.02 to 0.10)
SBP, *mm Hg*	−0.11 (−0.36 to 0.13)	−0.35 (−0.66 to −0.04)	−0.24 (−0.58 to 0.11)
LDL-C, *mg/dL*§	0.78 (0.21 to 1.35)	1.24 (0.51 to 1.97)	0.46 (−0.35 to 1.27)
Differences in odds of intermediate outcome control: odds ratio (95% CI)			
HbA_{1c} <7%	1.00 (0.95 to 1.05)	0.92 (0.86 to 0.98)	0.92 (0.85 to 1.00)
SBP <130 mm Hg	1.00 (0.96 to 1.05)	1.03 (0.97 to 1.10)	1.03 (0.95 to 1.11)
LDL-C <100 mg/dL§	0.98 (0.92 to 1.04)	0.93 (0.87 to 0.99)	0.95 (0.87 to 1.04)
Simultaneous control of intermediate outcomes	1.01 (0.93 to 1.10)	0.93 (0.85 to 1.02)	0.92 (0.82 to 1.04)
Additive difference in intermediate outcome control (95% CI), *percentage points*			
HbA_{1c} <7%	0.00 (−0.80 to 0.89)	−1.38 (−2.39 to −0.38)	−1.38 (−2.71 to −0.11)
SBP <130 mm Hg	0.09 (−1.03 to 1.23)	0.78 (−0.58 to 2.34)	0.69 (−1.12 to 2.47)
LDL-C <100 mg/dL§	−0.45 (−1.70 to 0.63)	−1.33 (−2.52 to −0.24)	−0.88 (−2.48 to 0.65)
Simultaneous control of intermediate outcomes	0.06 (−0.45 to 0.56)	−0.42 (−0.94 to 0.10)	−0.49 (−1.16 to 0.21)

HbA_{1c} = hemoglobin A_{1c}; LDL-C = low-density lipoprotein cholesterol; NP = nurse practitioner; PA = physician assistant; SBP = systolic blood pressure; VA = U.S. Department of Veterans Affairs.

* Differences in outcomes were based on continuous outcomes and estimated by using linear mixed models with provider- and VA site-level random intercepts. Binary control outcomes were estimated by using a logistic regression model fit with generalized estimating equations, with clustering by VA site. All models incorporated inverse probability of provider assignment weights and included provider type as the only covariate in the models.

† Number of patients not receiving insulin: 156 876, 38 855, and 14 905 with physician, NP, and PA providers, respectively.

‡ Number of patients receiving insulin: 119 133, 28 265, and 10 447 with physician, NP, and PA providers, respectively.

§ To convert LDL-C values from mg/dL to mmol/L, multiply by 0.0259.