Simultaneous Control of Intermediate Diabetes Outcomes Among Veterans Affairs Primary Care Patients

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BACKGROUND: Guidelines recommend tight control of hemoglobin A1c (HbA1c), low-density lipoprotein cholesterol (LDL-C), and blood pressure (BP) for patients with diabetes. The degree to which these intermediate outcomes are simultaneously controlled has not been extensively described.

OBJECTIVE: Describe the degree of simultaneous control of HbA1c, LDL-C, and BP among Veterans Affairs (VA) diabetes patients defined by both VA and American Diabetes Association (ADA) guidelines.

DESIGN: Cross-sectional cohort.

PATIENTS: Eighty-thousand two hundred and seven VA diabetes patients receiving care between October 1999 and September 2000.

MEASUREMENTS: We defined simultaneous control of outcomes using 1997 VA Guidelines (in place in 2000) (HbA1c < 9.0%; LDL-C < 130 mg/dL; systolic BP < 140 mmHg; and diastolic BP < 90 mmHg) and 2004 ADA guidelines (HbA1c < 7.0%; LDL-C < 100 mg/dL; systolic BP < 130 mmHg; and diastolic BP < 80 mmHg). A patient is considered to have simultaneous control of the intermediate outcomes for a given definition if the average of measurements for each outcome was below the defined threshold during the study period.

RESULTS: Using VA guidelines, 31% of patients had simultaneous control. Control levels of individual outcomes were: HbA1c (82%), LDL-C (77%), and BP (48%). Using ADA guidelines, 4% had simultaneous control. Control levels of individual outcomes were: HbA1c (36%), LDL-C (41%), and BP (23%). Associations between individual risk factors were weak. There was a modest association between LDL-C control and control of HbA1c (odds ratio [OR] 1.51; 95% confidence interval [CI] 1.44, 1.58). The association between LDL-C and BP control was clinically small (1.26; 1.21, 1.31), and there was an extremely small association between BP and HbA1c control (0.95; 0.92, 0.99). Logistic regression modeling indicates greater body mass index, African American or Hispanic race-ethnicity, and female gender were negatively associated with simultaneous control.

CONCLUSION: While the proportion of patients who achieved minimal levels of control of HbA1c and LDL-C was high, these data indicate a low level of simultaneous control of HbA1c, LDL-C, and BP among patients with diabetes.

KEY WORDS: blood pressure; diabetes mellitus; hemoglobin A-glycosylated; lipoproteins-LDL cholesterol; United States Department of Veterans Affairs.

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As individual risk factors, control of blood glucose,¹⁻³ low-density lipoprotein cholesterol (LDL-C),⁴ and blood pressure (BP)^{5,6} are associated with reduced risk of complications among patients with diabetes. However, most studies⁷⁻²² have concentrated on control of individual intermediate outcomes (i.e., vascular risk factors). A few studies reported on the number of categories of diabetes control achieved by individual patients.^{8,19,21} However, as complex and expensive interventions are developed to control multiple cardiovascular risk factors in patients with diabetes,^{23,24} it becomes important to understand the degree to which control of these risk factors may or may not be interrelated.

The present study describes the extent of simultaneous control of hemoglobin A1c (HbA1c), LDL-C, and BP, measures the association among intermediate outcomes, and identifies patient characteristics associated with simultaneous control of these outcomes among primary care patients with diabetes.

METHODS

For eligible patients who received care from the Veterans Affairs (VA) health care system in Fiscal Year (FY) 1999, we extracted data on HbA1c, LDL-C, and BP (systolic [SBP] and diastolic [DBP]) for FY2000 (October 1, 1999 to September 30, 2000). The study was approved by the Institutional Review Board of the Durham, NC, VA Medical Center.

Data Sources

Veterans Health Administration (VHA) Diabetes Registry and Dataset. The VHA Diabetes Registry and Dataset was used to obtain outcomes data and establish the diabetes cohort. The Registry contains 3 files. The Pharmacy File has medication data for patients who have filled an outpatient prescription for insulin, oral hypoglycemic agents, or blood glucose monitoring supplies at any VA. The Laboratory File contains data on tests directly related to diabetes (including HbA1c and LDL-C). The Vitals File has information on patient height, weight, body mass index (BMI), BP, and receipt of influenza and pneumonia vaccines.²⁵

Information is transmitted to the Registry via yearly downloads of diabetes-related data from individual VA-facility computer systems. Pharmacy file data are included on patients with a filled outpatient prescription for insulin, oral hypoglycemic agents, or glucose monitoring supplies. Laboratory and vitals data are included for patients who have ≥ 1 VA inpatient admission and/or ≥ 2 VA outpatient encounters with

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an associated International Classification of Disease 9-Clinical Modifications (ICD-9-CM) diagnosis code for diabetes.²⁶

Specific variables captured by the Registry include: HbA1c, LDL-C, BP, BMI, and pharmaceutical treatment.

VHA Corporate Databases. Multiple VHA databases housed at the Austin Automation Center were used to obtain data on patient demographics, health care utilization, comorbidities, and vital status.²⁷ Patients' vital status is recorded in the Beneficiary Identification and Record Locator System (BIRLS).²⁸ Encounter and demographic data were obtained from the VA Medical SAS Datasets.²⁷ Specific ICD-9-CM codes used to identify patients with diabetes were obtained from the 2003 version of the Agency for Healthcare Research and Quality Clinical Classification Software.²⁹ The Johns Hopkins Adjusted Clinical Groups (ACGs)/Aggregated Diagnostic Groups files contain information on patient comorbidities used for risk adjustment.³⁰

Subjects—Diabetes Cohort

We used the VHA Diabetes Registry, Medical SAS Datasets, and BIRLS to construct a national cohort of diabetes patients who received VA primary care services. Patients identified as having diabetes had to meet both pharmacy and utilization criteria.

During FY1999, 503,371 patients were in the VHA Diabetes Registry.²⁶ We identified 224,221 patients who met all the following inclusion criteria during FY1999: (1) were alive on October 1, 1999 (using BIRLS and Medical SAS Datasets); (2) ≥ 2 nonmental health outpatient visits with an associated diabetes diagnosis, and/or ≥ 1 nonmental health inpatient discharge with an associated diagnosis of diabetes (using Medical SAS Datasets); (3) filled ≥ 1 prescription for insulin, oral hypoglycemic agents, or blood glucose monitoring supplies (using Diabetes Registry); and (4) had ≥ 1 outpatient visit to a VA primary care clinic (using Medical SAS Datasets).

Individuals were considered primary care patients of the VA facility where they made the greatest number of primary care visits during 1999. In case of a tie, the patient was randomly assigned to 1 of the tied locations. Once patients' primary care clinics were determined, a random sample of 800 diabetes patients meeting the above criteria was drawn from each VA facility operating in 1999.³¹ If a location did not have 800 eligible patients, all eligible patients were retained.

Subjects—Study Exclusion Criteria

Patients were excluded from this study if they met any of the following criteria: (1) did not have a record for each intermediate outcome in 2000 and a BMI measurement (excluded so that all analyses include the same patients); (2) age < 18 years; (3) had a VA endocrinology visit during 1999 to 2000 (because determinants of control may be different for patients enrolled in specialty clinics³²); (4) had no VA primary care visit in 2000; (5) died during 2000 to 2001 (to avoid results being primarily related to imminent death); (6) had recorded laboratory values consistent with laboratory error or event unrelated to primary care (i.e., mean HbA1c $< 4.0\%$ or $\geq 18.0\%$, mean LDL-C < 40.0 or ≥ 350.0 mg/dL, mean SBP < 100.0 mmHg or ≥ 300.0 , mean DBP < 50.0 or ≥ 200.0 mmHg, BMI < 10.0 or ≥ 100.0 kg/m²); or (7) pregnant during 2000.

In 2000, 215,946 cohort members received care in the VA. There were 144,176 otherwise eligible patients with at least 1

intermediate outcome recorded and 80,207 patients with all 3 intermediate outcomes recorded.

Outcomes, Definitions of Simultaneous Control, and Unit of Analysis

Data on intermediate outcomes were obtained from the Diabetes Registry. We calculated the mean of all HbA1c and LDL-C results in 2000; for BP, we computed the mean of the last 3 available SBP and DBP results in 2000 (mean of all results if < 3). If a facility used total glycosylated hemoglobin, those measurements were converted to HbA1c using the laboratory equipment manufacturer's conversion formula.

In 2000, VA recommendations were based on the 1997 VHA Clinical Practice Guidelines for Diabetes Mellitus.³³ Thus, simultaneous control was defined as having mean HbA1c $< 9.0\%$, LDL-C < 130 mg/dL, SBP < 140 mmHg, and DBP < 90 mmHg in 2000. In addition, we conducted sensitivity analyses using more stringent definitions of control based on the 2004 American Diabetes Association (ADA) Clinical Practice Recommendations³⁴: mean HbA1c $< 7.0\%$, LDL-C < 100 mg/dL, SBP < 130 mmHg, and DBP < 80 mmHg. High-density lipoprotein cholesterol was not included in definitions because goals were not part of the 1997 VHA diabetes guidelines.³³

A patient was considered to have simultaneous control of the intermediate outcomes for a given definition if all mean measurements for HbA1c and LDL-C and last 3 measurements of BP were all below the defined threshold during 2000.

Data Analysis

Except where stated otherwise, statistical analyses were conducted using SAS[®] version 9.1.³⁵ We calculated the percentages of cohort members who achieved simultaneous diabetes control in 2000 using both of the above definitions.

To estimate the associations between having control of 1 intermediate outcome when having control of another, we calculated the percent of patients with control of other intermediate outcomes (e.g., LDL-C, BP) when a given outcome (e.g., HbA1c) is and is not in control. This was done to represent what might be seen among members of a clinic patient population. Unadjusted associations were also examined by calculating unadjusted odds ratios (OR) between control of different outcomes and Pearson correlations between intermediate outcomes (results available from authors).

It is possible that there is an overestimate of simultaneous control because patients without a record for a given outcome may be less likely to have control. As a result, a sensitivity analysis was conducted among all otherwise eligible patients with at least 1 intermediate outcome recorded. In this analysis, patients without all 3 intermediate outcomes were counted as not having simultaneous control.

Separate logistic-regression models were fit using both VA and ADA guidelines. The dependent variables were dichotomized (achieving control or not). For each model, ORs and Wald confidence limits were calculated for the simultaneously adjusted relationship between control and (1) BMI (categorized as: 10 to 24 kg/m² [referent category], 25 to 29, 30 to 34, 35 to 39 kg/m², and ≥ 40 kg/m²) (2) race/ethnicity (white [referent category], African American, American Indian, Asian, Hispanic-black, Hispanic-white, and unknown race/ethnicity); (3) gender; (4) age (categorized as: 18 to 49 [referent category],

50 to 64, 65 to 79, and ≥ 80 years); (5) VA primary care visits during 2000 (categorized as: 1 [referent category], 2 to 4, and ≥ 5); (6) individual variables indicating whether the patient had a filled prescription at a VA pharmacy in 2000 for an oral hypoglycemic agent, insulin, lipid-lowering agent (excluding niacin), and niacin; and (7) the number of types of antihypertensive medication for which the patients had a filled prescription in 2000 (categorized as: none [referent category], 1, 2, and ≥ 3). For control of individual outcomes, ORs are also adjusted for whether the patients met the control definitions for the other individual outcomes. Risk-adjustment for comorbidities was done using the Johns Hopkins ACG Case-Mix System[®].³⁰

To determine the difference in expected levels of other outcomes when 1 outcome is under control, separate simple linear-regression models were fit for each definition of individual control. The dependent variable was the continuous value for the outcome. Independent variables included control of the other 2 outcomes. For example, the model for HbA1c using the 1997 VHA guideline definition included LDL-C < 130 mg/dL and BP $< 140/90$ mmHg as independent variables. Other independent variables were identical to those in logistic-regression models.

Because patients are treated by individual primary care programs (clusters), we performed all logistic and linear regression models with the Huber-White estimate of variance³⁶ (using Intercooled Stata[®] version 8.2³⁷).

RESULTS

Analyses included 80,207 patients who met the inclusion/exclusion criteria. These individuals were primary care patients at 541 VA locations in 1999. Table 1 describes characteristics of the patients.

The following percentages of the 144,176 otherwise eligible patients with at least 1 intermediate outcome reported did not have records for the individual outcomes: HbA1c (19.3%), LDL-C (38.5%), and BP (3.5%). Of 89,428 patients otherwise eligible, 9.8% were excluded from the final analyses based on requiring a record of a BMI.

Based on the VHA practice guidelines, 30.7% achieved simultaneous control (Table 2). Percentages for control of individual outcomes were: HbA1c (81.5%), LDL-C (77.2%), and BP (47.5%). Using the more stringent ADA guidelines, only 3.9% of patients achieved simultaneous control, and fewer patients achieved control for each individual outcome: HbA1c (36.2%), LDL-C (40.7%), and BP (22.7%). Sensitivity analyses counting patients without all 3 intermediate outcomes recorded as not having simultaneous control led to estimated rates of simultaneous control of 17.3% of patients based on 1997 VHA guidelines and 2.2% of patients based on 2004 ADA guidelines.

Patients with control of any 1 parameter of diabetes care (i.e., HbA1c, LDL-C, BP) were only slightly more likely to have control of other parameters. For example, 48% of patients with LDL-C < 130 mg/dL had good BP control, compared with 44% of patients with LDL-C ≥ 130 mg/dL. The unadjusted association between control of blood sugar and LDL-C was stronger but still not tightly correlated; adequate glycemic control was present in 83% of patients with LDL-C < 130 mg/dL, compared with 75% of patients with LDL-C ≥ 130 mg/dL. There was a very small unadjusted inverse relationship between

Table 1. Characteristics of Study Patients, $n=80,207$

Characteristic	Mean (SD) or %
Mean hemoglobin A1c in 2000 (%)	7.70 (1.56)
Mean low density lipoprotein cholesterol in 2000 (mg/dL)	108.75 (30.87)
Mean systolic blood pressure in 2000 (mmHg)	141.16 (17.12)
Mean diastolic blood pressure in 2000 (mmHg)	74.87 (9.64)
Mean body mass index closest to the beginning of fiscal year 2000 (kg/m^2)	30.86 (5.87)
Body mass index categories (kg/m^2)	
≤ 24	10.66
25 to 29	34.94
30 to 34	31.87
35 to 39	14.68
≥ 40	7.85
Race/ethnicity	
African American (not Hispanic)	10.32
Hispanic	3.90
White	52.12
Other	0.75
Unknown race/ethnicity	32.91
Gender	
Male	97.93
Mean age in 2000	65.10 (10.46)
Age in 2000	
18 to 49	7.80
50 to 64	34.18
65 to 79	52.63
≥ 80	5.39
VA primary care visits during 2000	
1	4.37
2 to 4	58.02
≥ 4	37.61
Pharmaceutical treatment-filled prescriptions for blood sugar and cholesterol medicines in 2000	
Oral hypoglycemic agent	59.17
Insulin	25.46
Lipid lowering agent (excluding niacin)	43.05
Niacin	1.03
Pharmaceutical treatment-number of classes of antihypertensive medication for which there was a filled prescription in 2000	
0	34.03
1	18.33
2	20.94
≥ 3	26.69

glycemic control and BP control. Results were generally similar using 2004 ADA definitions of risk factor control (Table 3).

The logistic-regression analysis for simultaneous control using 1997 VA guidelines is presented in Table 4. The likelihood of achieving simultaneous control was negatively associated with: having a BMI ≥ 40 kg/m^2 compared with 18 to 24 kg/m^2 (OR=0.66; 95% confidence interval [CI] 0.61 to 0.72); being African American (OR=0.65, 95% CI 0.61, 0.70), being Hispanic-black (OR=0.68, 95% CI 0.49, 0.93) compared with white; being female (OR=0.76, 95% CI 0.68, 0.85); and taking ≥ 3 classes of antihypertensive agents compared with taking no antihypertensive medications (OR=0.83, 95% CI 0.78, 0.88). In addition, simultaneous control was positively associated with being American Indian compared with white (OR=1.40, 95% CI 1.09, 1.81). Results for associations between control of vascular risk factors were similar to those found in the unadjusted analysis. The association between HbA1c control and LDL-C control was modest (OR=1.51; 95% CI 1.44, 1.59); association between BP and

Table 2. Control of Intermediate Diabetes Outcomes Among VA Patients in Fiscal Year 2000, n=80,207

Intermediate Outcome	Percent
1997 Veterans Health Administration Definitions of Control of Intermediate Outcomes*	
Simultaneous control of all intermediate outcomes	30.7
Hemoglobin A1c < 9.0%	81.5
Low density lipoprotein cholesterol < 130 mg/dL	77.2
Systolic blood pressure < 140 mmHg and diastolic blood pressure < 90 mmHg	47.5
2004 American Diabetes Association Control Definitions of Intermediate Outcomes*	
Simultaneous control of all intermediate outcomes	3.9
Hemoglobin A1c < 7.0%	36.2
Low density lipoprotein cholesterol < 100 mg/dL	40.7
Systolic blood pressure < 130 mmHg and diastolic blood pressure < 80 mmHg	22.7

*The above definitions of simultaneous control are not mutually exclusive.

LDL-C control was even smaller (OR=1.26; 95% CI 1.21, 1.30), and there was essentially no association between BP and HbA1c control (OR=0.95; 95% CI 0.92, 0.99). While fewer patients achieved control of these outcomes using the more stringent ADA definitions, the magnitudes of the associations were similar (results available upon request from authors).

In order to provide a context for the associations between control of individual outcomes, we performed linear regression analysis with each clinical risk factor as a continuous variable outcome (adjusting for all factors used in the logistic models). For example, Table 5 displays the expected differences in LDL-C, SBP, and DBP when 1 has control of HbA1c. Results show only small-adjusted differences in each outcome between patients in and out of control of each of the other clinical parameters. For example, the difference between LDL-C for patients with good control of HbA1c and those with poor control was 6.67 mg/dL, favoring those with good HbA1c control. Other differences were of even smaller magnitude.

DISCUSSION

In a health care system that has been shown to deliver superior quality care and provide access to comprehensive primary care services,^{13,38} simultaneous control of diabetes outcomes by the standards of the era was achieved only by approximately one-third of veterans. Furthermore, the associations between control of individual risk factors are, for the most part, clinically unimportant.^{3,5} Only the relationship between control of HbA1c and LDL-C has slight clinical relevance.

Numerous medical, behavioral, and organizational interventions have been developed in recent years aimed at controlling major cardiovascular risk factors among diabetic patients.^{23,24} This is often done under the assumption that there are underlying mechanisms that lead to overall lowering of risk if there is focus on a limited set of these outcomes (e.g., HbA1c). For example, many believe patient characteristics (e.g., nonadherence) may lead to inadequate control of chronic illnesses.³⁹ This perspective implies that interventions addressing these characteristics (e.g., pill boxes) can simultaneously improve multiple clinical outcomes. However, our results indicate that there is little relationship between control of the principal intermediate outcomes in diabetes. The present data suggest that success with 1 outcome may not portend the same benefits in other outcomes, even for the same disease.

Clinicians and researchers need to consider the potential implications of this research. Clinicians may not wish to aggressively pursue only 1 intermediate outcome under the assumption that others will then be controlled. Also, interventions may be faulty if they are based on an assumption that, for example, a patient is simply "nonadherent" or "passive." Rather researchers should explore adherence to or interest in specific behaviors and treatments relating to particular management problems.⁴⁰

Results from logistic-regression models for control of individual intermediate outcomes show a significant relationship between BMI and all outcomes. Among variables included in the analyses, the largest association with simultaneous control reflects the well-documented relationship between

Table 3. Percent of Patients with Control of Other Intermediate Outcomes When One is in Control, n=80,207

Level of Intermediate Outcome Control	HbA1c Control < 9.0% (% of Patients)	LDL-C Control < 130 mg/dL (% of Patients)	BP Control < 140/90 mmHg (% of Patients)
1997 Veterans Health Administration Definitions of Control of Intermediate Outcomes			
When HbA1c < 9.0%		79.0**	46.7**
When HbA1c ≥ 9.0%		69.5**	51.0**
When LDL-C < 130 mg/dL	83.4**		48.4**
When LDL-C ≥ 130 mg/dL	75.3**		44.4**
When BP < 140/90 mmHg	80.2**	78.7**	
When BP ≥ 140/90 mmHg	82.8**	75.9**	
Level of Intermediate Outcome Control	HbA1c Control < 7.0% (% of Patients)	LDL-C Control < 100 mg/dL (% of Patients)	BP Control < 130/80 mmHg (% of Patients)
2004 American Diabetes Association Control Definitions of Intermediate Outcomes			
When HbA1c < 7.0%		43.8**	22.5
When HbA1c ≥ 7.0%		39.0**	22.8
When LDL-C < 100 mg/dL	38.9**		24.9**
When LDL-C ≥ 100 mg/dL	34.3**		21.2**
When BP < 130/80 mmHg	35.9	44.7**	
When BP ≥ 130/80 mmHg	36.2	39.5**	

**P < .05 = (for difference in proportions).

HbA1c, hemoglobin A1c; LDL-C, low-density lipoprotein cholesterol; BP, blood pressure.

Table 4. Predictors of Control of HbA1c, LDL-C, BP and All 3 Simultaneously, using 1997 Veterans Health Administration Definitions, $n=80,207$

Patient Characteristic	HbA1c <9% OR (95% CI)	LDL-C <130 mg/dL OR (95% CI)	BP <140/90 mmHg OR (95% CI)	Simultaneous Control OR (95% CI)
Body mass index (kg/m ²)				
18 to 24	Referent (N/A)	Referent (N/A)	Referent (N/A)	Referent (N/A)
25 to 29	1.17 (1.10, 1.25)**	0.93 (0.87, 0.99) **	0.81 (0.76, 0.85) **	0.89 (0.84, 0.94) **
30 to 34	1.14 (1.07, 1.22) **	0.97 (0.91, 1.03) **	0.69 (0.66, 0.73) **	0.81 (0.77, 0.86) **
35 to 39	1.04 (0.97, 1.12)	0.98 (0.90, 1.06)	0.63 (0.59, 0.67) **	0.74 (0.69, 0.80) **
≥ 40	1.10 (1.01, 1.20) **	0.88 (0.81, 0.96) **	0.54 (0.50, 0.57) **	0.66 (0.61, 0.72) **
Race/ethnicity				
White	Referent (N/A)	Referent (N/A)	Referent (N/A)	Referent (N/A)
African American	0.68 (0.63, 0.74) **	0.66 (0.60, 0.72) **	0.76 (0.71, 0.82) **	0.65 (0.61, 0.70) **
American Indian	0.80 (0.60, 1.08)	1.22 (0.81, 1.84)	1.45 (1.11, 1.91) **	1.40 (1.09, 1.81) **
Asian	0.65 (0.49, 0.87) **	1.18 (0.86, 1.62)	1.18 (0.96, 1.45)	1.05 (0.81, 1.36)
Hispanic-black	0.56 (0.37, 0.85) **	0.84 (0.62, 1.14)	1.03 (0.78, 1.37)	0.68 (0.49, 0.93) **
Hispanic-white	0.54 (0.39, 0.73) **	1.07 (0.92, 1.25)	1.02 (0.92, 1.13)	0.87 (0.75, 1.01)
Unknown Race/ethnicity	0.96 (0.91, 1.02)	1.00 (0.93, 1.08)	0.90 (0.85, 0.94) **	0.91 (0.87, 0.96) **
Gender (referent =male)				
Female	1.12 (0.99, 1.26)	0.75 (0.67, 0.83) **	0.82 (0.75, 0.90) **	0.76 (0.68, 0.85) **
Age				
18 to 49	Referent (N/A)	Referent (N/A)	Referent (N/A)	Referent (N/A)
50 to 64	1.35 (1.27, 1.43) **	1.19 (1.12, 1.27) **	0.64 (0.60, 0.68) **	0.95 (0.89, 1.01)
65 to 79	2.56 (2.38, 2.75) **	1.54 (1.44, 1.65) **	0.46 (0.43, 0.49) **	0.95 (0.89, 1.01)
≥ 80	3.11 (2.77, 3.50) **	1.54 (1.39, 1.71) **	0.44 (0.40, 0.49) **	0.98 (0.89, 1.07)
VA Primary care visits during FY2000				
1	Referent (N/A)	Referent (N/A)	Referent (N/A)	Referent (N/A)
2 to 4	1.13 (1.03, 1.24) **	1.15 (1.06, 1.26) **	1.00 (0.93, 1.08)	1.12 (1.03, 1.22) **
5 or more	0.93 (0.84, 1.03)	1.18 (1.07, 1.30) **	0.94 (0.87, 1.02)	1.02 (0.93, 1.13)
Pharmaceutical treatment (referent=not having a filled prescription for drug category in FY2000)				
Oral hypoglycemic agent	0.62 (0.58, 0.66)**	0.99 (0.93, 1.04)	1.26 (1.20-1.33)**	0.98 (0.94, 1.03)
Insulin	0.36 (0.34, 0.38)**	1.01 (0.96, 1.06)	1.09 (1.05, 1.14)**	0.74 (0.71, 0.78)**
Lipid lowering agent (excluding niacin)	1.06 (1.01, 1.11)**	0.79 (0.75, 0.84)**	1.33 (1.29, 1.38)**	1.19 (1.14, 1.23)**
Niacin	1.45 (1.19, 1.76)**	0.72 (0.62, 0.84)**	1.21 (1.04, 1.41)**	1.13 (0.96, 1.33)
Pharmaceutical treatment (number of types of antihypertension medication fills in FY2000)				
None	Referent (N/A)	Referent (N/A)	Referent (N/A)	Referent (N/A)
1	1.47 (1.37, 1.57)**	1.09 (1.01, 1.17)**	0.76 (0.71, 0.81)**	1.00 (0.94, 1.06)
2	1.69 (1.58, 1.80)**	1.25 (1.15, 1.35)**	0.56 (0.53, 0.60)**	0.89 (0.84, 0.94)**
3 or more	2.00 (1.87, 2.15)**	1.57 (1.44, 1.70)**	0.44 (0.42, 0.47)**	0.83 (0.78, 0.88)**
Control of intermediate outcomes				
HbA1c <9%	N/A	1.51 (1.44, 1.58)**	0.95 (0.92, 0.99)**	N/A
LDL-C <130 mg/dL	1.51 (1.44, 1.59)**	N/A	1.26 (1.21, 1.30)**	N/A
SBP <140 mmHg and DBP <90 mmHg	0.96 (0.92, 0.99)**	1.26 (1.21, 1.31)**	N/A	N/A
Model intercept				
Intercept parameter and SE	Parameter=0.6695** SE=0.1237	Parameter=0.0679 SE=0.1178	Parameter=0.6399** SE=0.1092	Parameter= -0.7518** SE=0.1057

*Also adjusted for comorbidities using aggregated diagnostic groups, which is part of the Johns Hopkins Adjusted Clinical Groups Case-Mix System[®].

** $P < .05$.

HbA1c, hemoglobin A1c; LDL-C, low-density lipoprotein cholesterol; BP, blood pressure; SE, standard error; SBP, systolic blood pressure; DBP, diastolic blood pressure; FY, fiscal year; CI, confidence interval; OR, odds ratio.

greater weight and higher BP.⁴¹ Weight was the strongest modifiable factor associated with control of vascular risks and may be an appropriate focus for intervention by providers.

From the provider's perspective, better outcomes appear to be associated with simultaneously treating multiple risk fac-

tors, an indication of the aggressiveness of overall diabetes treatment. As expected, more intensive treatment with medication is associated with having worse control of that outcome, because providers are more likely to increase the intensity of treatment when patients do not have control. However, our re-

Table 5. Adjusted Expected Difference in other Intermediate Diabetes Outcomes When a Specific Outcomes is Under Control, $n=80,207$

Control Definition	Difference in HbA1c (%) (95% CI)	Difference in LDL-C (mg/dL) (95% CI)	Difference in SBP (mmHg) (95% CI)	Difference in DBP (mmHg) (95% CI)
1997 Veterans Health Administration Definitions of Control of Intermediate Outcomes				
HbA1c <9.0%	N/A	-6.67 (-7.33, -6.00)**	0.47 (0.15, 0.79)**	-1.01 (-1.19, -0.84)**
LDL-C <130 mg/dL	-0.29 (-0.32, -0.25)**	N/A	-2.38 (-2.70, -2.05)**	-1.45 (-1.63, -1.27)**
BP <140/90 mmHg	0.01 (-0.010, 0.037)	-3.38 (-3.91, -2.86)**	N/A	N/A

*The model also included other covariates used in the logistic regression model described in Table 4.

** $P < .05$.

HbA1c, hemoglobin A1c; LDL-C, low-density lipoprotein cholesterol; BP, blood pressure; SE, standard error; SBP, systolic blood pressure; DBP, diastolic blood pressure; FY, fiscal year; CI, confidence interval.

sults indicate that provider vigilance in 1 outcome may be associated with better results for other outcomes, even in the face of challenging biological disease. For example, more intensive treatment for BP increased the likelihood of having control of each intermediate outcome (e.g., the greater number of anti-hypertensive medication types used, the greater the chance of having HbA1c control). Rather than indicating a common underlying biological mechanism, these results likely represent the degree to which providers intensively treat patients with intermediate outcomes/risk factors that are out of control. The opposite of higher level of vigilance, clinical inertia, has been reported as a major issue in diabetes management.⁴²⁻⁴⁴

Demographic predictors of simultaneous control were consistent with previous literature. Age was not predictive of simultaneous control. Higher levels of hypertension were counterbalanced by better lipid control observed among older patients. Both these phenomena are well-described.^{45,46} As in other studies, African-American patients have worse control of vascular risk factors than whites.^{12,47} Better simultaneous control in American Indians is predicted based on lower rates of hypertension in this population.^{48,49} However, there were only, 234 American Indians in the study cohort. Finally, worse simultaneous control among women is likely because of the age distribution of cohort members reflecting the fact that VA patients, both women and men, tend to be older than those in other health care settings.⁵⁰ Most women in the sample were probably approaching or had reached menopause, and postmenopausal women have higher BP and lipids than men of a similar age.^{45,46}

This study has limitations and considerations. First, we lack data on important confounders, especially lifestyle behaviors associated with our outcomes (e.g., physical activity, diet, smoking status).^{41,51} Second, the study was conducted among VA users, virtually all of whom are male and many have complex chronic conditions. Finally, it is possible that our estimate of the rate of simultaneous control is high. Our calculation taking this possibility into account lead to estimates of simultaneous control as low as 17.3% for the definition based on the 1997 VHA guidelines and 2.2% for the more stringent 2004 ADA guidelines.

In summary, there is increasing recognition that control of vascular risk factors for patients with diabetes is critical to reduce morbidity and mortality.¹⁻⁶ Our results suggest that health care providers cannot assume that successfully achieving therapeutic goals for 1 risk factor will be associated with simultaneous control of other risk factors. Indeed, improving the quality and outcomes of diabetes care may require the consideration of individual characteristics when developing innovative strategies. These findings do not negate the importance of interventions that direct resources toward self-management support, organizational structures and processes, or broad behavioral adaptations.⁵² Rather, our findings suggest the importance of addressing and monitoring individual outcomes when attempting to achieve therapeutic goals for multiple outcomes simultaneously. This may include both specific medical management and addressing psychosocial issues faced by patients (e.g., readiness to change behaviors aimed at specific intermediate outcomes and social support for those changes).⁵³

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