Management of Type 2 Diabetes in the Primary Care Setting: A Practice-Based Research Network Study

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ABSTRACT

PURPOSE We wanted to describe how primary care clinicians care for patients with type 2 diabetes.

METHODS We undertook a cross-sectional study of 95 primary care clinicians and 822 of their established patients with type 2 diabetes from 4 practice-based, primary care research networks in the United States. Clinicians were surveyed about their training and practice. Patients completed a self-administered questionnaire about their care, and medical records were reviewed for complications, treatment, and diabetes-control indicators.

RESULTS Participating clinicians (average age, 45.7 years) saw an average of 32.6 adult patients with diabetes per month. Patients (average age, 59.7 years) reported a mean duration of diabetes of 9.1 years, with 34.3% having had the disease more than 10 years. Nearly one half (47.5%) of the patients had at least 1 diabetes-related complication, and 60.8% reported a body mass index greater than 30. Mean glycosylated hemoglobin (HbA_{1c}) level was 7.6% (SD 1.73), and 40.5% of patients had values < 7%. Only 35.3% of patients had adequate blood pressure control (< 130/85 mm Hg), and only 43.7% had low-density lipoprotein cholesterol (LDL-C) levels < 100 mg/dL. Only 7.0% of patients met all 3 control targets. Multilevel models showed that patient ethnicity, practice type, involvement of midlevel clinicians, and treatment were associated with HbA_{1c} level; patient age, education level, and practice type were associated with blood pressure control; and patient ethnicity was associated with LDL-C control.

CONCLUSIONS Only modest numbers of patients achieve established targets of diabetes control. Reengineering primary care practice may be necessary to substantially improve care.

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INTRODUCTION

In 2002, visits to primary care physicians accounted for 62.7% of all office visits in the United States, and diabetes mellitus ranked third, accounting for 3.1% of illness-related diagnoses.[1] Patients with type 2 diabetes often have acute or chronic comorbid health problems that force the clinician to prioritize and address the most pressing or symptomatic problems first.[2-6] The situation is further complicated by the lack of access to a complete multidisciplinary diabetes health care team or by the lack of systems within primary care practices to provide ongoing support for this chronic disease.[7]

In this article we describe the care provided by primary care clinicians to their patients who have type 2 diabetes using data from 3 sources: reports from physicians on their training and the patient care strategies they use to treat diabetes; surveys of patients about their diabetes care; and medical record reviews to determine medications used for diabetes and cardiovascular risk factor control, indicators of glycemic control, and diabetes-related com-

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plications. Our purpose was to describe the processes and outcomes of care of type 2 diabetes achieved by clinicians and their patients in member practices from 4 practice-based research networks (PBRNs). In particular, we examined practice design strategies for diabetes care, the composition of the health care team, the complexity of the health problems experienced by patients with type 2 diabetes (including comorbid conditions), control of diabetes (including cardiovascular risk-factor control), and the spectrum of treatment provided by their clinicians.

METHODS

Settings

The Diabetes Outcome Study was conducted in 4 primary care PBRNs in the United States from February 2001 to April 2002. PBRNs are collaboratives of physicians or clinics committed to performing research of importance and relevance to their clinical practice.[8-11] The American Academy of Family Physicians National Research Network (AAFP-NRN), the Minnesota Academy of Family Physicians Research Network (MAFPRN), the Texas Academy of Family Physicians Research Network (TAFP R-Net), and the Southern Primary Care Urban Research Network (SPUR-Net) each recruited constituent members for the study. The AAFP-NRN is a nationally distributed network of primary care physicians. The MAFPRN and TAFP R-Net are statewide networks administered through their respective state AAFP chapters, and SPUR-Net is a partnership of primary health-care organizations located in Houston, Texas.

Procedures

For this study, the term *primary care clinician* is used to include family physicians, general practitioners, general internists, and nurse-practitioners. Recruitment of clinicians began in July 2000.

Participating clinicians and study coordinators were instructed to enroll 10 consecutive patients who met the eligibility criteria for the study. Patients were considered eligible if they (1) had a current diagnosis of type 2 diabetes (based on clinician judgment), (2) were at least 18 years of age, (3) were seeing their primary care clinician at the study visit, (4) had visited the study clinic at least once within past 2 years, and (5) were able to speak and read English. The institutional review boards of Baylor College of Medicine and the University of Minnesota approved the study.

Measures

Clinicians completed a self-administered questionnaire at the initiation of the study. This instrument included demographic characteristics of the clinician (age, sex, years in practice) and the practice (eg, location, specialty, number of patients with diabetes seen in a typical month, specific practice management tools).[12]

After giving consent to participate in the study and before their outpatient clinic visit with the clinician, patients completed a self-administered questionnaire that solicited general demographic information and specific information about self-management of diabetes.

After the office visit, the study clinician or study coordinator completed a checklist of diabetes-related complications and clinical information from the patient's medical record, as well as the most recent laboratory values for glycosylated hemoglobin (HbA_{1c}) and low-density lipoprotein cholesterol (LDL-C). Diabetes and cardiovascular risk-reduction medications were also abstracted.

Control Targets

The clinical indicators used were those defined by the Diabetes Quality Improvement Project from the National Committee for Quality Assurance (NCQA).[13] The HbA_{1c} level was used as the primary indicator of diabetes control; a value <7% indicated controlled, a value from 7.0% to 7.9% indicated intermediate control, and a value ≥8% indicated uncontrolled. These categories correspond to the 2002 clinical practice recommendations from the American Diabetes Association (ADA)[14] and were used by Parnes et al[15] to classify action levels for HbA_{1c}. Similarly, blood pressure was considered to be uncontrolled if ≥130/85 mm Hg and further defined using the Joint National Committee 7 (JNC 7) categorizations.[16] Finally, a LDL-C level of ≥100 mg/dL was considered uncontrolled.[16]

Data Analysis

We report descriptive characterizations of the 95 eligible clinicians and their patients, and the numbers of patients meeting the control targets for HbA_{1c}, blood pressure, and LDL-C. Contingency tables were used to express the relations between the control of HbA_{1c}, cardiovascular risk factors, and treatment strategies. Analyses were performed with SAS Versions 8.2 and 9.1.[17]

To determine whether diabetes and cardiovascular outcomes were associated with patient characteristics, clinician characteristics, practice design strategies, or treatment, general linear mixed models (multilevel models) were used for continuous HbA_{1c} levels. Generalized linear mixed models with HbA_{1c}, blood pressure, and LDL-C lipid control (controlled or not controlled) as the outcome (logit link) were used to extend the traditional logistic regression model to accommodate the multilevel structure and clustering of patients within physicians (Proc MIXED with GLIMMIX macro).[18] Variance components were examined at each level to determine whether random effects should be retained at that level (physician/practice). To enhance stability of the models,

we used a model-building approach that involved determining which patient-level covariates were needed based on clinical or statistical significance (at $P < .15$), and then we added level-2 predictors (physician/practice) one at a time. We also calculated the intraclass correlation coefficient for each control variable across the 95 clinicians.

RESULTS

Clinician and Patient Characteristics

A total of 141 clinicians volunteered to participate in the study. Of this number, 127 were family physicians, 2 were general practitioners, 5 were general internists, 4 identified themselves as some combination thereof, and 3 were nurse-practitioners. Nine participants practiced in Canada, and 132 practiced in the United States.

Fourteen (10%) initial clinician volunteers withdrew before subject recruitment began, and 28 (20%) were unable to enroll any patients during the 15-month data-collection phase of the study. Of the remaining 99 clinicians, 4 were dropped from the analysis because they enrolled only 1 patient each.

The 95 participating clinicians had an average age of 45.7 years (SD, 7.8), and most (71.6%) were male. They had been in practice an average of 14.6 years (SD, 8.8). The average number of adult patients with diabetes seen by each clinician in a typical month was 32.6, with 21.2% of clinicians providing care to more than 40 adult patients with diabetes per month. Practice type varied widely, with 36.8% of clinicians working in single-specialty groups, 19.0% in academic settings, 15.8% in multispecialty groups, 14.7% in solo practice, and 13.7% in a combination of settings. Practice location also varied widely; 37.9% of practices were in large cities with populations of more than 250,000, whereas 21.1% were in rural areas.

When clinicians who enrolled at least 2 patients (n = 95) were compared with those who enrolled none or 1 patient (n = 46), the 2 groups differed statistically on 4 (6.3%) of 63 survey items: (1) use of patient-held mini-records (25% vs 48%, $P < .01$); (2) use of letters or postcards (6% vs 39%, $P < .01$); (3) use of patient registries (8% vs 23%, $P < .02$; and (4) mean number of adult patients with diabetes seen per month (33 vs 44, $P = .04$).

For the 92 physicians who enrolled 2 or more patients, their demographic data were compared with data from the AAFP Masterfile of active US members (32,219) reporting time in direct patient care as of February 2001 (the start of patient enrollment and data collection, this comparison does not include the 3 nurse-practitioners). Of the 6 demographic factors on which these comparisons were possible, the 92 study physicians did not differ statistically ($P > .05$) by sex, practice type, age, and years since medical school. The comparisons were statistically different ($P < .05$) for percentage of patients on Medicaid, with means of 11.5% (AAFP) and 15.2% (study), and for years in practice, with means of 11.3 years (AAFP) and 14.9 years (study), although for the study physicians this variable was measured as "years since residency."

Of the 834 patients who were enrolled in the study, only 822 patients were included in the analysis. Of the 12 that were dropped, 4 were the only patients their clinicians enrolled and 8 had a missing patient questionnaire or visit monitoring form. The characteristics of the 822 adult patients who were included in the analysis are given in Table 1.

Table 1. Characteristics of Study Patients (N = 822)

Patient Sociodemographics Characteristics*	No. (%)
Age, y	
Mean	59.5
Standard deviation	13.1
Ethnicity	
Non-Hispanic white	575 (71.4)
African American	121 (15.0)
Hispanic	63 (7.8)
Other and mixed	46 (5.7)
Sex, male	358 (44.5)
Highest level of education	
Did not graduate high school	201 (25.4)
High school graduate or general equivalency diploma	343 (43.3)
College or postgraduate training	248 (31.3)
Duration of diabetes, y	
Mean	9.1
Standard deviation	8.7
< 5 y	302 (39.9)
5-10 y	195 (25.8)
11-20 y	157 (20.7)
> 20 y	103 (13.6)
Body mass index†	
< 18.5, underweight	8 (1.1)
18.5-24.9, normal	81 (11.2)
25.0-29.9, overweight	194 (26.9)
30.0-34.9, obese class I	204 (28.3)
35.0-39.9, obese class II	117 (16.2)
≥ 40, obese class III	118 (16.3)
Reason for study office visit†‡	
Routine diabetes follow-up	575 (70.8)
Acute problem	174 (21.4)
Chronic problem, routine	165 (20.3)
Chronic problem, flare-up	43 (5.3)
Pre- or postsurgery follow-up	23 (2.8)
Nonillness care	59 (7.3)

Note: Frequencies may be less than the total sample size because of missing data. Percentages are based on valid observations.

* Data from patient survey.

† Data from visit monitoring form.

‡ More than 1 reason could have been listed.

Table 2. Diabetes-Related Complications and Other Comorbid Health Problems Experienced by Patients with Type 2 Diabetes (N = 822)

Complications and Comorbidities*	No. (%)	Complications and Comorbidities*	No. (%)
Complications related to diabetes†		**Other comorbid health problems†**	
Coronary artery disease	147 (18.6)	Hypertension	457 (56.7)
Neuropathy	146 (18.5)	Osteoarthritis	221 (27.6)
Nephropathy	125 (15.8)	Chronic low back pain	188 (23.4)
Retinopathy	78 (9.9)	Asthma	83 (10.3)
Peripheral vascular disease	78 (9.9)	Thyroid problems	82 (10.2)
Foot ulcer/infection	40 (5.1)	Congestive heart failure	52 (6.5)
Other infection	33 (4.2)	Chronic obstructive lung disease	51 (6.4)
Gastroparesis	29 (3.7)		

* Percentages are based on patients with complete complications data; 33 patients had missing data on complications.
† Complications are from visit monitoring form; comorbidities are from patient survey.

Table 3. Patients Meeting Control Targets for Glycosylated Hemoglobin and Cardiovascular Risk Factors

Control Target*	Frequency	Percent of Total
HbA_{1c}		
<7.0%	313	40.5
7.0% to 7.9%	217	28.1
8.0% to 8.9%	109	14.1
9.0% to 9.9%	61	7.9
≥10.0%	72	9.3
Blood pressure: ADA target		
Systolic <130 mm Hg and diastolic <85 mm Hg	285	35.3
Blood pressure: JNC 7 categories†		
Normal (systolic <120 mm Hg and diastolic <80 mm Hg)	146	18.1
Prehypertension (systolic 120-139 mm Hg or diastolic 80-90 mm Hg)	452	55.9
Stage 1 hypertension (systolic 140-159 mm Hg or diastolic 90-99 mm Hg)	176	21.8
Stage 2 hypertension (systolic ≥160 mm Hg or diastolic ≥100 mm Hg)	34	4.2
LDL-C		
<100 mg/dL	294	43.8
100-129 mg/dL	198	29.5
130-159 mg/dL	105	15.7
160-189 mg/dL	52	7.8
≥190 mg/dL	22	3.3
Combined targets		
HbA_{1c} (<7%) and LDL-C (<100 mg/dL)	111	16.7
HbA_{1c} (<7%) and blood pressure (<130/85 mm Hg)	104	13.7
HbA_{1c} (<7%) and blood pressure (<130/85 mm Hg) and LDL-C (<100 mg/dL)	45	7.0

HbA_{1c} = glycosylated hemoglobin; ADA = American Diabetes Association; JNC 7 = The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; LDL-C = low-density lipoprotein cholesterol.

Note: Percentage is based on cases where data were available and provided. Missing data rates are 6.1% for HbA_{1c}, 1.7% for blood pressure, and 18.4% for LDL-C. Data are from visit monitoring forms.

* Based on American Diabetes Association target for adults with type-2 diabetes.[14]
† Based on the JNC 7 for blood pressure.[16]

Practice Design and Health Care Team

Practice design features to enhance diabetes care included the use of diabetes management protocols/flow sheets (72.6%), the use of an electronic medical record (29.5%), and the involvement of a nurse-practitioner or physician's assistant (21%). Few clinicians (8.4%) used patient registries. The most common health professionals to whom the clinicians referred their diabetic patients included dietitians (88.4%), ophthalmologists (85.8%), diabetes educators (71.6%), podiatrists (58.9%), and endocrinologists (42.1%). These figures refer to health professionals that study clinicians reported they routinely used (within the practice or by referral) in the care of patients with type 2 diabetes, not actual referral rates.

Comorbid Health Problems

Table 2 displays the diabetes-related complications and other comorbid health problems reported by patients in the study. Nearly one half (47.5%) of the patients reported having had at least 1 diabetes-related complication, with coronary artery disease, neuropathy, and nephropathy the most common.

Clinical Measures of Diabetes and Control Targets

Table 3 displays the control of HbA_{1c}, blood pressure, and LDL-C for patients in the study (data from the visit monitoring form). The HbA_{1c} value was <7% for 313 (40.5%) patients, and the mean value was 7.6% (SD, 1.73). Using the ADA target of 130/85 mm Hg for blood pressure, 285 (35.3%) patients had adequate blood pressure control. For LDL-C, 294 (43.8%) patients had levels

Table 4. Diabetes and Cardiovascular Medications Used by Patients With Type 2 Diabetes (N = 822)

Drug Class or Description	No. (%)
Insulin	187 (22.7)
Oral diabetes medications	
Biguanide	439 (54.1)
Sulfonylurea	440 (53.3)
Alpha-glucosidase inhibitor	14 (1.7)
Thiazolidinedione	225 (27.4)
Antihypertensives	613 (74.6)
Aspirin	289 (35.7)
Any lipid-lowering drug	481 (58.5)
ACE Inhibitor or ARB	469 (57.1)

ACE = angiotensin-converting enzyme inhibitor; ARB = angiotensin receptor blocker.

Note: Data are from visit monitoring form.

<100 mg/dL, indicating adequate control. Finally, when the 3 control targets were considered together, 45 (7.0%) met all 3 targets.

Treatment

Treatment data were obtained from the visit monitoring form. Table 4 reports the specific diabetes and cardiovascular medications or classes of medications that the patients used. Nearly 3 in 4 patients were taking antihypertensive medications. More than one half were taking angiotensin-converting enzyme (ACE) inhibitors or angiotensin-receptor blockers (ARBs), and about one third were taking aspirin. More than one half were taking a lipid-lowering medication.

Table 5 shows the relationship between HbA_{1c} level and the diabetes treatment strategies, including oral medications and insulin. Overall, 88.7% of patients were being treated with oral medications and/or insulin. The use of oral medications and insulin was more common among patients with HbA_{1c} levels ranging from 7% to 8% than among patients whose levels were <7%. Among patients with HbA_{1c} levels >8%, 97.4% were treated with oral medications and/or insulin, and nearly one half (47.8%) were treated with at least 2 oral medications. Slightly more than one third (34.2%) of these patients were taking insulin.

To control cardiovascular risk factors (Table 6), 74.6% of patients were given prescriptions for an antihypertensive medication. There were 117 patients (14.5% of the total) who had poor blood pressure control and were receiving lifestyle change management only or no active treatment. There were 166 patients (24.7% of the total) with elevated LDL-C levels who received only lifestyle change management or no active treatment.

Factors Associated With Control of HbA_{1c} and Cardiovascular Risk Factors

Three of 4 variance components for physicians were significant at $P < .05$, with intraclass correlation coefficients of 0.022 (HbA_{1c} as a continuous variable), 0.045 (HbA_{1c} controlled or not controlled), 0.041 (blood pressure controlled or not controlled), and 0.074 (LDL-C controlled or not controlled), suggesting that it was necessary to use methods appropriate for clustered data. Results from multilevel models showing associations with these 4 control outcomes are given in Tables 7 and 8. The only patient-level factor associated with HbA_{1c} was ethnicity (poorer control for African American, Hispanic, and other patients, compared with white patients). Of the clinician-level characteristics, patients cared for in academic settings, by solo practitioners, and in multispecialty groups had higher HbA_{1c} values than patients cared for in single-specialty groups. The only significant practice design feature was involvement of nurse-practitioners or physician's assistants, where involvement was associated with lower HbA_{1c} values. Finally, treatment was strongly related to HbA_{1c} levels, where more aggressive treatment was associated with higher HbA_{1c} levels. Results for the continuous HbA_{1c}

Table 5. Relation Between Treatment Modality and Control for Adult Primary Care Patients with Type 2 Diabetes as Measured by HbA_{1c} Level

Glycosylated Hemoblobin Level	Diet Only n (%)	1 Oral Medication n (%)	2 Oral Medications n (%)	1 Oral Medication and Insulin n (%)	Insulin n (%)	Row Totals n (%)
HbA_{1c} <7%	55 (17.6)	118 (37.7)	100 (31.9)	26 (8.3)	14 (4.5)	313 (40.5)
HbA_{1c} 7%-8%	26 (11.3)	72 (31.2)	78 (33.8)	36 (15.6)	19 (8.2)	231 (29.9)
HbA_{1c} >8%	6 (2.6)	35 (15.4)	109 (47.8)	52 (22.8)	26 (11.4)	228 (29.5)
Column totals	87 (11.3)	225 (29.1)	287 (37.2)	114 (14.8)	59 (7.6)	772

HbA_{1c} = glycosylated hemoglobin.

Note: The data are expressed as frequencies and percentages (in parentheses); percentages in "Row Totals" are row percentages and in "Column totals" are column percentages. Sample size is 772 and excludes 50 cases with missing HbA_{1c} values. Data are from visit monitoring form.

Table 6. Relation Between Treatment and Control of Diabetes Cardiovascular Risk Factors for Adult Primary Care Patients With Type 2 Diabetes

Cardiovascular Risk Factors	Taking Medication* n (%)	Lifestyle Change or Not Treated n (%)	Row Totals† n (%)
Blood pressure			
<130/85 mm Hg	197 (69.1)	88 (30.9)	285 (35.3)
≥130/85 mm Hg	406 (77.6)	117 (22.4)	523 (64.7)
Column totals	603 (74.6)	205 (25.4)	808
LDL-C			
<100 mg/dL	200 (68.3)	93 (31.7)	293 (43.7)
≥100 mg/dL	212 (56.1)	166 (43.9)	378 (56.3)
Column totals	412 (61.4)	259 (38.6)	671

LDL-C = low-density lipoprotein cholesterol

Note: Data are expressed as frequencies and percentages (in parentheses); the percentages in the "Row Totals" are row percentages and those in the "Column totals" are column percentages. Data from visit monitoring form.

* Antihypertensive medications for blood pressure control, and lipid-lowering medications for low-density lipoprotein cholesterol control.

† Totals vary because of missing data.

models and models predicting poor control were generally similar.

Few patient-level variables were associated with poor control of blood pressure or LDL-C. Older patients and those with less than a high school education were more likely to have poor control of blood pressure. African American patients were more likely to have poor LDL-C control than white patients. The only significant clinician characteristic related to poor control of blood pressure was solo practitioner compared with single-specialty groups. No clinician characteristics were associated with control of LDL-C. Finally, none of the practice design features or treatment were associated with control of blood pressure or LDL-C.

DISCUSSION

We believe this cross-sectional study is the first published that describes how primary care clinicians (mostly family physician members of PBRNs) from across the United States manage patients with type 2 diabetes and some of the results that are achieved. Our study found that these patients have moderately advanced and complex disease of prolonged duration, as well as high rates of diabetes-related complications, obesity, and other comorbid conditions. Other studies in the literature addressing similar issues are based on retrospective analyses of large databases,[19] are limited to academic medical centers,[20] or involve experiments designed to test specific treatment interventions,[21] and may have different selection biases than would a primary care practice-based study of unselected patients.

We find that these patients are being treated with glucose-lowering medications, antihypertensives, and lipid-lowering agents by experienced primary care clinicians, who see many patients with type 2 diabetes in their practices. These clinicians use other health care professionals, including dietitians and diabetes educators, to help manage their patients and give them written educational materials on diabetes.

Despite the intensity of diabetes care being provided, only a modest number (40.5%) of patients actually achieved the established target for glycemic control, with a group mean HbA_{1c} of 7.6%. These results are similar to those from an analysis of a sample of patients with type 2 diabetes from the NHANES III study conducted in 1991-1994 (HbA_{1c} <7% in 42.3% of patients, mean value 7.8%)[19] and are better that those reported in a recent retrospective study of general medicine and endocrinology clinics in academic medical centers from 2000-2002 (HbA_{1c} <7% in 34% of patients, mean value 7.9%-8.1%).[20]

There are a number of potential explanations for this suboptimal level of glycemic control in our study patients. While "clinical inertia" and underprescribing of oral hypoglycemic medications and/or insulin may contribute to this problem,[21-24] it is noteworthy that patients with higher HbA_{1c} levels were more likely to be on more than 1 oral hypoglycemic agent and/or insulin than were patients whose HbA_{1c} levels were at or below target. This finding may well reflect the reality that the longer the duration of disease, the more difficult it is to maintain glycemic control, and the greater the need for multiple medications, as shown in the UK Prospective Diabetes Study study.[25] Suboptimal patient compliance is another potential explanation; many factors can affect patient compliance, including the patient's relative utilities or preferences for the short-term discomfort and side effects of treatment compared with the potential long-term benefits of decreased morbidity and mortality from diabetic complications.

Even fewer patients achieved the blood pressure and LDL-C target levels. Only 35.3% were at or below target blood pressure recommended by the ADA, with only 74% below the JNC 7 level for stage 1 hypertension (140/90 mm Hg). Only 50.1% of type 2 diabetics in the NHANES III sample had blood pressures below 140/90 mm Hg.[19] In our study, 43.7% of patients achieved LDL-C target levels of 100 mg/dL compared with 15.4% of patients in the NHANES III study[19] and 49.4% of diabetic patients from the Vermont Diabetes Information System Trial.[26] We found that it was even

harder to achieve target levels simultaneously for multiple risk factors. We believe that this finding reflects the enormous complexity involved in controlling multiple risk factors in patients with diabetes.[27]

Few patient factors, clinician characteristics, or practice design strategies were associated with the glycemic or cardiovascular risk factor control outcomes. The adverse impact of minority ethnicity status on HbA_{1c} and LDL-C levels may constitute examples of health disparities in minority populations. The finding that more aggressive treatment with diabetic medications was associated with higher HbA_{1c} values in the multilevel analysis again suggests the possibility that glycemic control becomes more difficult with time despite the use of multiple diabetic medications, including insulin.

Table 7. Patient, Clinician, Practice Design, and Treatment Predictors of HbA_{1c} From Multilevel Regression Analyses

Domain/Variable	Model Predicting HbA_{1c} as Continuous Variable (n = 666) β (95% CI)	Model Predicting HbA_{1c} >7% (Poor Control) (n = 666) OR (95% CI)
Patient Characteristics		
Age	-0.01 (-0.02 to 0.00)	0.99 (0.98 to 1.00)
Ethnicity (white is reference group)		
African American	0.47 (0.12 to 0.82)*	1.31 (0.77 to 2.23)
Hispanic	0.55 (0.10 to 0.99)*	1.25 (0.66 to 2.40)
Other	0.74 (0.18 to 1.30)*	4.33 (1.63 to 11.47)*
Sex, male	0.18 (-0.06 to 0.42)	1.26 (0.89 to 1.78)
Education (college graduate is reference group)		
Not a high school graduate	-0.02 (-0.36 to 0.32)	0.87 (0.53 to 1.41)
High school graduate or GED	-0.15 (-0.43 to 0.13)	0.89 (0.60 to 1.32)
Duration of diabetes	-0.00 (-0.02 to 0.02)	1.01 (0.99 to 1.03)
Provider characteristics†		
Years in practice	-0.01 (-0.02 to 0.01)	0.99 (0.98 to 1.01)
Sex, male	-0.15 (-0.43 to 0.13)	0.71 (0.44 to 1.37)
No. of patients with diabetes seen in typical month	-0.00 (-0.00 to 0.00)	1.00 (0.99 to 1.01)
Practice type (single specialty is reference group)		
Academic setting	0.61 (0.25 to 0.97)*	2.90 (1.56 to 5.38)*
Solo practice	0.40 (0.03 to 0.77)*	1.88 (1.01 to 3.50)*
Multispecialty group	0.39 (0.03 to 0.75)*	1.59 (0.88 to 2.88)
Combination of settings	0.21 (-0.16 to 0.58)	1.27 (0.69 to 2.36)
Practice design features†		
Flow sheets	-0.09 (-0.37 to 0.19)	0.81 (0.50 to 1.30)
Electronic medical record	-0.22 (-0.49 to 0.05)	0.75 (0.47 to 1.19)
Involvement of nurse-practitioners or physician's assistants	-0.37 (-0.67 to -0.08)*	0.67 (0.41 to 1.11)
Patient registries	0.06 (-0.38 to 0.49)	1.24 (0.57 to 2.70)
Dietician	0.28 (-0.09 to 0.64)	1.45 (0.77 to 2.70)
Diabetes educators	0.05 (-0.29 to 039)	0.88 (0.49 to 1.56)
Endocrinologists	-0.03 (-0.28 to 0.21)	1.09 (0.71 to 1.67)
Treatment (diet only is reference group)		
1 oral medication	0.48 (0.06 to 0.90)*	1.48 (0.84 to 2.62)
≥2 oral medications	1.10 (0.68 to 1.51)*	2.97 (1.68 to 5.24)*
≥1 oral medication and insulin	1.54 (1.03 to 2.04)*	5.72 (2.74 to 11.93)*
Insulin	1.62 (1.00 to 2.23)*	5.06 (2.06 to 12.43)*

HbA_{1c} = glycosylated hemoglobin; OR = odds ratio; CI = confidence interval; GED = general equivalency diploma.

Note. Results from 2 models presented. For the model predicting values of HbA_{1c} as a continuous variable to regression coefficients represent either (1) the change in HbA_{1c} associated with 1 unit change in the predictor variable (for continuous predictors) to or (2) the difference in HbA_{1c} for the predictor variable compared with the reference group (for categorical predictors). In the continuous HbA_{1c} model, if a CI that does not include 0, the regression coefficient is significant at $P < .05$. In the model predicting poor control; a OR that does not include 1.0 is significant at $P < .05$.

* Estimate significant at $P < .05$.

† Clinician characteristics and practice design features were entered one at a time after all patient characteristics and treatment are in the model.

These challenges underline the need for improving the systems that support the care of patients with chronic diseases,[7] including the use of disease registries for tracking patients,[28,29] along with specific clinically important parameters for managing the disease of interest. Only 8.4% of practices in our study reported using registries, suggesting an opportunity for improving active outreach to patients who have not reached target levels of risk factor control. Reengineering is supported by the 2004 Future of Family Medicine Report,[30] which strongly recommended reorganizing primary care practices to provide improved, proactive, patient-centered, population-based chronic care.

The limitations of the study are inherent in practice-based research and cross-sectional descriptive work of this kind. First, the physicians that volunteered to participate may have differed from the larger macrocosm of practicing primary care physicians. Second, we were not able to assess the degree to which the primary care clinicians were able to recruit patients consecutively. Although 52 (55%) clinicians enrolled a minimum of 10 patients, the other clinicians enrolled between 2 and 9. Third, the accuracy of the medical record data cannot be guaranteed. In addition, the laboratory

values were not standardized across practice sites, and blood pressure readings were based on a single reading. Only patients able to speak and read English were eligible for the study. This study was not able to address the spectrum of diabetes management for non-English speaking patients. Similarly, we did not assess health literacy level, although more than 25% of the patients were not high school graduates. Finally, it should be noted that most of the clinicians in the study were family physicians, and there may be differences in practice style across specialties we are not able to address.

In summary, patients with type 2 diabetes are commonly cared for in primary care settings and have a substantial burden of diabetes-related comorbidity. Whereas treatment of hyperglycemia is somewhat successful, control of cardiovascular risk factors is poor and remains a considerable challenge. Further research will help us better understand the complex process-to-outcome relationships in diabetes care. The structures and processes of primary care practice will require urgent changes that support a more proactive, population-based, patient-centered approach.

Table 8. Patient, Clinician, Practice Design, and Treatment Predictors of Cardiovascular Risk Factor Control from Multilevel Regression Analyses

Domain/Variable	Model Predicting Blood Pressure >130/85 mm Hg (n = 699) OR (95% CI)	Model Predicting LDL-C >100 mg/dL (n = 582) OR (95% CI)
Patient characteristics		
Age	1.03 (1.02-1.05)*	0.99 (0.98-1.01)
Ethnicity (white is reference group)		
African American	1.62 (0.96-2.76)	1.86 (1.08-3.20)*
Hispanic	0.72 (0.39-1.32)	1.31 (0.69-2.49)
Other	0.57 (0.27-1.20)	1.16 (0.50-2.69)
Sex, male	0.79 (0.57-1.12)	0.81 (0.57-1.16)
Education (college graduate is reference group)		
Not a high school graduate	1.63 (1.02-2.63)*	0.83 (0.51-1.36)
High school graduate or GED	1.44 (0.98-2.10)	0.90 (0.60-1.36)
Duration of diabetes	0.99 (0.97-1.01)	0.99 (0.97-1.01)
Provider characteristics†		
Years in practice	1.02 (1.00-1.05)	0.99 (0.96-1.01)
Sex, male	1.55 (1.00-2.40)	0.86 (0.53-1.39)
No.of patients with diabetes seen in typical month	1.01 (1.00-1.01)	1.00 (0.99-1.01)
Practice type (single specialty is reference group)		
Academic setting	0.90 (0.51-1.59)	0.75 (0.41-1.36)
Solo practice	2.12 (1.14-3.94)*	0.57 (0.30-1.06)
Multispecialty group	1.13 (0.63-2.00)	1.33 (0.71-2.49)
Combination of settings	0.81 (0.45-1.46)	1.12 (0.58-2.16)
Practice design features†		
Flow sheets	0.70 (0.44-1.12)	1.45 (0.91-2.33)
Electronic medical record	0.91 (0.59-1.39)	1.09 (0.68-1.72)
Involvement of nurse-practitioners or physician's assistants	1.35 (0.83-2.22)	1.15 (0.69-1.92)
Patient registries	0.94 (0.47-1.89)	1.37 (0.62-3.03)
Dietician	0.85 (0.46-1.56)	0.61 (0.32-1.19)
Diabetes educators	0.93 (0.53-1.61)	1.18 (0.66-2.08)
Endocrinologists	1.16 (0.78-1.72)	1.00 (0.66-1.52)
Treatment		
Any antihypertensive or lipid-lowering medication	1.37 (0.93-2.00)	0.71 (0.49-1.03)

CI = confidence interval; LDL-C = low-density lipoprotein cholesterol; GED = general equivalency diploma.

Note: In models predicting poor control, an odds ratio that does not include 1.0 is significant at $P < .05$.

* Estimate significant at $P < .05$.

† Clinician characteristics and practice design features were entered one at a time after all patient characteristics and treatment are in the model.

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