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Performance of Primary Care Physicians and Other Providers on Key Process Measures in the Treatment of Diabetes

FRITHA MORRISON, MPH¹
MARIA SHUBINA, SCD¹

SAVELI I. GOLDBERG, PHD²
ALEXANDER TURCHIN, MD, MS^{1,3,4}

OBJECTIVE—Studies have shown that patients without a consistent primary care provider have inferior outcomes. However, little is known about the mechanisms for these effects. This study aims to determine whether primary care physicians (PCPs) provide more frequent medication intensification, lifestyle counseling, and patient encounters than other providers in the primary care setting.

RESEARCH DESIGN AND METHODS—This retrospective cohort study included 584,587 encounters for 27,225 patients with diabetes and elevated A1C, blood pressure, and/or LDL cholesterol monitored for at least 2 years. Encounters occurred at primary care practices affiliated with two teaching hospitals in eastern Massachusetts.

RESULTS—Of the encounters documented, 83% were with PCPs, 13% were with covering physicians, and 5% were with midlevel providers. In multivariable analysis, the odds of medication intensification were 49% ($P < 0.0001$) and 26% ($P < 0.0001$) higher for PCPs than for covering physicians and midlevel providers, respectively, whereas the odds of lifestyle counseling were 91% ($P < 0.0001$) and 21% ($P = 0.0015$) higher. During visits with acute complaints, covering physicians were even less likely, by a further 52% ($P < 0.0001$), to intensify medications, and midlevel providers were even less likely, by a further 41% ($P < 0.0001$), to provide lifestyle counseling. Compared with PCPs, the hazard ratios for time to the next encounter after a visit without acute complaints were 1.11 for covering physicians and 1.19 for midlevel providers ($P < 0.0001$ for both).

CONCLUSIONS—PCPs provide better care through higher rates of medication intensification and lifestyle counseling. Covering physicians and midlevel providers may enable more frequent encounters when PCP resources are constrained.

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The disease burden from diabetes is increasing in the U.S. and worldwide (1,2). With this increased burden, efficient, quality care becomes even more important.

Many studies have shown that patients who see multiple providers have inferior outcomes (3–6). Continuity of care has further been associated with improved detection (7,8) and management of hypertension (8), greater adherence to diabetes preventive care and other guideline-consistent services (9–11), improved medication adherence (12), better

glycemic control in patients with diabetes (13,14), lower rates of hospitalizations (15–17), and lower long-term mortality (18).

Having multiple providers of primary care was also associated with increased medical services expenditures (17) through increased office visits, prescriptions, and number of specialists seen for disease-specific populations (19). Continuity of care was especially important to patients who perceived their health as poor (20), but the mechanisms for these effects are not fully understood.

However, modern models of health care delivery, such as the patient-centered medical home, emphasize a team-based approach to patient care (21,22). These teams will need to deliver effective care even when the patient is not always seen by the same provider. Under these circumstances, it becomes critical to recognize the benefits and mechanisms of continuity of care so they can be replicated in the team setting.

Process measures tightly linked to outcomes may be an effective way to measure quality of care (23). During the last decade, several process measures tightly linked to patient outcomes in the treatment of diabetes have been identified (24), including medication intensification, lifestyle counseling (25), and encounter frequency (25–28). We therefore conducted a study to determine whether primary care physicians (PCPs) perform better on these measures of care than other providers.

RESEARCH DESIGN AND METHODS

Design

We designed this retrospective cohort study to determine if PCPs are more likely than covering providers to intensify medications, provide lifestyle counseling, and have shorter intervals to the next encounter for patients with diabetes and elevated A1C, LDL, or blood pressure (BP).

Study cohort

Adults with diabetes treated at primary care practices affiliated with Brigham and Women's (BWH) and Massachusetts General (MGH) Hospitals for at least 2 years between 1 January 2000 and 1 January 2010 were studied. Primary care practices included internal medicine and family practice specialties. All of the practices in the study used Longitudinal Medical Record, an internally developed Office of the National Coordinator's Authorized Testing and Certification Body–certified electronic medical record (EMR) where all patient care documentation, including problem lists, electronic prescribing, and provider notes, was recorded. Patients were included in the study if they were at

From the ¹Division of Endocrinology, Brigham and Women's Hospital, Boston, Massachusetts; the ²Department of Radiation Oncology, Massachusetts General Hospital, Boston, Massachusetts; ³Harvard Medical School, Boston, Massachusetts; and ⁴Quality Performance Management, Partners HealthCare System, Boston, Massachusetts.

Corresponding author: Alexander Turchin, aturchin@partners.org.

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least 18 years old, had a documented diagnosis of diabetes or A1C $\geq 7.0\%$, and at least one instance of A1C, BP, or LDL above treatment target. Patients with missing zip codes were excluded to enable adjustment for median household income by zip code. We used treatment goals of $< 7.0\%$ for A1C, < 100 mg/dL for LDL, and $< 140/90$ mmHg for BP.

This study was approved by the Partners HealthCare System institutional review board, and the requirement for written informed consent was waived.

Study measurements

An encounter with a health care provider in a primary care practice served as the unit of analysis. Encounters during uncontrolled periods were included in the analysis. An uncontrolled period started on the day when A1C, BP, or LDL was first noted above the treatment target (27). The period ended on the first subsequent date when all measures fell below the target. Encounters that fell within the uncontrolled period were included in the analysis, whether or not measurements were taken on that date.

The lowest measurement on a given date was used in the analysis. Lowest BP was defined as the BP measurement with the lowest mean arterial pressure. BP measurements were only included in the encounter analysis if they were measured on the same date as the encounter. If A1C and LDL measurements were unavailable on the encounter date, the most recent was carried forward if the measurement was within 6 months of the encounter date. Transient elevations were defined as isolated elevated measurements that subsequently normalized without any medication intensification and were excluded from the analysis. Periods without any medication information available in the EMR were excluded to enable inclusion of insulin treatment as a confounder variable in the analysis. Periods that contained multiple encounters with an endocrinologist were excluded to focus the analysis on the primary care setting where, nationwide, most of diabetes care takes place. Hyperglycemic and hyperlipidemic periods in which rates of A1C and LDL change, respectively, were greater than three standard deviations from the mean were excluded to eliminate likely measurement errors. Finally, encounters with a time to the next encounter exceeding 1 year were excluded to ensure continuous receipt of care at study practices.

A PCP was defined as the PCP with whom the patient had the majority of

continuous encounters over a given interval and could change in the course of an uncontrolled period. A covering physician was any other physician in a primary care setting who treated a patient. These physicians were usually other PCPs in the same practice (similarly qualified with respect to specialty and board certification) who were assigned to urgent care or covering duty on a particular day. Encounters with nurse practitioners and physician assistants were assigned a mid-level provider category.

We identified face-to-face encounters based on availability of appropriate billing codes; all notes without corresponding billing codes were considered remote encounters. Acute encounters were defined by ICD-9 diagnosis codes for an acute complaint (e.g., acute pain and/or infection) as previously described (29).

Documentation of lifestyle counseling (diet, exercise, or weight loss) was computationally abstracted from the notes, including direct (eg, "strongly encouraged more walking") and inferred (eg, "weight has gone up") instances of lifestyle counseling,

as previously described (27,30). We inferred lifestyle counseling if the subject was referred to in a way that indicated it was likely discussed with the patient (eg, not simply weight recorded in the vital signs section). When compared with human double-entry, the software had a sensitivity of between 91 and 97% and a specificity of between 88 and 94%. Weight loss counseling was only considered for encounters when a patient had a BMI ≥ 30 kg/m². None of the practices studied during the study period had a program that encouraged a particular type of lifestyle counseling or monitored lifestyle counseling delivered by providers.

Medication intensification was defined as initiation of a new medication or an increase in the dose of an existing medication (29).

Demographic information, weight, height, BP measurements, and medication and laboratory data were obtained from the EMR at Partners HealthCare, an integrated health care delivery network in eastern Massachusetts that includes BWH and MGH.

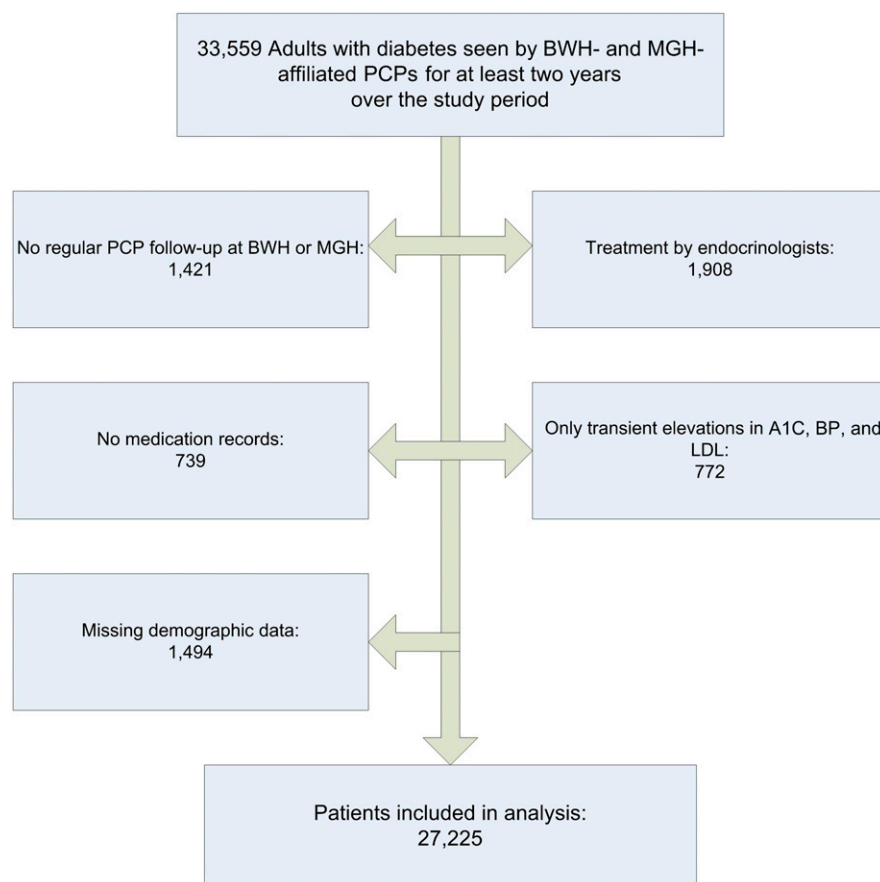


Figure 1—Flow chart shows selection of study patients.

Statistical analysis

Summary statistics were constructed by using frequencies and proportions for categorical data and using means, standard deviations, medians, and ranges for continuous variables.

The marginal Cox proportional hazards model for clustered data (31) was used to estimate the association between provider type and time to next encounter, and logistic regression models were used to calculate the odds of medication intensification and lifestyle counseling for different provider types. All models were adjusted for demographic confounders (age, sex, race, primary language, health insurance, and median income by zip code), as well as the patient's Charlson Comorbidity Index (CCI) (32), treatment with insulin as a marker of severity of disease, presence of obesity, diagnosis codes for metastatic cancer within 1 year before the encounter date; measurements of A1C, systolic and diastolic BP, and LDL, face-to-face versus remote encounters, acute complaints, hospitalization before the next encounter (time to next encounter analysis only), and an interaction term between acute status and provider type. Two-sided *P* values were obtained using type III test and were adjusted for multiple hypothesis testing using the Simes-Hochberg method (33,34). All analyses were performed with SAS 9.3 software (SAS Institute Inc., Cary, NC).

RESULTS—We identified 33,559 adults with diabetes who experienced at least one hyperglycemic, hypertensive, or hyperlipidemic period and were regularly seen in primary care practices associated with BWH or MGH (Fig. 1). After excluding patients regularly treated by endocrinologists, without medication records, only transient elevations in A1C, BP, and LDL, likely A1C or LDL measurement errors, and missing demographic information, the remaining 27,225 unique individuals with 584,587 primary care encounters were included in the study.

Study patients did not have at least one measure under control over a mean of 78% of total follow-up time (Table 1). During the study period, patients' mean maximum A1C was 8.7%, BP was 157/90 mmHg, and LDL was 131 mg/dL. The percentage of patients with measurements available during the follow-up period ranged from 92.9% of the time for A1C to 99.9% of the time for BP.

During uncontrolled periods, 83% of the encounters (Table 2) were with PCPs, 13% were with covering physicians, and

5% were with midlevel providers. Face-to-face visits constituted 49% and acute visits 19% of total encounters. PCP encounters constituted 84–85% of nonacute and remote encounters but only 77% of acute encounters. Covering physicians, however, had a higher proportion (19%) of acute encounters and 10–12% of nonacute and remote encounters. Midlevel providers consistently had 4–5% of acute, nonacute, and remote encounters. During all encounters, medication intensification occurred at 10% and lifestyle counseling occurred at 40% of encounters, whereas the mean time to the next encounter was 1.6 months. Mean times since last A1C and LDL measurements were 9 and 10 weeks, respectively. Providers had access to up-to-date A1C, BP, and LDL measures at 64.0, 56.4, and 53.5% of encounters, respectively.

In a multivariable logistic regression model that controlled for patient demographics, CCI, obesity, A1C, BP, and LDL measurements, metastatic cancer diagnosis, insulin status, and an interaction term between acute encounter status and provider type, the odds of medication intensification during nonacute encounters were 49% ($P < 0.0001$) and 26% ($P < 0.0001$) higher for PCPs than for

covering physicians and midlevel providers, respectively (Table 3). Odds of lifestyle counseling during nonacute encounters were 91% ($P < 0.0001$) higher for PCPs than covering physicians and 21% ($P = 0.0015$) higher than midlevel providers. During acute encounters, covering physicians were less likely to intensify medications by a further 52% ($P < 0.0001$), whereas midlevel providers were less likely to provide lifestyle counseling by a further 41% ($P < 0.0001$).

In a multivariable Cox proportional hazards model that adjusted for demographics, CCI, insulin status, obesity, metastatic cancer diagnosis, measurements of A1C, systolic and diastolic BP, and LDL, indicators for face-to-face and acute visits, hospitalization before the next encounter, and an interaction term between acute status and provider type, the hazard ratios for the time to the next encounter after a visit without acute complaints were 1.11 for covering physicians and 1.19 for midlevel providers ($P < 0.0001$ for both) compared with PCPs.

CONCLUSIONS—In this large retrospective study, we have demonstrated that PCPs were significantly more likely than other providers in the primary care

Table 1—Patient characteristics

	Mean or count	SD or percentage
Study patients, <i>n</i>	27,225	
Follow-up time (months)	65.9	29.1
Time with elevated A1C, LDL, or BP (months)	48.7	33.9
Age (years) ¹	59.6	14.0
Women, <i>n</i>	14,361	52.8
Race/ethnicity, <i>n</i>		
White	18,338	67.4
Black	3,040	11.2
Hispanic	3,309	12.2
Other ²	2,538	9.2
English as the primary language, <i>n</i>	22,563	82.9
Health insurance, <i>n</i>		
Private	11,404	41.9
Medicare	13,083	48.1
Medicaid	2,376	8.7
None/unknown	362	1.3
Median income by zip code (\$1,000s)	53.3	20.8
A1C (% [% of patients with data])	7.26 (91.9)	1.25
Systolic BP (mmHg [% of patients with data])	129.6 (99.9)	10.8
Diastolic BP (mmHg)	74.7	6.9
LDL cholesterol (mg/dL [% of patients with data])	100.0 (95.6)	27.2
CCI	5.4	4.5
BMI (kg/m ² [% of patients with data])	32.5 (66.3)	7.2

Continuous data are shown as the mean value, unless otherwise indicated. ¹Age calculated at the start date of the first uncontrolled period. ²Includes unknown.

Table 2—Encounter characteristics

Variable	Mean or count	SD or percentage
Study encounters, <i>N</i>	584,587	
Face-to-face visits, <i>n</i>	286,243	48.96
Acute visits, <i>n</i>	110,661	18.93
PCP encounters, <i>n</i>	483,890	82.77
Covering physician encounters, <i>n</i>	73,179	12.52
Midlevel encounters, <i>n</i>	27,518	4.71
Acute visits		
With PCPs, ¹ <i>n</i>	85,064	14.55
With covering providers, <i>n</i>	20,964	3.59
With midlevel providers, <i>n</i>	4,633	0.79
Nonacute visits		
With PCPs, <i>n</i>	148,952	25.48
With covering providers, <i>n</i>	17,422	2.98
With midlevel providers, <i>n</i>	9,208	1.58
Remove visits		
With PCPs, <i>n</i>	249,874	42.74
With covering providers, <i>n</i>	34,793	5.95
With midlevel providers, <i>n</i>	13,677	2.34
Encounters during which a patient is taking insulin, <i>n</i>	132,330	22.64
Encounters with a diagnosis of metastatic cancer within the previous year, ² <i>n</i>	15,787	2.70
Encounters during which patients are obese, <i>n</i>	302,270	51.71
Encounters with no next encounter, <i>n</i>	8,485	1.45
Encounters with an inpatient encounter before next primary care encounter, <i>n</i>	17,131	2.93
Time to next encounter (days)	48.78	59.57
Encounters with lifestyle counseling, <i>n</i>	233,440	39.93
Encounters with medication intensification, <i>n</i>	65,689	11.24
Time since last A1C measurement (days [% of encounters with recent measurements])	63.96 (64.0)	51.36
Time since last LDL measurement (days [% of encounters with recent measurements])	72.06 (53.5)	55.14
A1C measurements available within prior 6 months, <i>n</i>	374,097	63.99
BP measurements available on day of encounter, <i>n</i>	329,685	56.40
LDL measurements available within prior 6 months, <i>n</i>	312,632	53.48

Continuous data are shown as the mean value. ¹Percentages of encounters are of total encounters. ²Diagnoses of metastatic cancer required two ICD-9 codes for the condition in the outpatient setting or one in the inpatient setting.

setting to provide lifestyle counseling and medication intensification for patients with uncontrolled diabetes. This association was even stronger during visits in which the patient had an acute complaint. These results suggest that increased frequency of lifestyle counseling and medication intensification may be the mechanisms that underlie better outcomes seen in patients who have higher continuity of care.

Several other explanations for the effect of continuity of care have been proposed: increased time spent with one physician improved the patient's trust of his or her physician (4), enhanced communication between patient and physician, and increased the physician's knowledge of the patient (10), but the evidence for their

direct effect on patient outcomes is limited. Our study, however, describes mechanisms that have been directly linked to A1C, BP, and LDL control (25–28,35,36). It is likely that multiple mechanisms contribute to the effects of better disease outcomes and that the importance of provider type may vary by mechanism.

Many studies have shown that midlevel providers can be more effective than PCPs in treatment of chronic diseases such as diabetes and hypertension (37–40), particularly with respect to medication intensification (41). The major difference between our study and these clinical trials is that the trials usually required midlevel providers to follow a structured algorithm, whereas midlevel

providers in the practices we studied did not follow any particular algorithm. This current finding should be considered when designing new practice models, such as patient-centered medical homes.

Although PCPs are more effective than midlevel providers and covering physicians in providing lifestyle counseling and intensifying medication, a patient may be seen more frequently in practices with other providers available. This is corroborated by the shorter time to follow-up visits after encounters with covering physicians and midlevel providers found in our study. Therefore, practices with midlevel providers may provide more cost-efficient care because there are more opportunities for medication intensification and lifestyle counseling at a lower cost, even if they are not used as frequently. Midlevel providers could, therefore, be especially helpful in situations in which PCP resources are constrained, as they are almost universally across the country (42–44).

These findings have several implications for clinical practice. First, they suggest there should be less cross-covering by other physicians. If patients must be seen by a covering provider, better documentation of the PCP's treatment plan in the medical records may facilitate their decision making and lower the threshold for intervention. Finally, structured algorithms for treatment of chronic disease may be helpful in optimizing the care delivered by midlevel providers.

Lack of intervention for uncontrolled diabetes by a covering provider who does not know the patient well may be seen as appropriate. However, it results in additional delay in treatment; in our study, the average interval between encounters was at least 7 weeks. A proactive approach where the PCP documents a specific plan of action could improve coordination of care and allow covering providers to take timely action, accelerating achievement of diabetes control.

This study used natural language processing technology that permitted cost- and time-efficient computational analysis of thousands of patient encounters, including examination of hundreds of thousands of narrative provider notes in a matter of hours. In the future, similar technologies could also be used to monitor quality of patient care and/or supply feedback to providers. This feedback could help narrow the gap in care provided between PCPs and covering providers if feedback is used consistently.

Our study had a number of strengths. The analysis focused on process-of-care

Table 3—Encounter-level analysis estimates, comparing PCPs with other physicians and midlevel providers in multivariable analysis

Encounter type	Provider category	Medication intensification		Lifestyle counseling		Time to next encounter	
		(odds ratio)	<i>P</i> value	(odds ratio)	<i>P</i> value	(hazard ratio)	<i>P</i> value
Without acute complaints	Non-PCP MD	0.67	<0.001	0.52	<0.001	1.11	<0.001
	Midlevel	0.79	<0.001	0.82	0.0015	1.19	<0.001
With acute complaints	Non-PCP MD	0.50	<0.001	0.48	0.1382	0.98	<0.001
	Midlevel	0.67	0.2514	0.61	<0.001	1.16	0.1705

The *P* value in italics is <0.05, after Simes-Hochberg adjustment for multiple comparisons. PCP encounters serve as the reference category. Odds and hazard ratios in italics indicate those that are statistically significant.

measures that are tightly linked to better patient outcomes, allowing us to identify likely mechanisms for the beneficial effects of continuity of care. This was a large study, conducted in an ethnically and gender-diverse population, and thus is likely to be generalizable to other settings.

This retrospective cohort study also has some limitations, beyond its inability to establish causality. We did not use standard performance measures to assess provider performance. Instead, we focused on measures that have been shown to be tightly linked to patient outcomes. We used the CCI as a measure of the patients' overall disease burden in multivariable analyses. The CCI was originally developed and validated for hospitalized patients and may therefore have skewed the results. However, the CCI has also been shown to correlate with mortality in multiple outpatient populations (45–47), and the conditions it includes have face validity as predictors of mortality in both outpatients and inpatients.

Some of the data pertinent to the analysis might have been missing; for example, physicians may not have recorded some of the BP measurements they made. If missing data were distributed unequally between different provider categories, it could have biased the study findings. To minimize this effect, we used BP information from structured EMR records and also from narrative provider notes (obtained using natural language processing) where clinicians are more likely to document their own BP measurements. We have previously shown that this approach results in a more complete data collection (48). Physicians also might have been more likely to round the BP measurements down if they were individually judged according to BP-based quality indicators. However, no quality indicators were implemented at the individual provider level in the practices studied during the study period.

The study was conducted at two teaching hospitals in eastern Massachusetts. The

patients who seek care and the providers who work in such networks may be different from other populations. The practices we studied did not have a large number of midlevel providers, making it difficult to study the care they provide in more detail. Furthermore, because no treatment algorithms were in place in any of the practices studied, midlevel providers who followed an algorithm could not be compared with those who did not.

We did not have information on the patients' health-related behaviors that could have accounted for some of the observed effects if they were distributed unequally between PCP versus non-PCP encounters.

Finally, we were unable to distinguish patients with type 1 diabetes from those with type 2 diabetes. Because most of the patients studied likely had type 2 diabetes, our conclusions may not be applicable to patients with type 1 diabetes.

In conclusion, this large, long-term retrospective study showed that PCPs perform better on a number of critical process measures of diabetes care than covering physicians or midlevel providers. These findings suggest mechanisms for well-described improvements in quality of treatment seen with higher continuity of care. They should be taken into consideration in the design and evaluation of novel health care delivery models, such as patient-centered medical homes, and in quality improvement in traditional care settings.

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F.M. conducted data analysis and drafted the manuscript. M.S. assisted in study design, provided biostatistical support, and critically reviewed the manuscript. S.I.G. assisted in study design and analysis and critically reviewed the manuscript. A.T. designed the study, obtained funding, and critically reviewed the manuscript. F.M. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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