

Encounter Frequency and Blood Pressure in Hypertensive Patients With Diabetes Mellitus

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Abstract—The relationship between encounter frequency (average number of provider-patient encounters over a period of time) and blood pressure for hypertensive patients is unknown. We tested the hypothesis that shorter encounter intervals are associated with faster blood pressure normalization. We performed a retrospective cohort study of 5042 hypertensive patients with diabetes mellitus treated at primary care practices affiliated with 2 academic hospitals between 2000 and 2005. Distinct periods of continuously elevated blood pressure ($\geq 130/85$ mm Hg) were studied. We evaluated the association of the average encounter interval with time to blood pressure normalization and rate of blood pressure decrease. Blood pressure of the patients with the average interval between encounters ≤ 1 month normalized after a median of 1.5 months at the rate of 28.7 mm Hg/month compared with 12.2 months at 2.6 mm Hg/month for the encounter interval > 1 month ($P < 0.0001$ for all). Median time to blood pressure normalization was 0.7 versus 1.9 months for the average encounter interval ≤ 2 weeks versus between 2 weeks and 1 month, respectively ($P < 0.0001$). In proportional hazards analysis adjusted for patient demographics, initial blood pressure, and treatment intensification rate, a 1 month increase in the average encounter interval was associated with a hazard ratio of 0.764 for blood pressure normalization ($P < 0.0001$). Shorter encounter intervals are associated with faster decrease in blood pressure and earlier blood pressure normalization. Greatest benefits were observed at encounter intervals (≤ 2 weeks) shorter than what is currently recommended. (*Hypertension*. 2010;56:00-00.)

Key Words: hypertension ■ encounter frequency ■ visit frequency ■ outcomes

Elevated blood pressure is one of the major risk factors for macrovascular and microvascular complications in diabetic patients.¹⁻⁷ Treatment of hypertension decreases these risks⁸⁻¹² and is highly cost-effective.^{13,14} Despite abundant evidence of the benefits of lowering blood pressure, most patients with diabetes mellitus do not reach evidence-based treatment goals.¹⁵⁻¹⁷ The reasons for this are not well understood.

Current guidelines recommend that patients be followed up within a month when an elevated blood pressure is noted.¹⁸ However, the intervals between provider-patient encounters are substantially longer.¹⁹⁻²³ It is possible that this discrepancy between the guidelines and the practice of medicine contributes to the suboptimal outcomes in patients with hypertension. The currently available evidence on the relationship between encounter intervals and blood pressure is conflicting. Although a study of 400 patients by Guthmann et al²³ found a correlation between return visit interval and percentage of change in blood pressure, a smaller study of 100 patients by Parchman et al²⁴ failed to detect a statistically significant relationship. Furthermore, there are no data to

provide guidance with respect to the optimal encounter interval for blood pressure control, and the current (Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure) guidelines are based largely on expert opinion.¹⁸

We performed a retrospective study of > 5000 patients with diabetes mellitus and hypertension followed by primary care physicians to test the hypothesis that shorter encounter intervals are associated with faster blood pressure normalization and to establish the encounter interval associated with optimal blood pressure control.

Methods

Design

We conducted a retrospective cohort study to investigate whether shorter time between physician-patient encounters is associated with better blood pressure control in patients with diabetes mellitus. We evaluated the relationship between the average posthypertensive encounter interval (predictor variable) and time to blood pressure normalization (primary outcome variable). We also conducted a secondary analysis to determine the relationship between the average posthypertensive encounter interval and rates of decrease of systolic and diastolic blood pressure. Finally, we studied the associations

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between patient and encounter characteristics at a given physician-patient encounter with an elevated blood pressure and the interval to the next encounter.

Study Cohort

Hypertensive patients with diabetes mellitus followed by primary care physicians affiliated with Massachusetts General Hospital and Brigham and Women's Hospital for ≥ 2 years between January 1, 2000, and August 31, 2005 were studied. Patients were included in the analysis if they were ≥ 18 years old, had a documented diagnosis of diabetes mellitus, and had ≥ 1 encounter with a physician in a primary care specialty during the study period where a blood pressure above the recommended treatment target was recorded. To capture both face-to-face and remote interactions between patients and providers, we defined an encounter as any note in the electronic medical chart. Only encounters with documented blood pressures were used in the analysis.

We used 129 and 84 mm Hg as the recommended treatment goals of systolic and diastolic blood pressure, respectively, in accordance with the guidelines published before the beginning of the study period.²⁵ Diagnosis of diabetes mellitus was ascertained by analyzing the text of physician notes in the electronic medical chart as described previously.²⁶ Patients who had ≥ 1 encounter with an endocrinologist during the study period that addressed diabetes mellitus (as ascertained using billing data and computerized analysis of the text of the notes) were excluded to focus the analysis on the care in the primary care setting, where most patients with hypertension are treated. The institutional review board at Partners HealthCare System approved the study, and the requirement for written informed consent was waived.

Study Measurements

A single hypertensive period served as the unit of analysis for the evaluation of primary and secondary outcomes, as described previously.²⁷ The beginning of a hypertensive period was defined as the date of the first encounter when a blood pressure above the treatment target was recorded. If the first encounter during the study period had documented blood pressure above the treatment target, this encounter was considered to be the beginning of a hypertensive period. The date of the first subsequent encounter with a blood pressure below the treatment target served as the end of the hypertensive period. If the last encounter during the study period had blood pressure above the treatment target, the date of that encounter was considered the end of the hypertensive period. If >1 blood pressure was documented for any of the study encounters, blood pressure with the lowest mean arterial pressure was used for the analysis. Transient elevations of blood pressure defined as a single encounter with an elevated blood pressure and no treatment intensification, followed by normalization of the blood pressure at the next encounter, were excluded from the analysis.

Time to blood pressure normalization for any hypertensive period was defined as the length of that hypertensive period. Average encounter interval for the hypertensive period was calculated as the length of the period divided by the number of physician-patient encounters during the period. Treatment intensification rate was defined as the ratio of the number of encounters during the hypertensive period where a new antihypertensive medication was initiated, or the dose of an existing one was increased to the total number of encounters during the period, as described previously.²⁸ Average rate of blood pressure change was calculated as the difference between the blood pressure at the first and the last encounter during the hypertensive period divided by the length of the period. It was calculated separately for systolic and diastolic blood pressures. The number of acute conditions addressed at an encounter was defined as the number of International Classification of Diseases, 9th Revision, Clinical Modification billing codes associated with the encounter that represented an acute symptom (most commonly acute pain or infection), as described previously.²⁸ We identified a physician as the patient's primary care provider if he or she had the largest number of encounters with the patient over the study period.

Data Sources

Demographic information, laboratory and billing data, and the text of physician notes were obtained from the Research Partners Data Registry. Research Partners Data Registry is a data warehouse that serves as a central clinical data repository for participating hospitals and clinics within the Partners HealthCare System, an integrated healthcare delivery network in Eastern Massachusetts that includes Massachusetts General Hospital and Brigham and Women's Hospital. Blood pressure values and antihypertensive treatment intensification were computationally extracted from the text of computerized physician notes in the electronic medical chart as described previously.²⁹ The sensitivity and specificity of this method are 91% and 96%, respectively, for identification of blood pressure values, and 84% and 95% for identification of antihypertensive treatment intensification. Physician specialty was identified using a combination of the information available from the Massachusetts Board of Registration in Medicine and the specialty of the clinic where the physician practiced.

Statistical Analysis

Summary statistics were constructed by using frequencies and proportions for categorical data and by using means, SDs, medians, and ranges for continuous variables. The univariate associations between continuous variables were assessed using a 2-sided *t* test.

The log-rank test was used to compare Kaplan-Meier survival curves for time to blood pressure normalization between different lengths of encounter interval. Sensitivity analysis limited to the first hypertensive period for each patient was conducted to assess the possible effect of correlation between observations for individual patients. A marginal Cox proportional-hazards model for clustered data³⁰ was used to adjust for covariates and to estimate the hazard ratio for blood pressure normalization while accounting for clustering within individual patients. The covariates used in the Cox model included patient age, sex, ethnicity, primary language, and health insurance, as well as treatment intensification rate and initial systolic and diastolic blood pressures for the hypertensive period.

To determine the relationship between the encounter interval and the rate of blood pressure change, we constructed a hierarchical (multilevel) multivariable mixed linear regression model with random effects to account for clustering within individual patients and physicians. Random cluster effects were used to generate correlation structure for intracluster observations, as well as to account for individual patient and physician effect levels.³¹ The model also included patient age, sex, ethnicity, primary language, and health insurance, as well as the treatment intensification rate during the hypertensive period. Probability values were obtained using the type III test. All of the analyses were performed with SAS statistical software, version 9.1 (SAS Institute, Inc).

Results

We identified 22 675 adult patients with diabetes mellitus who had ≥ 1 outpatient encounter at a practice affiliated with either of the 2 hospitals between January 1, 2000, and August 31, 2005. We excluded 763 patients who were treated by an endocrinologist or a diabetologist and 8425 patients who did not have any encounters with primary care providers (ie, their primary care physicians were likely outside of the Massachusetts General Hospital and Brigham and Women's Hospital practice networks). We further excluded 7190 patients who had been followed for < 2 years and 604 patients who never had a blood pressure reading above the treatment target (129/84 mm Hg). Only transient blood pressure elevations (resolved at the next encounter without treatment intensification) were recorded for 651 patients. The remaining 5042 patients were included in the study.

The median age of study patients was 65 years; the majority were women (Table 1). On average, the patients

Table 1. Patient Characteristics

Variable	Value
Study patients, n	5042
Age, mean (±SD), y*	64.6 (±13.3)
Women, n (%)	2939 (58.3)
Ethnicity, n (%)	
White	2921 (57.9)
Black	914 (18.1)
Hispanic	793 (15.7)
Other (includes unknown)	414 (8.2)
English is the primary language, n (%)	4146 (82.2)
Health insurance, n (%)*	
Insured	3200 (63.5)
Underinsured†	1684 (33.4)
No prescription coverage‡	158 (3.1)
Blood pressure, mean (±SD), mm Hg§	
Systolic	133.5 (±10.4)
Diastolic	76.1 (±7.2)
Length of follow-up, mean (±SD), mo	48.2 (±12.9)
Total time with elevated blood pressure, mean (±SD), mo	29.1 (±16.6)
Frequency of treatment intensification, mean (±SD), %	20.7 (±21.4)

*Data shown are at the end of the study period.

†Data include Medicaid and FreeCare, a program that provides fully or partially (depending on the income) subsidized health care in Massachusetts.

‡Data include Medicare without supplemental insurance and patients with no reported insurance.

§Patient-weighted mean metric was calculated by taking the average of the mean metric calculated individually for all of the study patients.

were followed for 4 years during the study period. Their blood pressure was above the recommended target for >60% of that time. Antihypertensive treatment was intensified in 1 of 5 encounters with elevated blood pressure. On average, patients had 2 to 3 distinct periods of continuously elevated blood pressure during the study period. These periods had a median length of 9 months, with some lasting up to 68 months. On average, there were 3.8 documented physician-patient encounters during each period of continuously elevated blood pressure (Table 2). Distinct hypertensive periods

Table 2. Hypertensive Periods

Variable	Value
Total periods, n	10 447
Length, mean (±SD), mo	14.1 (±14.0)
Initial blood pressure, mean (±SD), mm Hg	
Systolic	141.4 (±13.6)
Diastolic	79.3 (±10.7)
Maximum blood pressure, mean (±SD), mm Hg	
Systolic	148.7 (±17.2)
Diastolic	84.1 (±10.8)
Periods ending in normal blood pressure, n (%)	8423 (80.6)
Encounter interval, mean (±SD), mo	3.7 (±4.1)

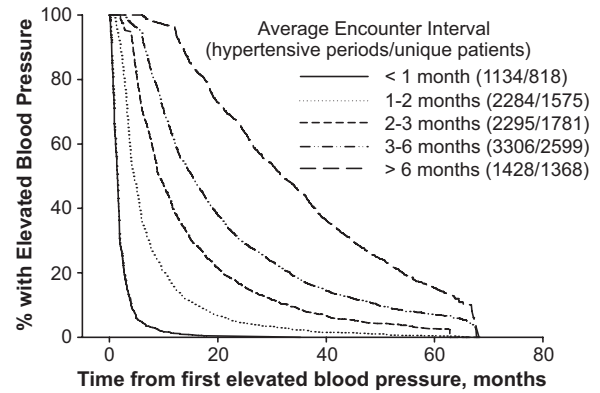


Figure 1. Encounter interval and time to blood pressure normalization. Kaplan-Meier curves for time to normalization of blood pressure during a period of continuously elevated blood pressure were plotted for different average encounter intervals. Distinct periods of elevated blood pressure (from the first elevated to the first normal blood pressure) for the same patient were analyzed separately.

for the same patient were, on average, 10.5 months apart (median: 8.0 months), separated by a mean of 3.2 encounters (median: 2.0 encounters) with documented blood pressure below the treatment target.

Encounter Interval and Time to Blood Pressure Normalization

In univariate analysis, for a given hypertensive period the average time from the first documented encounter (for the specific hypertensive period being analyzed) with elevated blood pressure to blood pressure normalization rose progressively from 1.8 months when the average interval between encounters was <1.0 month to 29.4 months when the average interval was >6.0 months (Figure 1). Blood pressure of the patients whose average encounter interval was ≤1.0 month (in accordance with the current guidelines¹⁸) normalized after a median of 1.5 months versus 12.2 months for the patients whose average encounter interval was >1.0 month (*P*<0.0001). Sensitivity analysis limited to the first hypertensive period for each patient had similar results (data not shown).

The difference in time to blood pressure normalization persisted at encounter intervals shorter than the currently recommended. In a subgroup analysis of 1158 hypertensive periods of 832 unique patients with an average encounter interval ≤1.0 month, blood pressure of the patients with the average encounter interval ≤2 weeks normalized after a median of 0.7 months versus 1.9 months for the average encounter interval between 2 weeks and 1 month (*P*<0.0001). The median encounter interval in this subgroup was 20 days, whereas the 10th and 90th percentiles were 7.5 and 28.0 days, respectively.

In multivariable analysis adjusted for the patient demographic characteristics, initial blood pressure, frequency of treatment intensification, and for clustering within individual patients, an increase of 1 month in the average interval between encounters was associated with a hazard ratio of 0.764 (95% CI: 0.755 to 0.774) for blood pressure normalization (*P*<0.0001). Increase in the patient’s age and initial

blood pressure were also associated with a longer time to blood pressure normalization ($P < 0.0001$ for each). The association between the average encounter interval and time to blood pressure normalization retained its significance at encounter intervals ≤ 1 month (hazard ratio: 0.017 [95% CI: 0.012 to 0.023]; $P < 0.0001$). Analysis that was limited to the encounters that had associated billing codes for hypertension showed similar findings (data not shown). Analysis of the relationship between encounter intervals and blood pressure at a prespecified time horizon showed that shorter encounter intervals were associated with increased probability of normalization of blood pressure at 2 years after the first elevated blood pressure was detected (data not shown).

Encounter Interval and Rate of Blood Pressure Change

The rate of decrease in systolic blood pressure was >10 -fold higher (28.7 versus 2.6 mm Hg/month) for patients with the average encounter interval ≤ 1 month compared with the patients with an encounter interval >1 month ($P < 0.0001$). The rate of decrease in diastolic blood pressure was similarly 10-fold higher (11.3 versus 1.0 mm Hg/month) for patients with the average encounter interval less than or equal versus >1 month ($P < 0.0001$). When plotted against the average encounter interval, the rates of change in systolic and diastolic blood pressures decreased progressively with longer encounter intervals. For an encounter interval of 1 to 2 weeks, the rates of decrease for systolic and diastolic blood pressures were 43.8 and 13.1 mm Hg/month, respectively, whereas encounter intervals of 6 months had rates of 0.9 (systolic) and 0.4 mm Hg/month (diastolic; Figure 2).

In multivariable analysis adjusted for the patient demographic characteristics, initial blood pressure of the hypertensive period, treatment intensification rate, and for clustering within individual patients, systolic blood pressure increased by 0.7 mm Hg/month for each additional month between encounters, whereas diastolic blood pressure increased by 0.3 mm Hg/month ($P < 0.0001$ for both). Both systolic and diastolic blood pressures decreased faster for patients who had higher treatment intensification rates ($P < 0.0001$).

Predictors of Encounter Interval Length

We studied 47 831 patient encounters with documented elevated blood pressure to establish patient and encounter characteristics that were associated with changes in the interval to the follow-up encounter (Figure 3). In a multivariable analysis that included patient demographics and adjusted for clustering within individual patients and providers, we found that patients whose antihypertensive treatment was intensified during the encounter also had a shorter (by 14.4 days) follow-up interval ($P < 0.0001$). Length of the interval to the next encounter also decreased by 3.6 and 3.9 days for each 10-mm increase in systolic and diastolic blood pressures during the encounter, respectively ($P < 0.0001$ for both). On the other hand, the interval to the next encounter increased by 20 days if the physician seeing the patient was not his or her regular primary care provider ($P < 0.0001$).

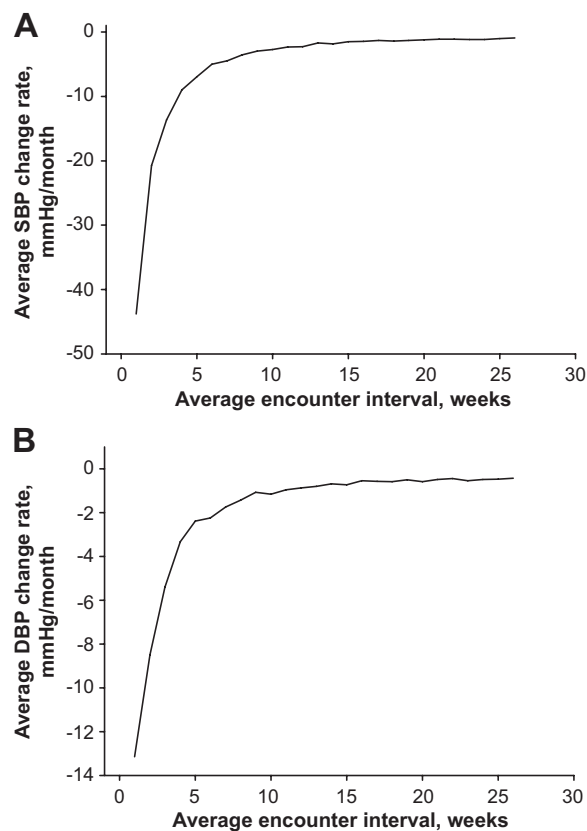


Figure 2. Encounter interval and rate of change of blood pressure. The average monthly change in systolic (A) and diastolic (B) blood pressure, respectively, was plotted against the average encounter interval. Distinct periods of elevated blood pressure (from the first elevated to the first normal blood pressure) for the same patient were analyzed separately.

Discussion

In this large, retrospective study of treatment of hypertension in patients with diabetes mellitus we have demonstrated that blood pressure decreases faster and blood pressure control is achieved sooner in patients who have shorter encounter intervals. We have confirmed previous reports that the current guidelines on the encounter interval for patients with elevated blood pressure are seldom followed.^{20,21,32} Importantly, our results show that encounter intervals shorter than currently recommended are associated with even greater rates of decrease in blood pressure levels and faster blood pressure normalization.

The relationship between encounter intervals and patient outcomes remains largely unexplored.³³ A study of patients with rheumatoid arthritis showed that shorter encounter intervals were associated with small decreases in the pain scores and the disability index.³⁴ However, 2 smaller studies of encounter intervals for hypertensive patients did not reach consistent conclusions,^{23,24} possibly because of insufficient sample size. To our knowledge, our report is the largest longitudinal study of the relationship of encounter intervals and outcomes to date, unequivocally showing that shorter encounter intervals are strongly associated with faster achievement of blood pressure control. This finding is particularly important in light of the recent evidence that even

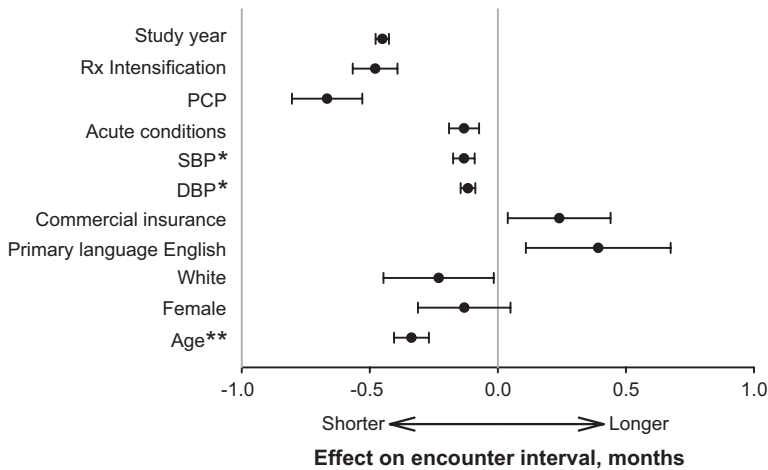


Figure 3. Effect of patient and encounter characteristics on encounter interval. Circles indicate effect estimates from a multivariable model that included all of the variables displayed in the figure. Whiskers indicate 95% CIs. “PCP” variable indicates that the encounter was with the patient’s primary care provider (as opposed to a covering physician). “Acute conditions” variable indicates the number of billing codes linked to the encounter that represented an acute symptom (most commonly acute pain or infection). “Commercial insurance” variable indicates that the patient’s health insurance was provided by a private company, as opposed to Medicare and/or Medicaid. “Rx intensification” indicates whether antihypertensive treatment was intensified (a new medication started or the dose of an existing medication increased) during the encounter. *For every 10 mm Hg; **for every 10 years.

short-term elevations in blood pressure are associated with adverse events.³⁵

There is a paucity of evidence to guide providers on the optimal encounter intervals. The report on patients with rheumatoid arthritis found a U-shaped relationship between encounter intervals and outcomes,³⁴ with the best outcomes achieved at encounter intervals between 1 and 2 months. However, this finding may have been biased by the fact that visits by patients with rheumatoid arthritis can be symptom driven, and, therefore, patients with more frequent visits may have more severe symptoms. This bias is likely to be less pronounced in patients with hypertension, which is commonly asymptomatic, particularly at the lower blood pressure levels prevalent in our study population. Our analysis did not reveal a U-shaped relationship. On the contrary, the magnitude of the rate of blood pressure decrease rose progressively with shorter encounter intervals, all the way down to weekly encounters. Although some recent studies reported an increased rate of cardiovascular events with aggressive lowering of blood pressure,³⁶ our analysis did not find a significant relationship between the rate of blood pressure decrease and mortality (data not shown).

There could be several explanations for our findings. Higher frequency of encounters provides more opportunities for medication intensification, and a number of studies have shown a strong relationship between the rate of treatment intensification and blood pressure control.^{19,20,27} In addition, increased encounter frequency has been linked to improved treatment adherence.^{37,38} It is possible that regression to the mean may have been a contributing factor as well. However, this phenomenon would have most likely manifested itself as spontaneous return of elevated blood pressure to normal without any intervention. We have, therefore, excluded patients whose blood pressure normalized after a single encounter with elevated blood pressure without any pharmacological intervention to reduce its effect.

Some of the blood pressure normalizations could have been attributed to random variations in blood pressure. More frequent encounters could have led to a higher probability of such random variations being captured in documented blood pressure measurements. This would result in an apparent association between more frequent encounters and faster

blood pressure normalization. However, our analysis showed that distinct hypertensive periods for the same patient were, on average, spaced 10.5 months apart, separated by a mean of 3.2 encounters with documented blood pressure below the treatment target. These findings are more consistent with a sustained decrease in blood pressure achieved by therapeutic intervention than with a random variation.

Similar to the previously reported smaller observational studies and clinician surveys,^{39,40} we have found that higher blood pressure and treatment intensification were associated with a shorter interval before the next encounter. Other measures of clinical instability, such as the number of acute conditions addressed during the encounter, were also linked with shorter follow-up intervals. On the other hand, encounter intervals were longer if the patient was seen by the physician who was not his or her regular caregiver. Combined with our previous findings of lower treatment intensification rate by covering providers,²⁸ this result points to the importance of continuity of care in providing optimal treatment.

Shorter encounter intervals may be difficult to implement in practice. Most hypertensive patients are treated by their primary care physicians, and the nationwide shortage of these providers is likely to only grow in the future.^{41,42} Primary care physicians may, therefore, have little room to increase the frequency of patient visits, particularly because the demands on their time are already excessive.⁴³ Furthermore, patients may prefer longer visit intervals,⁴⁴ possibly because even a 15-minute appointment with a physician imposes a much more extensive temporal cost on the patient, including the time spent on travel and waiting to be seen.

It is evident, therefore, that if shorter encounter intervals are to be achieved, more creative approaches to patient care are needed.⁴⁵ Not all of the encounters need to be face-to-face visits by individual patients: some could be group visits or telephone or e-mail communications.⁴⁶ Midlevel providers could take over algorithm-based medication titration to relieve the time pressure on the physicians, an approach shown to be effective in a number of studies,^{47–49} even while the intervals between physician visits increased.⁵⁰

Our study had a number of strengths. First, it included a large number of ethnically diverse patients treated at 2 hospitals that serve individuals from all socioeconomic strata.

Our findings support the current recommendations for frequent follow-up for patients with uncontrolled blood pressure. Finally, our study focused on the treatment of high blood pressure in primary care practices, because this is the setting where the majority of patients with hypertension receive their care.

Our study had several limitations. It was conducted in clinics affiliated with 2 academic medical centers in Eastern Massachusetts, and this could limit its generalizability to other geographic and practice settings. The study focused on patients with diabetes mellitus and, therefore, the findings may not apply to other patients with hypertension. We do not have information on the blood pressure measurement techniques that may not have been consistent both between and within individual patients. We also did not have information on the antihypertensive medications that the patients were taking at the study entry or their adherence to medications throughout the study period, limiting our ability to analyze potential etiologic relationships. Hypertensive periods were censored at the beginning of the study. However, unless encounter intervals were systematically uneven over the duration of the period, this should not have biased our results. Our study focused on treatment delivered by physicians because physicians composed the majority of healthcare providers in the primary care clinics studied.⁵¹ Therefore, our findings may not apply to midlevel providers. Our study used electronic medical chart data recorded in the course of routine clinical care, and it is, therefore, possible that some of the data could be missing. If the missing data were not missing at random with respect to the outcome variable, this could potentially confound our results. For example, it was not possible to ascertain exactly when the patient blood pressure normalized. Consequently, shorter encounter intervals could lead to an appearance of accelerated normalization of blood pressure, introducing a bias in our findings. However, a separate analysis showed that shorter encounter intervals were associated with increased probability of normalization of blood pressure at 2 years after the first elevated blood pressure was detected. This finding supports our interpretation in a manner not subject to bias by the missing blood pressure data. Our analysis included all of the provider-patient encounters, independent of whether hypertension was addressed during the encounter. However, a separate analysis that was limited to the encounters that had associated billing codes for hypertension showed similar findings. Finally, retrospective nature of the study does not allow us to infer causality in the associations that we have found.

Perspectives

In summary, we have shown that shorter encounter intervals for diabetic patients with elevated blood pressure are associated with shorter time to blood pressure control and faster decrease in blood pressure. Based on our findings, optimal encounter intervals may be shorter than what is currently recommended. Interventional studies are now needed to confirm the direction of causality in these findings and to provide evidence-based guidance for choosing encounter intervals for the thousands of primary care physicians who care for these patients.

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Disclosures

None.

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