

Failure to Intensify Antihypertensive Treatment by Primary Care Providers: A Cohort Study in Adults with Diabetes Mellitus and Hypertension

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BACKGROUND: Although tight blood pressure control is crucial in reducing vascular complications of diabetes, primary care providers often fail to appropriately intensify antihypertensive medications.

OBJECTIVE: To identify novel visit-based factors associated with intensification of antihypertensive medications in adults with diabetes.

DESIGN: Non-concurrent prospective cohort study.

PATIENTS: A total of 254 patients with type 2 diabetes and hypertension enrolled in an academically affiliated managed care program. Over a 24-month interval (1999–2001), we identified 1,374 visits at which blood pressure was suboptimally controlled (systolic BP \geq 140 mmHg or diastolic BP \geq 90 mmHg).

MEASUREMENTS AND MAIN RESULTS: Intensification of antihypertensive medications at each visit was the primary outcome. Primary care providers intensified antihypertensive treatment in only 176 (13%) of 1,374 visits at which blood pressure was elevated. As expected, higher mean systolic and mean diastolic blood pressures were important predictors of intensification. Treatment was also more likely to be intensified at visits that were “routine” odds ratio (OR) 2.08; 95% Confidence Interval [95% CI] 1.36–3.18), or that paired patients with their usual primary care provider (OR 1.84; 95% CI 1.11–3.06). In contrast, several factors were associated with failure to intensify treatment, including capillary glucose >150 mg/dL (OR 0.54; 95% CI 0.31–0.94) and the presence of coronary heart disease (OR 0.61; 95% CI 0.38–0.95). Co-management by a cardiologist accounted partly for this failure (OR 0.65; 95% CI 0.41–1.03).

CONCLUSIONS: Failure to appropriately intensify anti-hypertensive treatment is common in diabetes care. Clinical distractions and shortcomings in continuity and coordination of care are possible targets for improvement.

KEY WORDS: diabetes mellitus; hypertension; health services; cohort study.

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Although tight blood pressure control reduces vascular complications,^{1–7} diabetes patients commonly have inadequately controlled blood pressure.^{8–14} Recent evidence suggests that physician failure to intensify hypertensive medications is a powerful explanatory factor.^{9,15–17}

Identifying barriers and promoters of treatment intensification is a crucial first step toward developing strategies to improve blood pressure control in diabetic adults. Three published studies have evaluated visit-based barriers to intensification in a hypertensive cohort, but were limited by small sample size,¹⁷ potential self-report bias,¹⁷ limited information on visit, patient, and physician characteristics,¹⁶ or the use of special populations.^{15,17} One additional study evaluated factors related to treatment intensification in a diabetic cohort, yet was limited in the number of visit factors evaluated and potential self-report bias.⁹ No study has focused in detail on visit-based factors that might influence blood pressure treatment intensification in diabetic adults.

Therefore, we conducted a non-concurrent prospective cohort study (i.e., a retrospective evaluation of prospectively collected data) to identify novel visit-based barriers and promoters of intensification of blood pressure medications in adults with diabetes. We focused on visit-based factors as we felt these may be more modifiable than durable patient and physician factors such as age or gender. We paid special attention to factors that may imply the provider had competing demands (such as capillary blood glucose levels and patient volume on the day of the visit), which were beyond the scope of the previous studies.

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METHODS

Identification of Study Subjects

We studied a cohort of federal employees and their dependents with type 2 diabetes and hypertension who received primary care at any of 17 sites of an academically affiliated managed care program in Maryland. Individuals were classified as having diabetes if: (1) claims data showed ICD-9 codes 250.xx, 357.2, 362.0, 366.41, or 648.0; or (2) electronic pharmacy data indicated that insulin or oral diabetes medications had been prescribed. Eligible subjects had made 2 or more primary care visits or 1 emergency department visit or hospital stay during the 24-month interval from January 1, 1999 to December 31, 2001. From this population of 1,120 patients with diabetes, 411 patients were chosen by systematic random sampling using criteria based on the Health Plan Employer Data and Information Set (HEDIS) sampling strategy. Of the 411, we focused on the 344 who were also receiving 1 or more antihypertensive medications. Electronic pharmacy data were not available for 21 (5.1%) of the 411 patients.

From July 1, 1999 to December 31, 2001, these 344 patients with diabetes and hypertension made 3,384 visits. At 1,421 of these visits (in 254 unique patients who saw 68 primary care providers), blood pressure was high enough at 1 or more visits (i.e., systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg) to possibly require treatment intensification. We chose $\geq 140/90$ mmHg as an "actionable" blood pressure, although the Joint National Committee (JNC) prescribed target blood pressure for patients with diabetes was $\geq 130/85$ mmHg at the time the data were collected.¹⁸ Our object was to avoid problems related to rounding and digit preference and thereby identify visits at which blood pressure was unequivocally elevated. We excluded 47 visits owing to missing data on key variables such as appointment date. Thus, 1,374 primary care hypertensive visits (corresponding to 254 patients and 68 primary care providers) remained for analysis.

Data Collection

Absent standardized factors associated with intensification, a group of physicians developed a data collection form based on prior literature and knowledge to capture factors relevant to this analysis. Data were collected from 2 main sources. From electronic files, we abstracted data on enrollment, utilization, laboratory results, pharmacy use, and provider appointments. From written medical records, 2 trained registered nurses used a standardized instrument to abstract data on medical history and visit-based clinical factors. A physician double-reviewed 98 (24%) of the 407 patient charts, with kappa results greater than 0.80 for all objective measurements such as hemoglobin A1c and blood pressure. We grouped these data into 3 categories: (1) durable patient-related factors, (2) durable provider-related factors, and (3) transient visit-related factors.

Patient-related factors. From medical records, we abstracted data on weight and height, cardiovascular comorbid conditions, and history of coronary heart disease (defined as coronary artery disease, myocardial infarction, or angina). From enrollment databases, we obtained age, gender, and race. Using the electronic pharmacy database, we calculated

patient adherence according to an algorithm using number of pills and days supply developed by Steiner et al.¹⁹ A score of 1.0 corresponds to 100% adherence and score of 0.50 to 50% adherence. The score can exceed 1.0 (100%) if a patient refills early and ends up with extra pills. From claims data, we determined comorbidity using ICD-9 codes and patient demographics to create resource utilization bands (RUBs).²⁰ The higher the RUB, the higher the patient comorbidity. Lastly, we searched an appointment database to detect cardiologist co-management.

Provider-related factors. Using data from public websites posted by the Maryland Board of Physicians and American Medical Association, we determined provider gender and graduation year.^{21,22} Provider specialty was identified from the electronic appointment database.

Visit-related factors. From medical records, we abstracted data for each visit on blood pressure; prescription side effects; provider counseling regarding diet, exercise, medication adherence; and other factors that might indicate competing demands besides hypertension as the visit focus (including, visit type [routine vs urgent]; capillary blood glucose level; specialty referrals; provider counseling regarding glucose control or smoking cessation; and ordering an influenza and/or pneumonia vaccination).

We used the electronic appointment database to determine other visit-related factors including missed appointments or emergency department care between visits; the interval since the last visit; the number of appointments with the primary care provider; or visit factors potentially associated with competing demands (i.e., patient volume for a specific provider on the day of the appointment, the appointment time and day of the week, or whether the patient saw their regular or a covering provider).

From the electronic pharmacy database, we also determined the number of blood pressure, acute and chronic medications being taken or prescribed at the time of the visit.

From the laboratory database, we abstracted hemoglobin A1c, low-density lipoprotein cholesterol, and serum creatinine.

Intensification of Antihypertensive Treatment

Using the electronic pharmacy database, we defined an episode of "intensification" as either (a) filling a prescription for a new blood pressure medication or (b) filling a prescription for a higher dose of a previously prescribed medication, without a corresponding decline in the dose of another antihypertensive medication.

Statistical Analysis

We used generalized estimating equations (GEE) with an exchangeable correlation structure to construct unadjusted and partially adjusted (for patient age, race, gender, and blood pressure) logistic regression models for each of these variables. As individual patients typically made 4–8 visits during the 24-month study interval, all models accounted for clustering by patient. We used weight stratified by gender as a marker of adiposity, as height was only present in 69% of patients, precluding calculation of body mass index.

Table 1. Selected Patient, Provider, and Visit Characteristics in Patients with Suboptimally Controlled Hypertension*

| | No. of patients |
|--|-----------------|
| Patient Characteristics | N=254† |
| Mean (SD) Age (years) | 164.2 (7) |
| 40–49 | 3% |
| 50–59 | 24% |
| 60–69 | 49% |
| 70–79 | 24% |
| Gender | |
| Male | 59% |
| Female | 41% |
| Race | |
| White | 55% |
| African American | 35% |
| Asian | 2% |
| Other/Unknown/Missing | 8% |
| Body weight, (lbs) | |
| Men | 40% |
| Women | 36% |
| Mean (SD) Adherence Score‡ | 1.05 (0.5) |
| Current or ex-smoker§ | 20% |
| Current or ex-alcohol use§ | 17% |
| Comorbid Conditions/Complications | |
| Coronary heart disease | 28% |
| Stroke/Transient ischemic attack | 10% |
| Hyperlipidemia | 64% |
| Retinopathy | 9% |
| Neuropathy | 8% |
| Nephropathy | 8% |
| Peripheral vascular disease | 9% |
| On ≤ 3 blood pressure medications | 89% |
| Co-managed by a cardiologist | 26% |
| Using insulin | 22% |
| Primary Care Provider Characteristics | N=68 providers |
| Year of Graduation from Medical School | 1985 (9) |
| Male | 57% |
| Female | 43% |
| Provider Specialty | |
| Internal Medicine | 44% |
| Family Practice | 34% |
| Physician Assistant, Nurse Practitioner, or Resident | 22% |
| Visit Characteristics | N=1,374 visits |
| Mean (SD) Systolic Blood Pressure (mmHg) | 152 (14) |
| Mean (SD) Diastolic Blood Pressure (mmHg) | 82 (11) |
| Mean (SD) visits to the primary care provider (over 24 months) | 6 (5) |
| Visit Type | |
| Routine visit | 66% |
| Urgent visit | 34% |
| ≥ 4 blood pressure medications at time of visit | 17% |
| Mean (SD) interval since the last visit (days) | 58 (60) |
| Prescription side effects noted in the chart | 3% |
| Patient counseled on diet | 22% |
| Patient counseled on smoking | 2% |
| Patient counseled on medication adherence | 10% |
| Patient counseled on glucose control | 7% |
| Primary care provider type | |
| Internal Medicine | 67% |
| Family Practice | 29% |
| Physician Assistant, Nurse Practitioner, or Resident | 4% |
| Patient seen by the regular provider at the visit | 77% |
| Mean (SD) patients on provider’s schedule on day of visit | 17 (5) |

Table 1. (continued)

| | No. of patients |
|-------------------------------------|-----------------|
| Capillary glucose done at the visit | 17% |
| Mean (SD) capillary glucose (mg/dL) | 174 (79) |

*Suboptimally controlled hypertension was defined as a systolic blood pressure ≥140 mmHg or a diastolic blood pressure ≥90 mmHg.

†In certain categories, percents do not equal 100% owing to missing data.

‡Mean adherence score of 1.0 means that the subject was 100% adherent. Subjects could have greater than 100% adherence if they refilled their prescription early.

§Current or ex-smoker defined as having smoking use listed on the problem list in the medical record. Current or ex-alcohol use defined as having alcohol use listed on the problem list in the medical record.

We then used a 2-step approach to develop the final multi-variable model. First, we used our clinical judgment and prior literature to choose factors for the final model. These variables included: the presence of coronary heart disease, having a routine visit, systolic and diastolic blood pressure for the index and previous visit, and patient age and gender. Blood pressure was handled as a continuous variable, as there were no statistically significant changes in slope over the range of blood pressures. We then constructed separate multivariable models for patient, provider, and visit characteristics.

In addition to variables included based on clinical judgment, we also included in the final model several of the most statistically significant variables from each of the first-step models ($p < 0.05$). Clinic site was not included in these models as there were no statistically or clinically significant differences between clinic sites. We chose not to include the comorbidity (RUB) variable in the analysis as it was not significantly associated with intensification of antihypertensive medications ($p > 0.05$). Tests of significance were 2-tailed, with an alpha level of 0.05. Analyses were performed using Stata, Intercooled Version 8.0 (Stata Corporation, College Station, TX).

RESULTS

Patient, Visit, and Provider Characteristics

Table 1 presents selected characteristics of 254 patients and their 1,374 visits at which blood pressure was unequivocally elevated. Most were older male Whites or African Americans. These federal employees and their dependents were highly adherent to their blood pressure medications. About two thirds had hyperlipidemia and over 1 quarter had coronary heart disease. At baseline, most patients (89%, $n=227$) were taking 3 or fewer blood pressure medications, suggesting that addition of 1 or more classes of antihypertensive medications might have been used for intensification.

The 68 primary care providers were comprised mostly of Internal Medicine (44%, $n=30$) or Family Practice (34%, $n=23$) physicians; most had graduated from medical school before 1990.

Primary care providers intensified blood pressure medications at only 176 (13%) of 1,374 hypertensive visits among this diabetic cohort. One hundred and nineteen (68%) of these intensifications occurred within 24 hours of the patients’

Table 2. Visit Factors Associated with Intensification of Antihypertensive Medications in 254 Diabetic Adults with Elevated Blood Pressure*

| Visit-related Factors | Intensification (N=176) | No Intensification (N=1198) | Univariate Model: OR (95% CI)† | Partially adjusted Model: OR (95% CI)† |
|--|-------------------------|-----------------------------|--------------------------------|--|
| Number of blood pressure (BP) medications | | | | |
| <4 | 88% | 83% | – | – |
| ≥4 | 12% | 17% | 0.57 (0.33, 0.99) | 0.55 (0.32, 0.94) |
| Acute medication prescribed | | | | |
| No | 72% | 61% | – | – |
| Yes | 28% | 39% | 0.61 (0.43, 0.87) | 0.61 (0.42, 0.88) |
| Number of chronic medications | | | | |
| <5 chronic meds | 38% | 38% | – | – |
| 5–9 chronic meds | 52% | 52% | 0.96 (0.67, 1.36) | 0.97 (0.67, 1.40) |
| ≥10 chronic meds | 10% | 10% | 0.96 (0.52, 1.79) | 1.10 (0.58, 2.05) |
| Time since last visit (in days) | | | | |
| ≤30 days | 43% | 39% | – | – |
| 31–90 days | 30% | 38% | 0.74 (0.51, 1.07) | 0.81 (0.55, 1.19) |
| 91–180 days | 20% | 20% | 0.94 (0.61, 1.44) | 1.06 (0.68, 1.65) |
| >180 days | 7% | 3% | 1.99 (0.99, 3.99) | 1.92 (0.93, 3.95) |
| Visit type | | | | |
| Urgent | 20% | 36% | – | – |
| Routine | 80% | 64% | 2.27 (1.53, 3.37) | 2.51 (1.66, 3.79) |
| Prescription side effects | | | | |
| No or Not Mentioned | 96% | 97% | – | – |
| Yes | 4% | 3% | 1.29 (0.57, 2.88) | 1.46 (0.60, 3.52) |
| Regular provider seen at visit | | | | |
| No | 12% | 23% | – | – |
| Yes | 87% | 76% | 2.10 (1.30, 3.40) | 2.18 (1.34, 3.55) |
| Missing | 1% | 1% | 0.63 (0.06, 6.60) | 0.71 (0.08, 6.43) |
| Counseled patient on diet | | | | |
| No or Not Mentioned | 72% | 79% | – | – |
| Yes | 28% | 21% | 1.49 (1.04, 2.14) | 1.50 (1.03, 2.18) |
| Counseled patient on medication adherence | | | | |
| No or Not Mentioned | 88% | 91% | – | – |
| Yes | 12% | 9% | 1.30 (0.78, 2.14) | 1.23 (0.73, 2.07) |
| Counseled patient on glucose control | | | | |
| No or Not Mentioned | 94% | 93% | – | – |
| Yes | 6% | 7% | 0.81 (0.41, 1.59) | 0.83 (0.42, 1.64) |
| Changed BP meds at last visit | | | | |
| No or Not Mentioned | 87% | 87% | – | – |
| Yes | 13% | 13% | 0.73 (0.44, 1.21) | 0.60 (0.36, 1.00) |
| Missed appointment or non-adherent between visits | | | | |
| No | 85% | 91% | – | – |
| Yes | 15% | 9% | 1.78 (1.12, 2.84) | 1.65 (1.00, 2.72) |
| Influenza vaccine ordered | | | | |
| No | 91% | 93% | – | – |
| Yes | 9% | 7% | 1.43 (0.82, 2.49) | 1.53 (0.86, 2.72) |
| Pneumonia vaccine ordered | | | | |
| No | 98% | 99% | – | – |
| Yes | 2% | 1% | 1.65 (0.53, 5.17) | 1.91 (0.58, 6.33) |
| Referred to specialist at visit‡ | | | | |
| No | 82% | 87% | – | – |
| Yes | 18% | 13% | 1.55 (1.02, 2.35) | 1.71 (1.12, 2.64) |
| Capillary glucose | | | | |
| Not done | 63% | 67% | 0.56 (0.38, 0.85) | 0.54 (0.35, 0.83) |
| ≤150 mg/dL | 22% | 14% | – | – |
| >150 mg/dL | 15% | 17% | 0.54 (0.32, 0.92) | 0.56 (0.33, 0.98) |
| Number of patients seen by the doctor that day | | | | |
| <10 | 14% | 9% | – | – |
| 10–20 | 64% | 65% | 0.64 (0.39, 1.04) | 0.66 (0.40, 1.11) |
| >20 | 22% | 26% | 0.57 (0.33, 0.99) | 0.62 (0.35, 1.10) |
| Appointment time | | | | |
| <1 pm | 69% | 62% | – | – |
| ≥1 pm | 31% | 38% | 0.74 (0.53, 1.05) | 0.76 (0.53, 1.08) |
| Mean blood pressure of current and prior visit (mmHg)§ | | | | |
| Mean BP<140/90 | 13% | 23% | – | – |
| Mean BP=140–159/90–99 | 59% | 62% | 1.74 (1.08, 2.80) | 1.79 (1.11, 2.89) |
| Mean BP=160–179/100–109 | 24% | 13% | 3.17 (1.82, 5.52) | 3.37 (1.93, 5.89) |
| Mean BP≥180/110 | 3% | 1% | 3.86 (1.26, 11.80) | 4.09 (1.33, 12.61) |

Table 2. (continued)

| Visit-related Factors | Intensification (N=176) | No Intensification (N=1198) | Univariate Model: OR (95% CI)† | Partially adjusted Model: OR (95% CI)† |
|--|-------------------------|-----------------------------|--------------------------------|--|
| Mean SBP from current and prior visit (per 10 mmHg)§ | – | – | 1.40 (1.24, 1.58) | 1.31 (1.15, 1.49) |
| Mean DBP from current and prior visit(per 10 mmHg)§ | – | – | 1.64 (1.35, 2.00) | 1.43 (1.15, 1.76) |
| Mean SBP from current and prior visit (per SD)§ | – | – | 1.56 (1.34, 1.83) | 1.43 (1.20, 1.70) |
| Mean DBP from current and prior visit (per SD)§ | – | – | 1.58 (1.32, 1.90) | 1.39 (1.14, 1.69) |

*Elevated blood pressure was defined as systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg.

†The univariate model is a crude odds ratio of intensification of antihypertensive medications, which takes into account clustering by patient. The partially adjusted model is the odds ratio of intensification of antihypertensive medications adjusting for age, gender, race, and mean systolic and diastolic blood pressure from the index and prior visit.

‡Subjects could have been referred to any of the following specialists: neurologist, nephrologist, ophthalmologist, podiatry, nutrition, or endocrine.

§Mean SBP from current and prior visit was defined as taking the mean of the 2 systolic blood pressures (1 blood pressure reading from the current visit and 1 from the prior visit). Mean DBP from current and prior visit was defined as taking the mean of the 2 diastolic blood pressures (1 blood pressure from the current visit and 1 from the prior visit). The blood pressure per standard deviation allows comparisons of the effects on intensification of systolic and diastolic blood pressure as these blood pressures have different scales. In this case, there was no difference between the effect of systolic and diastolic blood pressure on intensification by the primary care provider as seen by the similar point estimates and confidence intervals. BP blood pressure, SBP systolic blood pressure, DBP diastolic blood pressure, SD standard deviation.

appointment with their primary care provider; 27 (15%) of the intensifications occurred between 2 days and 1 week; 15 (8.5%) occurred between 1 and 2 weeks; and the remaining 15 (8.5%) occurred between 2 weeks and 1 month of their appointment date. The intensification rate was similar (14%) when including only the visits where patients had a prior and index blood pressure ≥140/90 mmHg.

Using the 1,374 index visits with elevated blood pressure, the mean systolic and diastolic blood pressures for the 254 patients were 152 mmHg and 82 mmHg, respectively. Most of the provider visits were routine (66%, n=906 visits) appointments with regular providers (77%, n=1,062). A capillary blood glucose was performed at 17% (n=235) of visits, yielding an average blood glucose of 174±79 mg/dL.

Factors Associated with Treatment Intensification

Patient factors. Most patient factors were not associated with intensification including age, race (white versus non-white), gender, weight, comorbid conditions, mean adherence score, alcohol use, smoking status, insulin use, and family history of heart disease (p>0.05; data not shown). The associations we did find were surprising. First, laboratory results used to assess risk of diabetic complications (2-year mean hemoglobin A1c, LDL-cholesterol, and serum creatinine) were not associated with intensification (OR per standard deviation; 0.96 95% CI 0.69–1.34, OR 1.00; 95% CI 0.99–1.001, and OR 1.09; 95% CI 0.23–5.18, respectively). Second, coronary heart disease (CHD) was associated with failure to intensify antihypertensive treatment. Compared to their counterparts without CHD, those with CHD were 42% less likely to have their treatment intensified at visits with elevated blood pressure (OR 0.58; 95% CI 0.37–0.90).

Primary care provider factors. No provider factors (including provider type, year of graduation from medical school, and gender) were significantly related to intensification of antihypertensive therapy (all p>0.05; data not shown).

Visit-related factors. Table 2 shows associations between visit-related factors and intensification. As expected, blood pressure at the index visit showed a strong positive association with treatment intensification (Fig. 1). Compared to circumstances when the mean blood pressures at the index and preceding visit were in fair or optimal range (<140/90 mmHg), providers were about twice as likely to intensify treatment when the mean blood pressure was in suboptimal range (140–159/90–99 mmHg) and about 3 times as likely to intensify treatment when the mean blood pressure was in poor range (>160/100 mmHg). Inclusion of blood pressure data from the visit before the immediately preceding visit had little marginal effect.

Other positive associations with the decision to intensify treatment included: having a routine visit, seeing one’s regular provider, receiving counseling on diet, receiving a diabetes-related referral, or having missed an appointment between visits.

In contrast, inverse associations with the decision to intensify treatment included: taking 4 or more antihypertensive medications, receiving a medication for an acute condition, not having a capillary blood glucose done at the visit, or having a capillary glucose with a level >150 mg/dL.

Finally, the number of chronic medications, time of day, day of the week, and the provider’s patient volume on the day of the visit had no significant association with the intensification by the primary care provider.

Final Multivariable Model

Most of the associations identified in the partially adjusted models persisted in the final multivariable model (Table 3). Visit-related factors independently associated with treatment intensification were: higher blood pressure, having a routine visit, receiving a diabetes-related referral, and seeing one’s regular provider. No durable patient or provider characteristics were associated with intensification.

Visit-related factors independently associated with the failure to intensify treatment were: having a capillary glucose >150 mg/dL, or not having a capillary glucose performed. The

only durable patient characteristic associated with failure to intensify was having a prior history of coronary heart disease. Surprisingly, compared to their counterparts without such a history, patients with a history of coronary heart disease were about 40% less likely to have their antihypertensive treatment intensified, even after accounting for blood pressure at the visit and a variety of other patient- and visit-related factors.

Coronary Heart Disease and Cardiology Co-Management

A possible explanation for this surprising observation was that patients with coronary heart disease were more likely to have their antihypertensive medications advanced by a co-managing cardiologist. To test this hypothesis, we went back to the appointment database to identify patients who visited a cardiologist during the 24-month interval, and back to the pharmacy database to identify episodes of treatment intensification after cardiology visits. We then developed an additional multivariable logistic regression model, using generalized estimating equations, which included decisions to intensify treatment made by cardiologists.

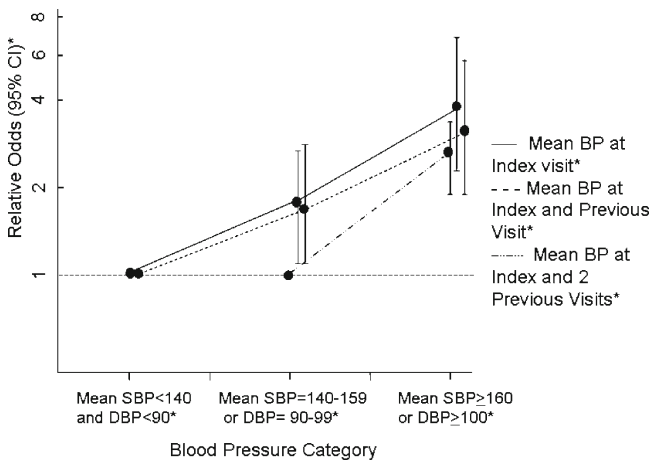


Figure 1. Relative odds of intensifying antihypertensive medications by blood pressure category and visit number. *In 254 adults with Type 2 diabetes, we show the unadjusted relative odds of intensification of antihypertensive medications in their 1,374 visits with uncontrolled hypertension by mean blood pressure category and visit number. Blood pressure categories more strictly defined are: (1) mean SBP < 140 and DBP < 90 mmHg, (2) mean SBP = 140–159 and mean DBP < 90 OR mean SBP < 160 and mean DBP = 90–99, (3) mean SBP ≥ 160 and mean DBP < 100 OR mean SBP < 160 and DBP ≥ 100. The solid line indicates the relative odds of intensification of antihypertensive medications with their 95% CI using the mean blood pressure at the index visit of each patient. The dashed line indicates the relative odds of intensification of antihypertensive medications with their 95% CI using the mean blood pressure at the index and previous visit of each patient. The dashed and dotted line indicates the relative odds of intensification of antihypertensive medications with their 95% confidence intervals using the mean blood pressure at the index and 2 previous visits of each patient. Relative odds are plotted on a log scale. Bars indicate 95% confidence intervals. *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *BP* blood pressure, *95% CI* 95% confidence interval.

Table 3. Factors Independently Associated with Intensification of Antihypertensive Medications at 1367 Visits With Elevated Blood Pressure*

| Characteristics (N=1,367 visits for 253 patients)† | Adjusted Odds Ratio (95% CI)† | p value |
|---|-------------------------------|---------|
| Patient Factors | | |
| Age (in 10-year increments) | 1.09 (0.81, 1.45) | 0.57 |
| Male (vs Female) | 0.97 (0.67, 1.40) | 0.88 |
| History of coronary heart disease‡ | 0.61 (0.38, 0.95) | 0.03 |
| Visit Factors | | |
| Mean SBP from current and prior visit (per 10 mmHg§ | 1.34 (1.17, 1.53) | <0.001 |
| Mean DBP from current and prior visit (per 10 mmHg§ | 1.42 (1.15, 1.76) | 0.001 |
| Capillary glucose >150 mg/dL (vs ≤ 150 mg/dL) | 0.54 (0.31, 0.94) | 0.03 |
| Capillary glucose not performed (vs ≤ 150 mg/dL) | 0.59 (0.39, 0.91) | 0.02 |
| Routine visit (vs urgent) | 2.08 (1.36, 3.18) | 0.001 |
| Regular provider (vs covering provider) | 1.84 (1.11, 3.06) | 0.02 |
| Diabetes-related referrals given at the visit | 1.63 (1.05, 2.53) | 0.03 |

*Elevated blood pressure was defined as systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg.

†Odds ratios have been adjusted for all other variables in the model, and takes into account clustering by the patient. Because of missing data, only 1,367 of the 1,374 visits (253 out of 254 patients) have been analyzed in the final model. *CI* denotes confidence interval.

‡Coronary heart disease is defined as having coronary artery disease, myocardial infarction, or angina.

§Mean SBP from current and prior visit was defined as taking the mean of the 2 systolic blood pressures (1 blood pressure reading from the current visit and 1 from the prior visit). Mean DBP from current and prior visit was defined as taking the mean of the 2 diastolic blood pressures (1 blood pressure from the current visit and 1 from the prior visit). *SBP* systolic blood pressure, *DBP* diastolic blood pressure.

Of 71 patients with coronary heart disease, 32 (45%) were also seeing a cardiologist. Compared to their counterparts without a cardiologist, patients with a cardiologist were less likely to have their antihypertensive prescriptions advanced by their primary care provider (age, sex, and blood pressure-adjusted OR 0.62; 95% CI 0.40–0.95), whether the cardiologist ever independently intensified treatment (OR 0.69; 0.40–1.19) or whether the cardiologist never intensified treatment (OR 0.50; 95% CI 0.26–0.93). Additional adjustment for comorbid conditions and number of blood pressure medications did not change these results significantly. After adjustment for cardiology co-management in the multivariable model, the association persisted between patients with coronary heart disease and lack of intensification but became insignificant (OR 0.65; 95% CI 0.41–1.03).

DISCUSSION

In this highly adherent cohort of adults with diabetes and hypertension, failure to intensify treatment for high blood pressure was a common problem: primary care providers intensified treatment at only 13% of visits where blood pressure was unequivocally elevated. As hypothesized, a variety of modifiable visit-related factors appeared to influence the decision to intensify antihypertensive treatment. Providers

were more likely to intensify treatment at routine visits and with their regular patients, but less likely to do so in the setting of coronary heart disease, or an elevated capillary glucose. When providers decided to intensify treatment, they also tended to make a diabetes-related referral, and perform a capillary glucose.

The main strength of our study was the availability of detail at the level of the individual clinic visit, made possible by rigorous, standardized data abstraction from medical records linked to all available electronic databases. Unlike most previous studies, this detail allowed us to investigate specific modifiable visit-based factors.

Nonetheless, several limitations should be considered when interpreting these results. First, because we used pharmacy records to identify intensification, we likely missed some episodes when the provider recommended intensification but the patient declined or significantly delayed filling the prescription. However, our patient population was otherwise highly adherent and the intensification rate we observed of 13% was similar to the rates in other studies (range 4–38%).^{9,15,16,23,24}

Second, our data were collected from 1998 to 2001 and may not be fully generalizable to the present day. Systems changes including electronic medical record availability may impact some of the associations reported, such as the decreased intensification by the primary care provider when the patient was co-managed by a cardiologist. However, in a recent qualitative study,²³ co-management was listed as a barrier to intensification. Physician rates of intensification are also still quite low (13–35%) in 2 recently conducted qualitative studies.^{9,23} Also, our choice of patients from a single managed care provider enhanced convenience at the possible expense of generalizability. However, our study sample was racially diverse, included men and women, who saw multiple providers at 17 different clinic sites.

Third, many of the visit-based factors were based on medical record review. Although we attempted to evaluate all clinical variables at the visit that could impact intensification by the provider, we were unable to capture everything. We may have missed instances where a patient brought a log of blood pressure readings from the home if the provider did not record this in the medical record. In addition, if a physician did not record anything related to prescription side effects in the medical record, then we coded this as no side effects. This potential for misclassification along with the low rate of intensification may have biased some of these items toward the null of no significant effects (i.e., type II error). For instance, patient volume was not significantly associated with lack of intensification, yet a suggestion of an association was noted when patient volume exceeded 20 patients per provider. We only had 50% power to detect this difference as intensification occurred rarely; therefore, we were unable to conclusively state that physician workload does not effect intensification. Finally, we were unable to assess some relevant provider characteristics such as knowledge, beliefs, and attitudes about diabetes and antihypertensive therapy.

Since 1980, at least 3 studies have evaluated visit-based factors associated with intensification of antihypertensive patients without diabetes,^{15–17} and 1 study evaluated visit-based factors in antihypertensive patients with diabetes.⁹ These 4 studies found that higher systolic and diastolic blood pres-

ures at the visit were associated with treatment intensification by the provider.^{9,15–17} Berlowitz et al. found that having a routine visit was associated with decisions to intensify treatment.¹⁵ The 3 studies that evaluated patient demographics found no significant association between patient demographics and intensification of antihypertensive therapy.^{9,15,17} Two studies evaluated provider type and found no significant associations between provider type and treatment intensification.^{9,15} These results are consistent with our findings.

In contrast to previous studies, we had access to more data at the level of the individual visit. These data yielded several novel observations. Providers that intensified antihypertensive treatment were more likely to order a diabetes-related referral, or perform a capillary blood glucose at the visit. An elevated capillary glucose was 1 barrier to intensification of antihypertensive medications even after adjusting for blood pressure and age. The average serum glucose in visits reporting a fingerstick was 174 mg/dL, suggesting that the provider may have been focusing on diabetes management instead of blood pressure management. Berlowitz et al, in an analysis of 274 diabetic hypertensive patients, did not find an association between intensification of diabetes medications and lack of intensification of antihypertensive medications. He concluded that providers were not being distracted by diabetes management,²⁴ yet our results suggest the opposite. In a survey of primary care providers, Hicks et al. found that competing demands was the second major reason providers reported for not intensifying antihypertensive medications at hypertensive visits.⁹ This supports our finding related to glucose management being the focus of some visits. Primary care providers working to manage multiple concurrent problems may choose to optimize therapy of only a limited number of conditions at 1 time.

Unexpectedly, we found that a diagnosis of coronary heart disease was a strong barrier to intensification in our study. Berlowitz et al., in their analysis of 274 patients with diabetes and hypertension, found a similar but statistically ambiguous association between coronary artery disease and lack of intensification.²⁴ Cotton et al. recently reported that providers listed co-management with a cardiologist or nephrologist as a reason for lack of intensification, as primary care providers were unsure of their role.²³ In our study, many patients with coronary heart disease were under co-management by a cardiologist, but the cardiologist frequently failed to intensify blood pressure medications. There appeared to be little or no coordination of decision-making with the primary care provider. Several studies show improved quality of care outcomes with the use of care management systems including a patient care coordinator.^{25,26}

In summary, our findings suggest 2 potential complementary approaches to improve treatment intensification for elevated blood pressure in adults with diabetes. First, clinics could promote continuity of care by scheduling routine appointments with a patient's usual care provider at which blood pressure control would be an explicit focus. Second, cardiologists and primary care providers could organize to improve co-management and communication related to treatment intensification. Given the overall low rate of intensification, however, we may need to think of other creative ways to solve this substantial health problem. By targeting intensification at more than 1 level, we may improve clinical outcomes for patients with significant risks for complications from hypertension.

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