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INADEQUATE MANAGEMENT OF BLOOD PRESSURE IN A HYPERTENSIVE POPULATION

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ABSTRACT

Background Many patients with hypertension have inadequate control of their blood pressure. Improving the treatment of hypertension requires an understanding of the ways in which physicians manage this condition and a means of assessing the efficacy of this care.

Methods We examined the care of 800 hypertensive men at five Department of Veterans Affairs sites in New England over a two-year period. Their mean (±SD) age was 65.5±9.1 years, and the average duration of hypertension was 12.6±5.3 years. We used recursive partitioning to assess the probability that antihypertensive therapy would be increased at a given clinic visit using several variables. We then used these predictions to define the intensity of treatment for each patient during the study period, and we examined the associations between the intensity of treatment and the degree of control of blood pressure.

Results Approximately 40 percent of the patients had a blood pressure of ⩾160/90 mm Hg despite an average of more than six hypertension-related visits per year. Increases in therapy occurred during 6.7 percent of visits. Characteristics associated with an increase in antihypertensive therapy included increased levels of both systolic and diastolic blood pressure at that visit (but not previous visits), a previous change in therapy, the presence of coronary artery disease, and a scheduled visit. Patients who had more intensive therapy had significantly ($P<0.01$) better control of blood pressure. During the two-year period, systolic blood pressure declined by 6.3 mm Hg among patients with the most intensive treatment, but increased by 4.8 mm Hg among the patients with the least intensive treatment.

Conclusions In a selected population of older men, blood pressure was poorly controlled in many. Those who received more intensive medical therapy had better control. Many physicians are not aggressive enough in their approach to hypertension. (N Engl J Med 1998;339:1957-63.)

ALTHOUGH hypertension is among the most common reasons for an outpatient medical visit,[1] many patients with established hypertension have poorly controlled blood pressure.[2] For example, in the 1988–1991 National Health and Nutrition Examination Survey (NHANES III), only 24 percent of the patients with a diagnosis of hypertension had blood pressures of <140/90 mm Hg.[3] Although limited access to medical care and financial barriers to obtaining medications play a part,[4-6] blood-pressure control is suboptimal even among patients who receive regular care.[7] Consequently, it has been emphasized that control of hypertension could be increased if physicians improved the process of care.[7,8] Most research has focused on patients' noncompliance with recommended therapies[9] and has not examined the way in which physicians actually treat patients with hypertension. In particular, physicians' willingness to change patients' medications during office visits may affect the outcomes of care.

We evaluated the treatment of hypertension in patients with access to physicians and medications through the Department of Veterans Affairs as a means of determining ways in which such care may be improved and reducing the number of patients with suboptimal control of blood pressure. We addressed the following questions: Which characteristics are associated with a decision to start a new medication or increase the dose of an existing medication? Does the intensity of treatment for hypertension vary? Is hypertension better controlled among patients who receive more intensive medical therapy?

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METHODS

Identification of Study Subjects

We studied men with hypertension who were receiving regular medical care in outpatient clinics at five Veterans Affairs sites in New England. Sites included urban and suburban hospitals as well as a free-standing ambulatory care center. We used a data base, the Outpatient Clinic File,[10] to identify men at these sites who had made at least three clinic visits over a period of approximately two years. Eligible patients had to meet three criteria. First, they had to have made at least one visit to a general-medicine or medical-subspecialty clinic during a six-month period beginning January 1, 1990 (three sites), or January 1, 1993 (two sites). If a patient had made more than one visit during this period, we randomly selected one visit as the index visit. Second, they had to have made at least one visit 1½ to 2½ years after the index visit (referred to as the outcome visit). This visit was randomly selected from among all visits made during this period. Third, the patients had to have made at least one visit between the index visit and the outcome visit. The study sample was randomly selected from among the eligible patients stratified according to site. All medical care was delivered between 1990 and 1995.

Because the Outpatient Clinic File contains neither medical diagnoses nor provider-specific information, we reviewed the medical records of eligible patients to determine whether two additional criteria were met. First, both the index and outcome visits had to be with a physician. If either visit was not with a physician, another visit with a physician that had occurred close to the disqualified visit was substituted. Second, hypertension had to be deemed an active problem during the year preceding the index visit. Hypertension was deemed active if it was listed as a problem in any progress note made before the index visit or if it had ever been diagnosed and the patient was currently receiving therapy.

Abstraction of Data

We examined all visits that could plausibly be related to the management of hypertension. We defined hypertension-related visits as visits to general-medicine clinics or any medical-subspecialty clinic as well as unscheduled visits to the emergency room or walk-in clinic, regardless of the listed diagnoses.

Nurses reviewed medical records to obtain clinical information, including dates of visits, reasons for visits, types of providers, symptoms, physical-examination findings, diagnoses, test results, and medications prescribed during the period between the index visit and the outcome visit. Additional data on demographic characteristics and coexisting conditions were abstracted from entries made before the index visit. We recorded up to four blood-pressure measurements for each visit. In 80.5 percent of the visits during which blood pressure was measured, it was measured only once. When multiple measurements were made during a visit, we averaged them.

Information on changes in antihypertensive medications was abstracted from physicians' orders, progress notes, and pharmacy records and was classified in the following manner: the dose was considered to have been increased if the dose of any antihypertensive medication had been increased or a new type of medication had been started; the dose was considered to have been decreased if the dose of medication had been decreased or the medication had been discontinued and there had been no increase in the dose of another medication; a change within a class of antihypertensive medication, such as diuretics, was considered to have occurred if one medication had been substituted for another in the same class; in all other cases, no change was considered to have occurred.

We recorded the interval between hypertension-related visits, as well as the interval between visits with a blood-pressure measurement, and examined the relation between these intervals and the blood pressure recorded at the earlier visit. We categorized blood pressure for this purpose as well controlled (systolic blood pressure of $<$140 mm Hg and diastolic blood pressure of $<$90 mm Hg), poorly controlled (systolic blood pressure of $\geq$160 mm Hg or diastolic blood pressure of $\geq$95 mm Hg), or moderately well controlled (all other measurements).

Statistical Analysis

Analyses consisted of three steps. First, we evaluated individual visits to construct models that could be used to determine the probability that a visit would result in an increase in antihypertensive medications. Next, for each patient we compared the actual number of increases in therapy during the two years of observation with the number of increases predicted with use of the model to assess the intensity of treatment. Finally, we related the intensity of treatment to the degree of blood-pressure control.

We used recursive partitioning (classification trees),[11] as outlined in S-Plus software version 3.3,[12] to model changes in therapy. This procedure repeatedly partitions the data to create subgroups with highly homogeneous outcomes. At each iteration, it splits off cases in which the value of a single independent variable differs from that of the rest of the group. The goal is to produce the maximal discrepancy in the distribution of the outcome among the subgroups. Resulting models can be displayed as bifurcation trees. To prevent overfitting, we used a pruning procedure that penalizes trees with many partitions. We chose the size of the penalty by fitting the tree model on 10 different 90 percent samples of the data to evaluate the accuracy of the predictions concerning the remaining 10 percent.

We used our clinical judgment to identify factors that are likely to influence decisions to change therapy and that thus could be used as potential predictors in the model. These factors included systolic and diastolic blood-pressure values from the visit being assessed and from the two previous visits; demographic characteristics of the patients; the reasons for the visits; the types of providers; the number of antihypertensive medications prescribed; prior changes in therapy; cardiovascular risk factors such as hyperlipidemia, cigarette smoking, and left ventricular hypertrophy; late complications of hypertension such as cerebrovascular disease, coronary artery disease, peripheral vascular disease, and congestive heart failure; the number of coexisting conditions (according to a modified Charlson Index)[13]; and other factors associated with poor outcomes for hypertension.[14]

Modeling was carried out once with use of all four categories of changes in antihypertensive medications and once with use of a dichotomous variable: increase in antihypertensive medications or no increase. The results of the two analyses were similar, and we report only the results for the model that included the simpler, dichotomous outcome. The initial partition in the model split visits with a blood-pressure measurement from those without a blood-pressure measurement (changes in therapy were uncommon if blood pressure was not measured). Therefore, we removed visits without a blood-pressure measurement from the analyses and thereafter considered blood pressure as a continuous variable. The predicted probability of an increase in antihypertensive medications during a visit, used in subsequent analyses, was determined on the basis of the actual percentage of visits with such increases in each partition of the tree.

We next determined for each patient the intensity of medical therapy using the following equation: the patient's actual number of increases in antihypertensive medications minus the expected number, divided by the number of visits. The expected number was the sum of the predicted probability of an increase at each visit. The midpoint of the intensity score was 0, with positive scores indicating more increases than expected. For example, a patient with one more increase than expected in 10 visits was given a score of 0.10.

Finally, we described the outcomes of care for individual patients using three measures: the dichotomous measure of whether or not blood pressure was $\geq$160/90 mm Hg at the outcome visit and continuous measures of change in systolic and diastolic blood pressure between the index and outcome visits. Outcomes were adjusted for the base-line characteristics of the patients according to previously described models that considered initial blood pres-

sure, race, serum creatinine concentrations, presence of diabetes, age, the number of coexisting conditions, and body-mass index.[14] To examine whether the process of care was associated with risk-adjusted outcomes, we used logistic-regression analysis to determine whether patients with higher treatment-intensity scores were more likely to have a blood pressure of <160/90 mm Hg at the outcome visit and linear-regression analysis to examine whether the intensity score was associated with declines in systolic and diastolic blood pressure. To assess whether there was confounding between the number of visits and the intensity scores, we repeated these analyses and included the number of visits as an additional dependent variable.

RESULTS

We evaluated 800 male veterans with hypertension, most of whom were elderly and white and had many coexisting conditions (Table 1). Thus, they represented a selected patient population that may not be representative of all patients with hypertension. Many of the patients had poorly controlled blood pressure. The mean (±SD) systolic blood pressure at the time of the index visit was 146.2±18.8 mm Hg, and it was virtually unchanged (145.4±19.3 mm Hg, $P>0.1$) after two additional years of care. Diastolic blood pressure, however, decreased from 84.3±10.3 mm Hg at the index visit to 82.6±10.4 mm Hg two years later ($P<0.001$). The percentage of patients with a blood pressure of ≥160/90 mm Hg decreased during this period (from 46.3 percent to 39.4 percent, $P=0.001$), although it remained high.

Despite the poor control of their blood pressure, patients made frequent visits for health care. They made a mean of 6.4±3.3 hypertension-related visits per year, with blood pressure measured at 5.1±2.5 of these visits. Most visits were with a staff physician; only 19 percent were with resident physicians. The degree of blood-pressure control had a significant influence on the number of days between visits: lower blood pressure was significantly associated with longer intervals between visits ($P<0.001$) (Table 2).

The recursive-partition model was based on 6391 hypertension-related visits with a blood-pressure determination and resulted in seven groups with widely differing expected probabilities of increased therapy (Fig. 1). We rounded the blood-pressure cutoff points selected by the model as follows: 90.2 was rounded to 90 mm Hg, 164.8 to 165 mm Hg, and 156.5 to 155 mm Hg. The c statistic, which measures how well the model predicts which visits are more likely to result in an increase in therapy, was 0.76 (95 percent confidence interval, 0.74 to 0.77).

Overall, antihypertensive medications were increased at 6.7 percent of hypertension-related visits and 11.2 percent of visits with a blood-pressure measurement. Factors associated with decisions to increase therapy were increased levels of both systolic and diastolic blood pressure at the visit, a change in therapy at the preceding visit, the presence of coronary artery disease (among patients with a blood pressure of <165/90 mm Hg), and a scheduled visit. Blood pressure recorded during previous visits and cardiovascular risk factors other than hypertension were not identified as predictors by the model. Increases in therapy were most common (35.0 percent) during the 412 visits in which a diastolic blood pressure of ≥90 mm Hg was recorded and there had been a change in therapy at the preceding visit. At the 2106 visits in which a diastolic blood pressure of <90 mm Hg and a systolic blood pressure of <165 mm Hg were recorded and coronary artery disease was not present, increases in antihypertensive medications were rare (only 3.2 percent).

The intensity of medical therapy received by individual patients varied considerably, with scores ranging from −0.27 to +0.65. Patients in the highest quintile had an average score of +0.18, as compared with a score of −0.13 for those in the lowest quintile. More intensive therapy was associated with better control of blood pressure. Only 35.0 percent of those in the highest quintile had a blood pressure of ≥160/90 mm Hg at the outcome visit, as compared with 59.6 percent in the lowest quintile. The mean decreases in systolic and diastolic blood pressure between the index and outcome visits for the highest quintile were 6.3 and 4.5 mm Hg, respectively; patients in the lowest quintile had increases of 4.8 and 0.8 mm Hg, respectively. These associations between the intensity of therapy and the degree of blood-pressure control remained significant after adjustment for various base-line characteristics ($P<0.01$) (Table 3). The inclusion of the number of visits as a dependent variable in the models did not affect the results.

DISCUSSION

Clinical trials have demonstrated that treatment for hypertension helps avert cardiovascular disease and stroke.[15,16] Yet despite the availability of new medications and increasing awareness of the dangers

TABLE 1. BASE-LINE CHARACTERISTICS OF THE 800 MEN WITH HYPERTENSION.*

CHARACTERISTIC	VALUE
Age — yr	65.5±9.1
Duration of hypertension — yr	12.6±5.3
White race — no. (%)	733 (92)
No. of antihypertensive medications — no. (%)	
0	68 (8)
1	264 (33)
2	254 (32)
≥3	214 (27)
Selected coexisting conditions — no. (%)	
Diabetes mellitus	274 (34)
Hyperlipidemia	205 (26)
Coronary artery disease	297 (37)
Cerebrovascular disease	87 (11)

*Plus–minus values are means ±SD.

TABLE 2. INTERVALS BETWEEN HYPERTENSION-RELATED VISITS AND BETWEEN VISITS WITH A BLOOD-PRESSURE RECORDING.*

VARIABLE	WELL-CONTROLLED BLOOD PRESSURE		MODERATELY WELL CONTROLLED BLOOD PRESSURE		POORLY CONTROLLED BLOOD PRESSURE	
	NO. OF VISITS	NO. OF DAYS BETWEEN VISITS	NO. OF VISITS	NO. OF DAYS BETWEEN VISITS	NO. OF VISITS	NO. OF DAYS BETWEEN VISITS
Hypertension-related visit	1589	84±75	2234	81±69	1859	67±70
Visit with blood-pressure recording	1561	102±85	2208	101±84	1851	80±80

*Plus–minus values are means ±SD. Blood pressure was categorized as well controlled (systolic blood pressure of <140 mm Hg and diastolic blood pressure of <90 mm Hg), poorly controlled (systolic blood pressure of 160 mm Hg or diastolic blood pressure of ≥95 mm Hg), or moderately well controlled (all other measurements). Lower blood pressures were significantly associated with longer intervals between visits ($P<0.001$).

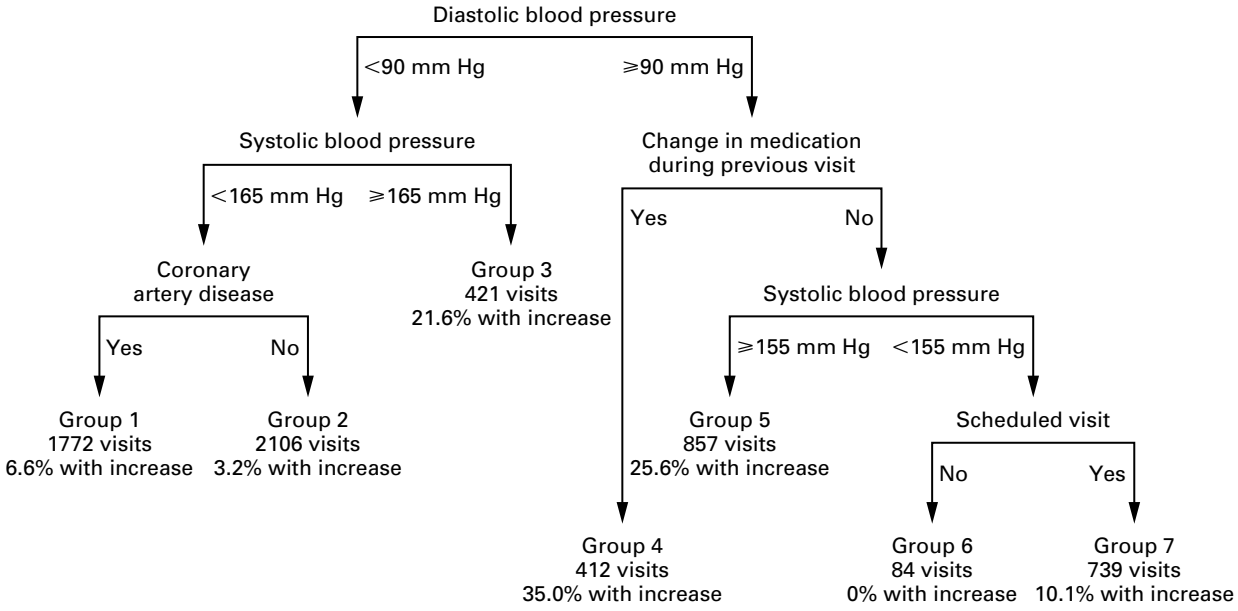

Figure 1. Model Used to Describe Factors Associated with the Decision to Increase Antihypertensive Therapy.
The numbers of visits in each group, as well as the percentages with increases in antihypertensive medications, are given.

of even mild elevations in blood pressure, little improvement has been made in the control of blood pressure. Reducing the number of patients with poorly controlled hypertension to no more than 50 percent is a national public health goal for the year 2000.[17] Although studies have focused on factors such as access to medical care and noncompliance with prescribed therapies, major improvements in outcomes of hypertensive patients will most likely require changes in the process of care. We assessed the type of care given to a group of hypertensive patients who were followed for two years to determine the ways in which physicians manage hypertension and whether treatment decisions affect the degree of blood-pressure control.

Our results reinforce findings reported in other settings: Many patients with hypertension have inadequate control of blood pressure. In NHANES III, 45 percent of patients who were receiving treatment for hypertension had a blood pressure of ≥160/95 mm Hg, as compared with 46.3 percent of those who had a blood pressure of ≥160/90 mm Hg in our study.[3,18] Fewer than 25 percent of our patients would be considered to have well-controlled blood pressure with the use of the stricter threshold of 140/90 mm Hg.

TABLE 3. MULTIVARIATE REGRESSION MODELS RELATING THE INTENSITY OF THERAPY TO RISK-ADJUSTED OUTCOMES OF HYPERTENSION CARE.*

VARIABLE†	BLOOD PRESSURE ≥160/90 mm Hg		CHANGE IN SYSTOLIC BLOOD PRESSURE		CHANGE IN DIASTOLIC BLOOD PRESSURE	
	ODDS RATIO	95% CI	COEFFICIENT	P VALUE	COEFFICIENT	P VALUE
Intensity of therapy (per increase of 0.1)	0.77	0.67–0.89	−2.02	<0.001	−0.90	0.003
Initial systolic blood pressure (per increase of 10 mm Hg)	1.39	1.27–1.52	−6.23	<0.001	—	—
Initial diastolic blood pressure (per increase of 10 mm Hg)	—	—	—	—	−7.24	<0.09
Serum creatinine (per increase of 1 mg/dl [88.4 μmol/liter])	2.17	1.21–4.02	5.14	0.03	4.51	<0.001
White race (vs. all other racial and ethnic groups)	0.60	0.34–1.03	−1.10	0.63	−2.67	0.03
Age (per increase of 10 yr)	0.81	0.67–0.97	1.61	0.03	−1.33	0.001
No. of coexisting conditions	0.90	0.80–1.00	−1.11	0.02	−0.78	0.002
Body-mass index (per increase of 1)‡	1.04	1.00–1.08	−0.01	0.97	0.19	0.02
Diabetes	1.09	0.76–1.56	4.24	0.004	1.31	0.10

*A logistic model was used to predict the odds of a blood pressure of ≥160/90 mm Hg (as compared with a blood pressure of <160/90 mm Hg). Linear regression analysis was used to predict changes in systolic blood pressure and diastolic blood pressure. CI denotes confidence interval. Each odds ratio or coefficient was adjusted for all the other listed variables. The odds ratios indicate the likelihood of having a blood pressure of ≥160/90 mm Hg associated with a particular characteristic, after adjustment for the other variables in the model.

†The covariates used in the models were derived from previous risk-adjustment models.[14]

‡The body-mass index is expressed as the weight in kilograms divided by the square of the height in meters.

Poor control of blood pressure could not be explained by a lack of access to medical care. Our patients were regular users of health care, averaging more than five medical-clinic visits with a blood-pressure measurement per year. Medications for patients who are treated at Veterans Affairs hospitals are either free or available for a small copayment.

Noncompliance with therapy is an important cause of poor control of blood pressure.[9] We had limited information on compliance: the number of antihypertensive pills dispensed[19] and whether noncompliance was noted in the medical record. Neither measure was associated with control of blood pressure. Had more complete information on compliance been available, the underlying reasons behind decisions not to increase therapy might have been clearer in some cases.

In our study, physicians frequently failed to increase the dose of antihypertensive medications or to try new treatments in patients with elevated blood pressure. Overall, antihypertensive medications were increased at 6.7 percent of hypertension-related visits. Among visits in which a diastolic blood pressure of ≥90 mm Hg and systolic blood pressure of ≥155 mm Hg were recorded, the frequency of increases in antihypertensive medications was 25.6 percent. At visits in which a diastolic blood pressure of <90 mm Hg and a systolic blood pressure of ≥165 mm Hg were recorded, the frequency was 21.6 percent. Thus, for about three quarters of visits in which elevated blood pressures were recorded, physicians did not increase medications. Nonetheless, the clinicians did not seem to ignore patients with elevated blood pressure. Follow-up visits occurred approximately two to three weeks sooner for patients with poorly controlled blood pressure than for those with normal blood pressure.

Since changes in antihypertensive-medication regimens should rarely be based on measurements obtained at a single visit, the clinicians might have been carefully monitoring patients for several visits before they decided to change the regimen. This possibility appears unlikely, however, for two reasons. First, we found no association between the presence of elevated blood pressures at a previous visit and a subsequent decision to change the regimen. Second, despite two years of care, with many opportunities to increase antihypertensive medications, blood pressure continued to be poorly controlled in many patients. Thus, although physicians may have been closely monitoring patients' blood pressure, they repeatedly delayed making changes in the regimen.

Various characteristics of the patients, such as age, cardiovascular risk factors other than hypertension, and the presence of late complications of hypertension, should also be considered in the management of hypertension.[20] However, these factors did not emerge as predictors of the decision to change antihypertensive medications. Only the presence of coronary artery disease was associated with an increased likelihood of increases in therapy, and only among patients with a blood pressure of <165/90 mm Hg. This may result from the fact that many antihypertensive medications serve a dual function

and are also used to treat manifestations of coronary disease.

Our model allowed us to define the intensity of treatment for each patient. We found significant variation, with some patients receiving considerably more therapy than is the norm for this population. Importantly, these differences in the intensity of treatment were associated with the outcome. We evaluated three measures of blood-pressure control and consistently found that patients who received more intensive therapy had better-than-expected control of blood pressure.

Our results suggest that many patients with hypertension are not being treated aggressively enough and indicate ways of improving the management of hypertension. Linking process and outcome measures has long been a goal of health services research because it is such a powerful tool for assessing and improving care.[21,22] Such links imply that the process measure truly captures the quality of care and that as a result, changes in performance may be expected to improve outcomes. The method that we used to link process and outcome measures for hypertension may also prove useful in assessments of the quality of care for other diseases.

Previous studies of hypertension have rarely demonstrated links between processes and outcomes,[23-26] possibly because these studies aggregated the processes of care reported for several visits, whereas we studied in detail the process of care at single visits. Only Haynes et al. reported that the vigor of therapy, defined on the basis of the relative potency of various antihypertensive drugs, was associated with decreases in diastolic blood pressure.[25] Our measure of the process of care for hypertension may be particularly useful in profiling physicians. In such profiling, physicians would learn when the care they provided was less intensive than the norm, and they could be encouraged to be more aggressive in pursuing better control of blood pressure. Further studies will be needed to evaluate such interventions.

Although the results of our study are likely to be generalizable, our patient population was a highly selected one. Although we studied older male veterans with adequate access to medical care, the degree of blood-pressure control in this group was similar to that reported in other settings and populations. Care was provided by clinicians with extensive experience, including attending physicians with medical-school affiliations. However, our model for predicting changes in medical therapy must be validated before it can be applied to other settings.

Our results do not merely confirm the findings of randomized, clinical trials that antihypertensive medications successfully lower blood pressure. Studies of efficacy must be combined with studies of effectiveness that evaluate care in the real world. We have developed a measure for assessing the process of care for hypertension in clinical practice and applied it to the problem of poorly controlled blood pressure. Our results indicate that improved control of blood pressure is possible. Physicians should examine their approach to individual patients and identify situations in which more aggressive management of hypertension may be appropriate. Inadequate control of blood pressure can no longer be ascribed solely to the lack of access to medical care and noncompliance with therapy; physicians themselves must accept some responsibility for the problem.

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