Comparing Methods of Measuring Treatment Intensification in Hypertension Care

Adam J. Rose, MD, MSc; Dan R. Berlowitz, MD, MPH; Meredith Manze, MPH; Michelle B. Orner, MPH; Nancy R. Kressin, PhD

Methods and Results—We enrolled 819 hypertensive outpatients from an urban academic hospital. Each patient was assigned 3 scores to characterize TI. The any/none score divides patients into those who had any therapy increases during the study versus none. The norm-based method models the chance of a medication increase at each visit, then scores each patient based on whether they received more or fewer medication increases than predicted. The standard-based method is similar to the norm-based method but expects a medication increase whenever the blood pressure is uncontrolled. We compared the ability of these scores to predict the final systolic blood pressure (SBP). The any/none score showed a paradoxical result: any therapy increase was associated with SBP 4.6 mm Hg higher than no increase (P<0.001). The norm-based method score did not predict SBP in a linear fashion (P=0.18); further investigation revealed a U-shaped relationship between the norm-based method score and SBP. However, the standard-based method score was a strong linear predictor of SBP (2.1 mm Hg lower for each additional therapy increase per 10 visits, P<0.001). Similarly, the standard-based method predicted dichotomized blood pressure control, as measured by SBP <140 mm Hg (odds ratio, 1.30; P<0.001).

Conclusions—Our results suggest that standard-based method is the preferred measure of treatment intensity for hypertension care. (Circ Cardiovasc Qual Outcomes. 2009;2:385-391.)

Key Words: hypertension ▪ chronic disease ▪ research ▪ quality of health care ▪ ambulatory care
WHAT IS KNOWN

- More intensive management of hypertension improves blood pressure over time in both experimental and observational studies.
- Several different systems of measuring treatment intensification have been used in the literature, but these systems have not previously been compared regarding their ability to predict blood pressure over time (predictive criterion validity).

WHAT THE STUDY ADDS

- We found that a standard-based method, which essentially “expects” a medication change whenever the blood pressure is elevated, performs better than other methods of measuring treatment intensification.
- Future research and quality improvement efforts should preferably use the standard-based method of measuring treatment intensification rather than the other methods we studied.
- Improved measures of treatment intensification and other quality-related constructs can increase the relevance of research efforts and magnify the effect on clinical care.

on a norm-based method (NBM) for defining care as more or less intensive, whereas the other relies on a standard-based method (SBM). The NBM, described by Berlowitz et al., first derives a model to predict the probability of a dose increase at each visit according to various visit characteristics, then compares observed versus predicted dose changes to characterize each patient’s care as more or less intensive than expected. The SBM, described by Okonofua et al., simply compares the number of dose changes observed with the number of occasions on which the BP was 140/90 mm Hg or higher. In this system, a dose change is essentially “expected” whenever the BP is uncontrolled. Some have noted that NBM has certain inherent advantages over NBM because it is easier to calculate and interpret. However, NBM incorporates a more nuanced view of clinical decision making because it allows for the possibility that factors other than the BP may influence the decision to intensify therapy, as well as the possibility that gradations of BP may exert differential influence on this decision. If NBM were the most valid measure of TI, as measured by BP control, it might be preferred, despite difficulties of calculation and interpretation.

However, different methods of measuring TI have not been directly compared regarding their ability to predict BP control over time. Because TI is a measure of process of care, linking it to BP control outcomes can demonstrate its validity and utility. We therefore used data from a study of hypertensive patients at an academic urban safety net medical center to address 2 questions: (1) To what extent do these different measures of TI identify the same patients as having received more or less intensive management, and (2) Which, if any, of these 3 measures of TI best predicts BP control over time? Whatever our results, we expected them to inform future efforts to measure TI in the management of hypertension.

Methods
Enrollment
This report is a secondary analysis of data from a randomized trial designed to test whether a clinician-directed curriculum about patient-centered counseling could improve doctor–patient communication, adherence to therapy, and BP control (clinicaltrials.gov identifier: NCT00201149). Patients were enrolled from 7 outpatient primary care clinics at Boston Medical Center, an inner-city safety net hospital affiliated with the Boston University School of Medicine. The study was approved by the Institutional Review Board of Boston University Medical Center. We identified all patients of white or black race, age 21 and older, with outpatient diagnoses of hypertension on at least 3 separate occasions between August 2004 and June 2006.

Using this “universe” of 10 125 hypertensive patients from 7 clinics, the study staff tracked these patients’ clinic visits over a 19-month period, and, as they presented for care, approached 3526 of them to request participation in the study. All willing respondents were then asked a series of questions and administered a cognitive screen to determine eligibility. A total of 1082 patients were excluded. Reasons included seeing a medical student at their visit (n = 257), use of a daily medication dispenser (because it might invalidate collection of adherence data, n = 247), cognitive impairment according to our cognitive screen (n = 199), ethnicity other than white or black (n = 149), unable to speak English (n = 71), not prescribed antihypertensive medication (n = 61), participation in another hypertension study (n = 30), hearing impairment (n = 16), and other (n = 52), leaving 2444 eligible patients. Of those, 654 patients overtly refused to participate and 920 patients responded that they did not have time to participate that day. Total enrollment was therefore 870 patients.

Dependent Variable: Final Systolic Blood Pressure
The primary outcome was each patient’s final systolic blood pressure (SBP) value, drawn from the clinical record of Boston Medical Center. We chose SBP rather than diastolic blood pressure (DBP) as our primary outcome because many more patients have poorly controlled SBP. However, we also examined several secondary outcomes of hypertension care, including DBP and dichotomized measures of SBP, DBP, and overall BP control.

Categorizing Medication Increases
Automated data from Boston Medical Center’s electronic medical record were examined. Our database included all prescriptions written, as well as all clinical BP values recorded within the study period. The unit of analysis was a visit to the primary care clinic, as identified by a date on which a BP value was recorded. When there were multiple BP values recorded on one date, we chose the one with the lowest SBP; if two values were tied, we selected the one with the lower DBP.

We recorded the patient’s initial regimen of antihypertensive medications, ie, the regimen before study inception. One of the authors (A.J.R.) manually reviewed all prescriptions for each patient to see when the BP regimen was increased. An increase in medication was defined as either a new medication being added to the regimen or an increase in the dose of an existing medication. The period between each 2 BP values was assigned a 1 if the regimen was increased during that period, or a 0 if it was not. Multiple increases during a single period were counted as a 1. Dose changes occurring after the final visit were not recorded. A subset of 42 patients, representing 495 (5%) of all clinic visits, were randomly selected for adherence data, n = 257), use of a daily medication dispenser (because it might invalidate collection of adherence data, n = 247), cognitive impairment according to our cognitive screen (n = 199), ethnicity other than white or black (n = 149), unable to speak English (n = 71), not prescribed antihypertensive medication (n = 61), participation in another hypertension study (n = 30), hearing impairment (n = 16), and other (n = 52), leaving 2444 eligible patients. Of those, 654 patients overtly refused to participate and 920 patients responded that they did not have time to participate that day. Total enrollment was therefore 870 patients.

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Covariates
We collected patient demographic data, including race (black or white), gender, and age. Using both ICD-9 codes and problem lists from the electronic medical record, we noted whether the patients had the following comorbid conditions, all of which could impact the BP, the use of antihypertensive medications, or the perceived urgency of controlling hypertension: benign prostatic hypertrophy,
Independent Variable: Any/None Score

The any/none score was “1” if the patient had at least 1 therapy increase during the study; otherwise, it was “0.” The any/none score does not account for the number of visits or the degree of BP elevation.

Independent Variable: Norm-Based Method Score

To create the NBM score, we began by deriving and validating a model to predict medication increases at each visit. The unit of analysis was each individual clinic visit; the outcome was whether or not the medications were increased at the visit. Our hypotheses regarding likely predictors were derived from our clinical judgment as well as our experience with the strongest predictors in previous similar models.2,11,12 We considered the following possible predictors: SBP at the current and the previous visit, DBP at the current and the previous visit, number of days since the previous visit, whether the medications were increased at the previous visit, and the entire list of variables described above under “Covariates.”

We initially screened variables using recursive partitioning (CART modeling),13 using the R statistical package, version 2.6 (R Foundation, 2007). This method assigns each clinic visit into 1 of several categories according to several important predictors; each category is characterized by a particular frequency of medication increase. The important variables and cutoff values are empirically determined by the modeling procedure.

Having used CART to screen variables, we proceeded to derive and validate our predictive model using logistic regression. The dataset was split 60/40, with the larger subset used for derivation and the smaller for validation. We tried all candidate variables in our models, focusing particularly on those identified as important by CART modeling. In selecting cutoff values for continuous variables, we were guided by the output from CART model results and results of bivariate analyses. There were 5 predictors in the final model: (1) current SBP, (2) current DBP, (3) days since last visit, (4) DBP at previous visit, and (5) whether the medication was adjusted at the last visit (see online-only Data Supplement A for model details). The c-statistic was 0.74 in the derivation set and 0.72 in the validation set; the Hosmer–Lemeshow test indicated good model fit (P = 0.59 in the derivation set and 0.44 in the validation set).

We then calculated the total number of expected medication changes for each patient in the dataset by summing probabilities over all of their visits. For example, if a patient had 3 visits, with predicted probabilities of a medication change of 0.20, 0.30, and 0.50, then exactly one medication change would be expected over this 3-visit period. We assigned each patient an NBM score, using the following formula:

\[
\text{NBM score} = \frac{\text{observed medication changes} - \text{NBM-predicted medication changes}}{\text{number of clinic visits}}
\]

NBM scores are between -1 and 1, with 0 as the midpoint of the score. A score of 0 indicates a precise match between observed and expected medication increases, with positive numbers indicating more medication increases than expected and negative numbers indicating fewer increases than expected. As an example, over a 10-visit period, a patient might have a total of 5 predicted medication increases using NBM. If this patient actually had 3 visits with medication increases, the NBM score would be -0.2, indicating 2 fewer medication increases than expected per 10 visits. If the patient had 6 visits with therapy increases, the NBM score would be 0.1, indicating 1 more medication increase than expected per 10 visits.

We also created an alternative NBM score for each patient, based solely on the results of our CART model (online-only Data Supplement B), as in the original article by Berlowitz et al.2 Results obtained using this score were not meaningfully different from our main NBM score and are not shown.

Independent Variable: Standard-Based Method Score

For the SBM analysis, the expected number of medication increases was the number of occasions on which the recorded BP was 140/90 mm Hg or higher. Using this number and the number of occasions on which the medication was intensified each patient was assigned a score between -1 and 1. To make comparisons with NBM more straightforward, we reversed the polarity of the SBM score from what was originally described by Okonofua et al.3 Therefore, we computed the SBM score using the following formula:

\[
\text{SBM score} = \frac{\text{expected medication changes} - \text{SBM-predicted medication changes}}{\text{number of clinic visits}}
\]

For example, a patient with 5 elevated BP values over 10 visits would have a predicted value of 5 therapy increases. If this patient actually had 3 visits with medication increases, the score would be 3/10 to 5/10 = -0.2, or 2 fewer therapy increases than expected per 10 visits. If the patient had 6 visits with therapy increases, the score would be 6/10 to 5/10 = 0.1, or 1 more therapy increase than expected per 10 visits.

We recognize that for patients with diabetes or chronic kidney disease, current guidelines set a lower BP target (ie, 130/80 mm Hg),14 We therefore created an alternative SBM score only for patients with a low BP target. For this alternative SBM score, a medication increase was expected on each occasion when the recorded BP was 130/80 mm Hg or higher as opposed to 140/90 mm Hg for the main TI score. We divided the sample into patients with the higher and the lower BP thresholds and repeated our analyses for each group using the appropriate TI score. Results of this sensitivity analysis were similar to our main analysis and are not shown.

Statistical Analyses

Each patient was assigned 3 scores to measure TI in their hypertension care: any/none, NBM, and SBM. We examined the degree to which these 3 measures of TI were intercorrelated. For comparisons involving the any/none score, we used t tests to compare means of the other 2 scores when the any/none score was “any” versus “none.” We compared the NBM and SBM scores using Spearman correlation (because of the non-Gaussian distribution of the SBM score) as well as dividing them into quartiles and constructing a 4×4 table.

We then examined the predictive validity of these 3 scores for the main independent variable, the final SBP (continuous), as well as several secondary measures of BP control, including final DBP (continuous) and whether the final SBP was <140 mm Hg (categorical). For the any/none score, we compared the “any” group with the “none” group using t tests or χ², as appropriate. For the NBM and SBM scores, we used linear or logistic regression to model the relationship between the score and the BP outcomes, as appropriate. We repeated these analyses, controlling for patient-level covariates. We also divided the NBM and SBM scores into quartiles and performed ANOVA tests regarding the ability of the quartiles to predict the final SBP. For all analyses except the CART modeling, we used SAS, version 9.1 (SAS Institute). The authors had full access to the data and take responsibility for their integrity. All authors have read and agree to the manuscript as written.

Results

Patient Characteristics

Of 870 patients enrolled in the study, 51 were excluded from this analysis because they had 2 or fewer BP values. Therefore, 819 patients with hypertension, managed at Boston Medical Center, constituted our study population (Table 1). The mean follow-up time was 24 months; on average, patients visited the clinic once every 2 months. The mean age was 59.6 years, 34% of patients were male, and most (58%) were of black race. Considering their relatively young age, the
population had a high burden of comorbidity: 54% had hyperlipidemia, 33% had diabetes, 13% had coronary artery disease, and 59% were obese. Most patients (74%) were receiving 2 or more antihypertensive medications at study inception. The population was characterized by relatively well controlled hypertension at baseline: the mean BP was 134/80 mm Hg, and 55% of patients were below 140/90 mm Hg.

Medication Increases and Measures of Treatment Intensity
After excluding the initial and final clinic visits for each patient (which were not analyzed regarding therapy increases), therapy was increased at 835 of the 9828 clinic visits (8.5%); 406 patients (50%) had at least 1 therapy increase during the study. Among patients with at least 1 therapy increase, the mean number of increases was 2.1, and the median was 2.0. We calculated NBM and SBM scores for each patient in the database. NBM scores were narrowly distributed (median, -0.04; interquartile range, [IQR] -0.06, 0.05; 5th and 95th percentiles, -0.13, 0.25). SBM scores were more widely distributed (median, -0.25; IQR, -0.50, -0.05; 5th and 95th percentiles, -0.80, 0.05).

Before examining the scores as predictors of BP control, we compared their classification of patients. The mean NBM score was 0.09 when the any/none score was “any,” versus -0.07 when it was “none” (P<0.001). In contrast, the SBM score did not differ meaningfully between the 2 groups (-0.27 versus -0.30, P=0.15). The Spearman correlation between the NBM and SBM scores was 0.44, a fairly low correlation for 2 scores that are intended to measure the same construct. We also divided the NBM and SBM scores into quartiles and compared their classification of patients (Table 2). The χ² statistic for agreement between these 2 scores was 0.14 (95% CI, 0.09 to 0.18). Extreme differences in quartile classification were not uncommon; for example, there were 209 patients (26%) whose quartile classifications differed by more than 1 category.

Any Therapy Increases as a Predictor of Blood Pressure Control
Any therapy increase (versus none) was examined as a predictor of the final BP. Patients with at least 1 therapy increase had a mean final SBP of 135.2 mm Hg as compared with a mean final SBP of 130.6 mm Hg among patients who had no therapy increases (P<0.001). As expected, because this measure does not control for confounding by indication, it produces a paradoxical result (therapy increases are associated with a higher final BP).

Norm-Based Method Score as a Predictor of BP Control
NBM score was a poor predictor of BP control (Table 3). In a linear regression, the NBM score was not a significant predictor of the final SBP (model R²=0.001, P=0.28). Adding patient-level covariates improved the model fit somewhat. We investigated further by dividing the NBM score into quartiles (Table 4). A U-shaped relationship, rather than a linear relationship, was observed between NBM score quartiles and the final SBP. The NBM score also performed
poorly as a predictor of the final DBP ($R^2=0.002$, $P=0.19$) and as a predictor of whether the final SBP would be below 140 mm Hg (OR, 1.06 per change of 0.1; c-statistic, 0.56, $P=0.28$).

**Standard-Based Method Score as a Predictor of Blood Pressure Control**

In contrast to the NBM score, the SBM score was an excellent predictor of the final BP (Table 5). In a linear regression, the $\beta$ coefficient was $-2.1$, indicating that for each 0.1 of the SBM score (1 more therapy change per 10 visits), the final SBP was $2.1$ mm Hg lower ($R^2=0.12$, $P<0.001$). Adding covariates to the model improved its fit by a margin similar to that with the NBM model, but SBM persisted as a powerful predictor of the final SBP. In additional stratified analyses, SBM performed similarly in males and females, in white and black patients, and among subgroups of patients with particularly severe comorbid conditions such as chronic kidney disease, congestive heart failure, and peripheral vascular disease.

We investigated further by dividing the SBM score into quartiles (Table 4). A strong linear relationship was observed between SBM score quartiles and final SBP ($P$ for linear trend $<0.001$). The SBM score was also a predictor of the final DBP ($\beta$ coefficient, $-0.8$; $P<0.001$) and of whether the final SBP would be below 140 mm Hg (OR, 1.30 per change of 0.1; c-statistic, 0.70, $P<0.001$).

**Discussion**

Optimizing approaches to measuring the quality of care delivered to patients with chronic diseases is an important research goal. This is particularly true for measuring treatment intensity in the care of hypertension because we have decades of evidence showing that more intensive treatment improves BP control.\(^1\)\(^-\)\(^3\) We therefore compared the predictive criterion validity of 3 approaches of measuring TI in hypertension care. We found that the any/none measure produces paradoxical results because it does not account for confounding by indication. To our surprise, we found that the
NBM score was not predictive of BP control. Further investigation demonstrated that the NBM score appeared to have a U-shaped relationship with BP outcomes, complicating its use as a predictor and calling into question its validity as a measure of TI, which is meant to be monotonic.

In contrast, the SBM score was a powerful predictor of the final BP, a relationship that remained undiminished after controlling for covariates. It is important to remember that the β coefficient we found for the effect of SBM on final SBP, −2.1 mm Hg, was for each additional therapy increase per 10 visits, a relatively small difference in management. Larger differences in management would obviously improve BP control much more. For example, the difference in final SBP between the highest and lowest quartiles of TI (125 mm Hg versus 141 mm Hg) suggests an effect of considerable magnitude and clinical significance.

We had expected to find that the any/none measure performs poorly as a measure of TI because previous studies have shown that a failure to account for confounding by indication produces paradoxical (or attenuated) results.1–6 We had also expected to find that NBM is superior to SBM as a predictor of BP control because it incorporates a more nuanced representation of clinical decision making. The apparent lack of predictive criterion validity for NBM in our study contrasts with the findings of earlier studies, particularly the original article by Berlowitz et al.2 This difference may be attributable to improved BP control; mean initial BP was 134/80 mm Hg in our study versus 146/83 in the earlier study.2 NBM may have worked better in an era of mediocre BP control, whereas SBM may be more suited to pursuing what are ultimately smaller improvements in BP.

Our study has several limitations. First, TI is not universally accepted as an ideal theory to understand poor control of asymptomatic chronic conditions, especially when it is presented as “clinical inertia.”15 The obverse of TI. Some studies have suggested that on deeper inspection, what seems to be clinical inertia could also be attributed to “competing demands,”16,17 “clinical uncertainty,”18 or “appropriate inaction.”19 Other studies have explored the relationship between TI and adherence,20–23 or the patient and visit-level predictors of TI.10,17,24–26 This study did not include specific measures of adherence, competing demands, patient complexity, clinical uncertainty, or appropriate inaction, although we did account for the burden of comorbid disease, which relates to several of these concepts (competing demands and patient complexity). However, because we compared multiple measures of TI using the same database, we can be assured that unmeasured covariates would have been equally true for all comparisons. In addition, although refinements to the TI concept are always welcome, our study reinforces the notion that TI, as embodied in the SBM score, is an important determinant of BP control.

Second, our study compared different methods of measuring TI in hypertension care. It should not be assumed, however, that SBM would also be the ideal system for measuring TI in the care of diabetes or hyperlipidemia; future research should address those questions. Finally, our data were drawn from an academic urban hospital, which may limit generalizability. The clinicians at Boston Medical Center may have managed hypertension differently than nonacademic clinicians. Similarly, the BP control in this cohort was quite good; it is possible that the SBM score may work particularly well in such a setting. In addition, many of the patients in our study were immigrants, ethnic minorities, and of low socioeconomic status. However, given the relatively good BP control achieved among this population, the challenges these patients face in their everyday lives do not seem to threaten the generalizability of our findings.

We have known for 30 years that more intensive management leads to better hypertension outcomes, in both clinical trials and observational settings.1–3 What we have lacked is consensus about the best method to measure TI in the care of hypertension. Our study found that any/none and NBM were not valid measures of TI, whereas a SBM was an excellent predictor of BP control. Unless these results are challenged by other studies, SBM should be the preferred method of characterizing TI in future studies of hypertension care. SBM can now serve as the basis of research and quality improvement efforts to improve the process and outcomes of hypertension care.

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Disclosures

None.

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**SUPPLEMENTAL MATERIAL**

**Appendix A**: Logistic model to predict medication dose increases. Odds ratios above 1.0 indicate greater likelihood of a dose increase at a visit. While this model was derived and validated using a split dataset, the entire dataset was used for the analysis presented here (n = 9828 clinic visits).

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Unadjusted OR (95% CI)</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Systolic BP at current visit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 130 mm/Hg</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>130-139 mm/Hg</td>
<td>1.5 (1.2 – 1.9)*</td>
<td>1.4 (1.1 – 1.7)*</td>
</tr>
<tr>
<td>140-149 mm/Hg</td>
<td>3.3 (2.6 – 4.1)*</td>
<td>2.6 (2.1 – 3.3)*</td>
</tr>
<tr>
<td>150 mm/Hg and above</td>
<td>6.3 (5.2 – 7.6)*</td>
<td>4.7 (3.8 – 5.7)*</td>
</tr>
<tr>
<td>2. Diastolic BP at current visit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 90 mm/Hg</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Above 90 mm/Hg</td>
<td>3.4 (2.9 – 4.0)*</td>
<td>1.7 (1.5 – 2.1)*</td>
</tr>
<tr>
<td>3. Diastolic BP at previous visit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 90 mm/Hg</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Above 90 mm/Hg</td>
<td>2.3 (1.9 – 2.7)*</td>
<td>1.4 (1.2 – 1.7)*</td>
</tr>
<tr>
<td>4. Days since previous visit</td>
<td></td>
<td></td>
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<tr>
<td>Up to 119 days</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>120 days or more</td>
<td>1.5 (1.2 – 1.8)*</td>
<td>1.5 (1.2 – 1.8)*</td>
</tr>
<tr>
<td>5. Medication change at previous visit?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Yes</td>
<td>2.7 (2.2 – 3.3)*</td>
<td>2.2 (1.8 – 2.7)*</td>
</tr>
</tbody>
</table>

*p < 0.001
Appendix B: CART-based model for predicting medication dose increases. The best model (presented here) had 7 terminal nodes, the same number as the model in the original paper by Berlowitz, et al. Cutoff BP values have been rounded to the nearest 5 mm/Hg for convenience and interpretability. This model had similar performance to our main model in terms of predicting which visits would have medication changes (c-statistic = 0.71, compared to 0.73 for the main model).

<table>
<thead>
<tr>
<th>Group</th>
<th>Current SBP</th>
<th>Current DBP</th>
<th>DBP at previous Visit</th>
<th>Dose Change at Previous Visit?</th>
<th>Number of Visits in Category</th>
<th>Chance of dose increase at each visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;140 mm/Hg</td>
<td>&lt; 90 mm/Hg</td>
<td></td>
<td>No</td>
<td>5700</td>
<td>3.8%</td>
</tr>
<tr>
<td>2</td>
<td>&lt;140 mm/Hg</td>
<td>&lt; 90 mm/Hg</td>
<td></td>
<td>Yes</td>
<td>399</td>
<td>8.4%</td>
</tr>
<tr>
<td>3</td>
<td>&lt;140 mm/Hg</td>
<td>&gt; 90 mm/Hg</td>
<td></td>
<td></td>
<td>442</td>
<td>11.0%</td>
</tr>
<tr>
<td>4</td>
<td>140 - 154 mm/Hg</td>
<td>&lt; 90 mm/Hg</td>
<td></td>
<td></td>
<td>1727</td>
<td>11.6%</td>
</tr>
<tr>
<td>5</td>
<td>155+ mm/Hg</td>
<td>&lt; 90 mm/Hg</td>
<td></td>
<td></td>
<td>792</td>
<td>18.9%</td>
</tr>
<tr>
<td>6</td>
<td>140 - 144 mm/Hg</td>
<td>&gt; 90 mm/Hg</td>
<td></td>
<td></td>
<td>244</td>
<td>15.9%</td>
</tr>
<tr>
<td>7</td>
<td>145+ mm/Hg</td>
<td>&gt; 90 mm/Hg</td>
<td></td>
<td></td>
<td>472</td>
<td>30.1%</td>
</tr>
</tbody>
</table>
Figure: Graphic Representation of CART-based model.

- **SBP 140 mm/Hg**
  - `<`
  - `≥`
    - `<` DBP 90 mm/Hg
      - `<` Dose change at previous visit
        - `N`
          - Group 1
        - `Y`
          - Group 2
      - `≥`
        - Group 3
    - `≥`
      - `<` DBP 90 mm/Hg at previous visit
        - `≥`
          - `<` SBP 155 mm/Hg
            - `<`
              - Group 4
            - `≥`
              - Group 5
          - `≥`
            - `<` SBP 145 mm/Hg
              - `≥`
                - Group 6
              - `≥`
                - Group 7