Predictors of Uncontrolled Hypertension in the Stroke Belt

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This is the accepted version of the following article:

Dave, G. J., **Bibeau, D. L., Schulz, M. R., Aronson, R. E.**, Ivanov, L. L., Romanchuk R, Spann L (2013). Predictors of Uncontrolled Hypertension in the Stroke Belt. *Journal of Clinical Hypertension, 15 (8)*, 562-569. doi: 10.1111/jch.12122,

which has been published in final form at http://dx.doi.org/10.1111/jch.12122.

Abstract:

Inadequate control of high systolic blood pressure in older adults has been largely attributable to poor control of overall hypertension (HTN). The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) guidelines emphasize the importance of controlling isolated systolic HTN in older adults. The study examined demographics, self-reported health information, and clinical measures as predictors of uncontrolled HTN among individuals taking antihypertensive medications. The Community Initiative to Eliminate Stroke, a stroke risk factor screening and prevention project, collected data in two North Carolina counties. Statistical modeling of predictors included odds ratios (ORs) and logistic regression analyses. Of the 2663 participants, 43.5% and 22.8% had uncontrolled systolic and diastolic HTN, respectively. African Americans were more likely to have uncontrolled systolic (60%) or diastolic HTN (70.9%) compared with whites (40% and 29.1%, respectively). Participants 55 years and older were more likely to have uncontrolled systolic HTN compared with younger individuals. Regression analyses showed that race (OR, 1.239; *P*=.00), age (OR, 1.683; *P*=.00), and nonadherence with medications (OR, 2.593; *P*=.00) were significant predictors of uncontrolled systolic HTN. Future interventions should focus on improving management of isolated systolic HTN in older adults and African Americans to increase overall control of HTN.

Keywords: Hypertension | Stroke | Cardiovascular Diseases | Risk Factors | Health Care

Article:

Hypertension (HTN) is a major risk factor for cardiovascular diseases (CVD) and stroke.[1] HTN was either the primary or contributing cause of death for more than 300,000 Americans in 2006.[2, 3] The National High Blood Pressure Education Program (NHBPEP) and

the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC 7) have stipulated guidelines for treatment and control of HTN. These guidelines serve as a platform for healthcare providers, public health researchers, and practitioners to focus on key elements of lifestyle modification and pharmacologic aspects of HTN management.[4,5] Due to ongoing efforts of NHBPEP, the number of individuals in the United States who are taking medication and thus controlling their BP levels has increased dramatically during the past 2 decades. But, according to the National Health and Nutrition Examination Survey (NHANES) 2001–2010 report, despite an increase in overall BP control rates by 47.2% (NHANES 2009–2010) compared with 28.7% (NHANES 2001–2002), approximately 40% of treated hypertensive patients did not have controlled BP levels by the 2009 to 2010 time period.[6]

In spite of continued efforts to treat and control HTN at a national level, success has been limited.[7] Furthermore, there are concerns that the trends described in the NHANES report may not be relevant to vulnerable populations. Their findings also showed persistent higher treated but uncontrolled HTN rates among older Americans.[6] An earlier NHANES study found that, although the elderly population (65 years or older) represented roughly one fifth of the total population, they represented almost a half of those unaware of their condition, a third of those who were aware of their condition but not being treated, and over half of those who had treated but uncontrolled HTN. A 2011 report from Aronow and colleagues[8] found that many factors, including use of multiple pharmacies, medication side effects, medication costs, and comorbidities, contribute to uncontrolled HTN in the elderly. Similar findings were reported in studies examining data collected in the 1990s from the Framingham Heart Study (FHS).[9]

In addition to age, race is another demographic factor that researchers have found to be associated with uncontrolled HTN rates. A study looking at data from the Multi-Ethnic Study of Atherosclerosis (MESA) found that across whites, Hispanics, Chinese, and African Americans, only African Americans shared a significant association with treated but uncontrolled HTN. They also recommended that future research specifically focus on strategies to prevent hypertension in these high-risk groups.[10] A Central North Carolina (NC) study examining racial differences in an elderly hypertensive population found that after adjusting for confounding variables, black race was an independent risk factor for HTN in the elderly. A large number of studies have also shown sex disparities associated with uncontrolled HTN. For example, a study examining data collected by the National Ambulatory Medical Care Survey and the National Hospital Ambulatory Medical Care Survey found that women in their sample were more likely to have uncontrolled HTN compared with men.[11] Research conducted in Ingham County, Michigan, found that female sex was a significant predictor of BP control.[12] Another study exploring HTN in the Iranian population found supporting evidence, emphasizing the need for advisement on monitoring and controlling HTN in women.[13]

Nonadherence to BP-lowering medications and recommendations is also cited as one of the leading contributing factors to uncontrolled HTN, especially among minority and elderly

populations. About half of all patients with HTN fail to consistently attend appointments and take prescribed medications. According to The Cohort Study of Medication Adherence in Older Adults (CoSMO), a prospective study among older adults with essential HTN, the authors found that black participants not only had a significantly higher prevalence of uncontrolled HTN, but also had a lower level of adherence to BP-lowering medications compared with whites. This study reported a strong association between self-reported nonadherence and uncontrolled BP levels determined by clinical readings.[14] Vawter and colleagues conducted a study to assess barriers to antihypertensive medication adherence among adults in the United States. The authors found that almost one third of the participants reported several barriers to antihypertensive therapy. “Not remembering” was the most common reason reported (32.4%), followed by high cost (22.6%), having no insurance (22.4%), side effects (12.5%), and other reasons.[15]

Hyman and Pavlik examined NHANES III data and found that SBP is most strongly related to age, and accounts for the majority of uncontrolled HTN cases in individuals 60 years and older.[16, 17] Systolic HTN prevalence rates increase with age, and SBP level is the main risk factor for CVD after the age of 50 years.[16,18] The JNC 7 report suggests that there is a greater need to focus on isolated SBP as a major risk factor for CVD and strokes. Studies have shown that SBP levels continue to rise throughout life, whereas DBP levels start to taper off after 50 years of age.[19, 20] Franklin and colleagues explored the hemodynamic patterns of age-related changes in BP and found that age-related changes leading to increasing SBP levels and decreasing DBP levels after 50 years of age are mainly attributed to large artery stiffness. They also suggest that the dominant hemodynamic factor in normotensive and hypertensive individuals is large artery stiffness compared with vascular resistance. If HTN is left untreated or uncontrolled, large artery stiffness would worsen, thereby perpetuating a vicious cycle of elevated BP levels and arterial stiffness.[20]

In many of these vulnerable populations, the uncontrolled BP cycle is easily maintained by a host of other barriers and factors that affect an individual's ability to meet BP goals.[21] Some of these include lack of support, lack of clarity and knowledge about their condition,[22, 23]physician inertia,[24-26] resistant HTN,[27, 28] comorbidities (diabetes, renal disease),[29] and adherence to prescribed medication.[30-35] For instance, in 2011, Persell examined NHANES data from 2003–2008 and found that 8.9% among all hypertensive adults and 12.8% among drug-treated hypertensive adults had resistant HTN in the United States. Resistant HTN was defined as having uncontrolled HTN (≥140/90 mm Hg) in spite of taking antihypertensive drugs from ≥3 drug classes or having controlled HTN after taking antihypertensive drugs from ≥4 drug classes. The author also noted that older age, black race, high BMI, and renal dysfunction was significantly associated with resistant HTN.[27] Pimenta and Calhoun (2012) reported an increasing trend in the prevalence of resistant HTN from 5.5% in 1988–1994 to 11.8% in 2005–2008. This trend has also increased CVD risk substantially among individuals with uncontrolled HTN compared with those who have controlled BP levels after taking ≥3 antihypertensive medications.[28]

Researchers have suggested that future research should focus on groups with the highest risk, including but not limited to black women and the elderly, and consider strategies to further understand the trends and patterns of uncontrolled HTN in these communities.[36] The relationship between demographics and other barriers specific to these populations should be further examined in developing a strategy to improve HTN control in this population.[14, 37]

In order to better develop and implement interventions that are population-specific, culturally competent, and community-based, it is important to understand and assess factors associated with uncontrolled HTN. This study aims to assess demographic, self-reported, and clinical predictors of uncontrolled HTN among individuals taking BP-lowering medications and add to the existing literature to better inform strategies and interventions aimed at improving HTN control in elderly and underrepresented populations.

Methods

CITIES Project

The CITIES Project of NC was supported for 3 years by the US DHHS, Office of Minority Health (OMH), and awarded to the Forsyth Medical Center (FMC) Foundation in formal partnership with the Cone Health, the University of North Carolina at Greensboro (UNCG), and the North Carolina Agriculture & Technical State University (NC A&T). This initiative was implemented in two NC counties, Guilford and Forsyth, and targeted minority populations, low-income individuals, those who spoke English as a second language, and persons who lived in rural areas. The main components of the CITIES project were to: (1) screen individuals for stroke risk factors; (2) make recommendations and referrals as appropriate for identified risk factors; and (3) provide health education and health promotion activities regarding stroke risk factors.[38]

Settings and Procedures

Each medical center used a mobile unit and registered nurses (RN) to screen individuals with preset appointments at designated sites in both counties, such as churches, factories, and health fairs and at sites with unscheduled appointments such as shopping mall parking lots, within the two respective counties. Participation was voluntary and each participant was included if they were 18 years or older and signed the consent form. The RNs used a standard questionnaire that gathered data on self-reported questions, stroke risk profile, and clinical and biomedical measurements. A total of 19,621 individuals were screened for stroke risk factors in the CITIES project. Of those, 2663 individuals who were taking BP-lowering medications were chosen for this study. The participants were asked to self-report their HTN medication status by answering the following question: “Do/Did you take any medications to control your blood pressure?” Inclusion in the sample was based on a “yes” response to the question about BP-lowering medications.

The RNs measured the BP of each participant using an electronic machine, DYNAMAP, which was wet-tested and calibrated every week. A minimum of 2 measurements were taken in the seated position with one of the arms outstretched and the lowest BP reading was recorded. If the first reading was high, ie, high systolic and/or diastolic BP, then BP was measured again after 2 minutes in the same arm. If the readings on the machine were found to be high on both occasions, then the RNs would manually measure the BP twice in the other arm, using a calibrated sphygmomanometer, and then record the lowest readings. All participants who had a BP measurement of 160 mm Hg for systolic and/or 100 mm Hg for diastolic or higher were referred to an emergency department promptly to get their BP checked again. All cut-points for uncontrolled HTN, SBP, and DBP levels were based on the JNC 7 definition and classification of HTN.[5]

Other self-reported information included perceived weight status, smoking, exercise status, presence or absence of diabetes mellitus, nonadherence with BP-lowering medications and use of lipid-lowering medications.[38] All self-reported information was collected prior to collection of blood samples and recording of clinical and biomedical measurements. Clinical and biomedical measurements included blood low-density lipoprotein (LDL), high-density lipoprotein (HDL), total cholesterol, triglycerides, and glucose levels. BMI was calculated based on self-reported height and measured weight. The project was approved by the respective institutional review boards for each institution. The RNs also collected demographic information from all participants. Age was dichotomized into two groups, 55 years and younger and older than 55 years.

Statistical Analyses

MS Access was used to input data, which was analyzed using IBM SPSS Statistics 20©.[39, 40] The final sample excluded individuals who were not taking BP-lowering medications in order to avoid confounding results. The participants' demographic characteristics, self-reported information, and clinical measurements were described using frequencies and percentages. Bivariate associations were calculated using cross-tabulations to compare self-reported information (yes and no) from the questionnaire with uncontrolled levels of SBP and DBP (yes and no) based on clinical measurements.

Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using standard procedures to assess determinants of uncontrolled SBP and DBP. Uncontrolled SBP and DBP, the outcome variables, were modeled as a function of independent variables including demographic characteristics, self-reported information, and clinical measurements reported. Binary logistic regression and forward likelihood ratio method were used to evaluate statistically significant predictors of BP control. Separate regression analyses were conducted on a subsample of individuals who self-reported to be compliant with BP-lowering medications. The Hosmer and Lemeshow Goodness-of-Fit test was conducted to assess the fit of the final model and its

estimates. The statistical significance for all analyses was based on the conventional α level of significance of 0.05.

Results

A total of 2663 participants who reported that they did or were taking BP-lowering medications were included in the final analysis. A description of demographic characteristics is provided in Table 1. More than two thirds of the participants were women. A majority of the participants were African American (52.2%) and 42% were white. Almost 50% of the participants had a high school level education or more.

Table 1. Demographic Characteristics of Respondentsa in the CITIES Project, NC 2004–2007

Personal Characteristics	**Total**	
	(N=2663)	**%**
Sex		
Female	1840	69.3
Male	816	30.7
Race		
Caucasian	1118	42.0
African American	1391	52.2
Hispanic	14	0.5
Asian/Pacific Islander	44	1.7
Other	52	2.0
Age, y		
18–55	1238	46.7
>55	1412	53.3
Income, $		
<35,000	1782	70.7
≥35,000	738	29.3

Education		
Less than high school	193	7.4
High school or GED	1008	38.8
More than high school	1396	53.8
Ethnicity		
Hispanic/Latino	44	1.7
Non-Hispanic/Latino	2575	98.3

a Totals do not sum to the sample size due to missing data.

Almost one third of the participants had LDL and HDL levels in the high-risk categories (Table 2). Approximately 40% of the participants had moderate to high total blood cholesterol and triglyceride levels. Less than 10% of the sample size had nonfasting blood glucose levels >150 mg/dL. Two thirds of the participants were either overweight or obese based on their BMI levels. The mean SBP and DBP levels were 138.39 mm Hg (standard deviation=19.58) and 81.67 mm Hg (standard deviation=10.65), respectively. The prevalence of uncontrolled systolic HTN and diastolic HTN in our population sample was 43.5 and 22.8, respectively.

Table 2. Clinical Characteristics of Respondents[a] in the CITIES Project, NC 2004–2007

Clinical Characteristics	**Total**	
	(N=2663)	**%**
LDL		
Optimum (≤99 mg/dL)	641	30.9
Near optimum/above optimum (100–129 mg/dL)	833	40.1
Borderline high risk (130–159 mg/dL)	434	20.9
High risk (160–189 mg/dL)	129	6.3
Very high risk (≥190 mg/dL)	38	1.8
HDL		
Preventive (≥60 mg/dL)	602	23.0

Normal (40–59 mg/dL)	1244	47.6
High risk (<40 mg/dL)	770	29.4
Total cholesterol		
Normal (≤199 mg/dL)	1649	62.7
Moderate risk (200–239 mg/dL)	741	28.2
High risk (≥240 mg/dL)	240	9.1
Triglyceride		
Optimum (≤149 mg/dL)	1385	52.7
Borderline high risk (150–199 mg/dL)	479	18.2
High risk (≥200 mg/dL)	762	29.0
Blood glucose		
Normal (50–149)	2359	89.9
Moderate risk (150–199 mg/dL)	174	6.6
High risk (≥200 mg/dL)	92	3.5
BMI		
Underweight (≤18.5)	24	0.9
Normal (18.5–24.9999)	436	16.5
Overweight (25–29.9999)	885	33.5
Obese (≥30)	1295	49.1
Systolic BP		
Controlled (normal) (≤140 mm Hg)	1485	56.5
Uncontrolled (≥140 mm Hg)	1141	43.5
Diastolic BP		
Controlled (normal) (≤90 mm Hg)	2022	77.2

Uncontrolled (≥90 mm Hg)	598	22.8
Combined systolic and diastolic BP		
Controlled (normal)	2121	81.5
Uncontrolled	480	18.5

Abbreviations: BMI, body mass index; BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein.
a Totals do not sum to the sample size due to missing data.

A description of self-reported information is presented in Table 3. Less than 15% of the participants reported a personal history while one third reported a family history of CVD. Slightly more than half (52.6%) of the participants reported a lack of exercise in their daily lives, while more than half of the participants reported that they were overweight. Approximately one fifth of the participants reported having diabetes. Less than 10% of the population sample reported nonadherence with their BP-lowering medications, citing forgetfulness, side effects, and high cost as potential reasons for nonadherence.

Table 3. Self-Reported Characteristics of Respondents[a] in the CITIES Project, NC 2004–2007

Self-Reported Characteristics	**Total**	
	(N=2663)	**%**
History of CVD		
No	2281	85.7
Yes	382	14.3
History of atrial fibrillation		
No	2548	95.7
Yes	115	4.3
Family history of CVD		
No	1774	66.6
Yes	889	33.4
Smoking		

No	2256	84.7
Yes	407	15.3
Overweight status		
No	941	35.3
Yes	1722	64.7
Lack of exercise status		
No	1263	47.4
Yes	1400	52.6
High blood cholesterol status		
No	1497	56.2
Yes	1166	43.8
Diabetes status		
No	2102	78.9
Yes	561	21.1
Stress status		
No	2044	76.8
Yes	619	23.2
Noncompliance with BP-lowering medications		
No	2453	92.1
Yes	210	7.9
Due to high costs	29	14.4
Due to side effects	45	22.4
Due to forgetfulness	56	27.9
Due to other reasons	71	35.3

Abbreviations: BP, blood pressure; CVD, cardiovascular disease.

a Totals do not sum to sample size due to missing data.

A significant correlation was observed between age of participants and SBP (.130, *P*<.05) and DBP (−.205, *P*<.05). A multivariate logistic regression using a stepwise forward likelihood ratio indicated that nonadherence to BP-lowering medications (OR, 2.450; *P*=.00), age (OR, 1.666; *P*=.00), race (OR, 1.558; *P*=.00), blood triglyceride levels (OR, 1.490; *P*=.00), and blood glucose levels (OR, 2.107; *P*=.01), were significant predictors of uncontrolled SBP levels (Table 4). Black patients, individuals older than 55 years self-reported to be nonadherent with BP-lowering medications, with high risk levels of blood glucose and a moderate risk for blood triglyceride levels were more likely to have uncontrolled SBP levels compared with the reference groups. A multivariate logistic regression using a stepwise forward likelihood ratio also indicated that age (OR, 0.461; *P*=.00), race (OR, 2.173; *P*=.00), sex (OR, 1.953, *P*=.00), nonadherence with BP-lowering medications (OR, 2.342; *P*=.00), personal history of atrial fibrillation (OR, 0.477; *P*=.03), and smoking (OR, 1.376; *P*=.03) were significant predictors of uncontrolled DBP levels. The final model showed that men, blacks, individuals 55 years or younger, smokers, and those with no personal history of atrial fibrillation were more likely to have uncontrolled DBP levels compared with the reference groups.

Table 4. Logistic Regression: Predictors of Uncontrolled SBP and DBP by Demographic, Self-Reported, and Clinical Characteristics in the CITIES Project, NC 2004–2007

Participant Characteristics	**β**	**SBP Odds Ratio (95% CI)**	***P* Value**
Adherence to BP medications			
Yes (reference)	–	–	–
No	0.896	2.450 (1.738–3454)[a]	.00
Age, y			
18–55 (reference)	–	–	–
>55	0.510	1.666 (1.376–2.017)[a]	.00
Race			
Caucasian (reference)	–	–	–
African Americans	0.443	1.558 (1.272–1.908)[a]	.00
Hispanics/Latinos	0.671	1.957 (0.508–7.541)	.32
Asians/Pacific Islander	0.487	1.627 (0.779–3.396)	.19

Others	0.452	1.572 (0.796–3.105)	.19
Triglycerides			
Normal (reference)	–	–	–
Moderate risk	0.399	1.490 (1.164–1.907)[a]	.00
High risk	0.217	1.242 (0.982–1.571)	.07
Blood glucose			
Normal (reference)	–	–	–
Moderate risk	−0.069	0.933 (0.610–1.427)	.74
High risk	0.745	2.107 (1.171–3.791)[a]	.01
Participant Characteristics	β	DBP Odds Ratio (95% CI)	*P* Value
Age, y			
18–55 (reference)	–	–	–
>55	−0.775	0.461 (0.367–0.579)[a]	.00
Race			
Caucasian (reference)	–	–	–
African Americans	0.776	2.173 (1.708–2.765)[a]	.00
Hispanics/Latinos	0.919	2.507 (0.588–10.682)	.21
Asians/Pacific Islander	1.050	2.857 (1.309–6.233)[a]	.00
Others	0.290	1.337 (0.580–3.082)	.49
Gender			
Female (reference)	–		–
Male	0.669	1.953 (1.543–2.472)[a]	.00
Adherence to BP medications			
Yes (reference)	–		–

No	0.808	2.242 (1.580–3.183)[a]	.00
History of atrial fibrillation			
No (Reference)	–		
Yes	−0.741	0.477 (0.242–0.938)[a]	.03
Smoking status			
Nonsmoker (Reference)	–		
Smoker	0.320	1.376 (1.029–1.842)[a]	.03

Abbreviations: BP, blood pressure; CI, confidence interval; DBP, diastolic blood pressure; SBP, systolic blood pressure.[a] Significant at $P<.05$.

In order to further evaluate, compare, and ascertain differences in the predictors of uncontrolled HTN for all individuals and a subsample of individuals who self-reported to be compliant with their medication recommendations, multivariate logistic regression analyses using a stepwise forward likelihood ratio using this subsample were performed. Age (OR, 1.682; *P*=.00), race (OR, 1.561; *P*=.00), and blood triglyceride levels (OR, 1.519; *P*=.00) were significant predictors of uncontrolled SBP levels (Table 5). African Americans, individuals older than 55 years, and those with high risk levels of blood triglycerides were more likely to have uncontrolled SBP levels compared with the reference groups. With the exception of high-risk blood glucose levels, these 3 predictors were also significantly associated with uncontrolled SBP for all individuals taking antihypertensive individuals. Age (OR, .508; *P*=.00), race (OR, 2.172; *P*=.00), sex (OR, 1.864;*P*=.00), and personal history of atrial fibrillation (OR, 0.374; *P*=.01) were significant predictors of uncontrolled DBP levels. Men, African Americans, individuals younger than 55 years, with no personal history of atrial fibrillation were more likely to have uncontrolled DBP levels compared with the reference groups. With the exception of smoking status, these 3 predictors were also significantly associated with uncontrolled SBP for all individuals taking antihypertensive individuals.

Table 5. Logistic Regression: Predictors of Uncontrolled SBP and DBP by Demographic, Self-Reported, and Clinical Characteristics Among Compliant Participants in the CITIES Project, NC 2004–2007

Participant Characteristics	**β**	**SBP Odds Ratio (95% CI)**	***P* Value**
Age, y			
18–55 (reference)	–	–	–

>55	0.520	1.682 (1.380–2.050)[a]	.00
Race			
Caucasian (reference)	–	–	–
African Americans	0.446	1.561 (1.267–1.924)[a]	.00
Hispanics/Latinos	1.020	2.773 (0.643–1.968)	.17
Asians/Pacific Islander	0.534	1.706 (0.822–3.542)	.15
Others	0.270	1.309 (0.636–2.697)	.46
Blood triglyceride levels			
Normal (reference)	–	–	–
Moderate risk	0.418	1.519 (1.179–1.958)[a]	.00
High risk	0.186	1.205 (0.943–1.539)	.13
Participant Characteristics	β	DBP Odds Ratio (95% CI)	*P* Value
Age, y			
18–55 (reference)	–	–	–
>55	−0.677	0.508 (0.401–0.644)[a]	.00
Race			
Caucasian (reference)	–	–	–
African Americans	0.775	2.172 (1.686–2.797)[a]	.00
Hispanics/Latinos	1.172	3.228 (0.735–14.165)	.12
Asians/Pacific Islander	1.056	2.876 (1.327–6.231)[a]	.00
Others	−0.063	0.939 (0.350–2.516)	.90
Sex			
Female (reference)	–	–	–
Male	0.623	1.864 (1.456–2.385)[a]	.00

History of atrial fibrillation			
No (reference)	–	–	–
Yes	−0.983	0.374 (0.168–0.835)[a]	.01

Abbreviations: CI, confidence interval; DBP, diastolic blood pressure; SBP, systolic blood pressure. [a]Significant at $P<.05$.

Discussion

The mean SBP and DBP levels of our sample fell into the classification for pre-HTN for high BP (JNC 7). The control rates for HTN in our cross-sectional population were slightly higher than the national rates and for those reported in other studies.[3,6,41,42] Among those who had comorbidities associated with HTN, approximately 25% of the population sample self-reported as having diabetes mellitus. In addition, two thirds of our population was either overweight or obese based on their BMI levels. Approximately 40% of the participants also had high blood cholesterol and triglyceride levels. The presence of comorbidities such as diabetes mellitus and high-risk BMI levels further compounds achievement of BP control.[41]

Despite continued efforts to reduce disparities in management and control of HTN, our results indicate that African Americans are at greater risk for both uncontrolled systolic and diastolic HTN. Fongwa and colleagues[43] conducted a qualitative study to evaluate and assess barriers to and facilitators of medication adherence among hypertensive African American women 35 years and older. They conducted 5 focus groups and found that barriers to effective control of high BP were mainly associated with side effects, cost of medications, personal stress, stress from the social system, socioeconomic status, and lack of physical activity among other barriers. The authors also found that facilitators to effective control included, but were not limited to, positive and proactive behavioral and lifestyle changes.

A similar study conducted by Ogedegbe and colleagues[44] found that among hypertensive African American patients in two primary care centers, patient-specific barriers were most commonly reported. These barriers included forgetfulness, beliefs that medications are undesirable and cause impotency, and attitudes such as not taking responsibility for one's health. Other barriers included medication-specific issues, such as side effects and cost; disease-specific issues, such as absence of symptoms vs having symptoms; and logistic-specific issues, such as access to health care and medications. The findings of these studies are consistent with the results of our analyses and other studies conducted among African American populations.[45-48]

Hyman and Pavlik[16] found that individuals who were at least 65 years were associated with the highest relative risk and attributable risk of uncontrolled HTN. Our findings suggest that individuals who are older than 55 years were at the greatest risk for failure to control their SBP levels whereas younger individuals were more likely to experience uncontrolled DBP levels.

Similar findings have been reported in other studies that investigated the role of SBP and DBP levels in coronary heart disease risk change with aging.[20,49] Other studies have also shown that lack of control of SBP as a result of inadequate management are largely responsible for poor overall control of HBP levels in the US population.[2,16,19,50] Growing evidence supports the notion that physicians should focus on controlling elevated SBP particularly in older individuals.[31,51] Studies that have surveyed physicians have shown that three fourths did not initiate appropriate treatment in older individuals with SBP of ≥140 mm Hg. Moreover, most providers did not pursue NHBPEP-stipulated goals of controlling SBP to levels <140 mm Hg.[50,26] JNC 7 reports that most physicians are trained to focus on DBP levels and treat it accordingly, as opposed to SBP levels, which have a more dire effect on individuals affected by HTN after the age of 50 years. Our findings support the recommendation purported by NHBPEP to focus on controlling SBP as a means to effectively manage HTN particularly in older adults. Based on our findings, it is also recommended for practitioners to design interventions and focus on targeting men, African Americans, and younger individuals to control their DBP levels.

Study Strengths and Limitations

The strengths of this study include a large cross-sectional sample size and the availability of clinical and biomedical markers of CVD and stroke risk factors. This study focuses on regional assessment of uncontrolled HTN particularly in the stroke belt state of NC, which has one of the highest stroke mortality rates in the United States. One limitation of this study was that only two readings of clinical measures of BP were collected. This may have led to overestimation of HTN. Individual BP levels vary throughout the day and from day to day; therefore, a more stringent criterion is recommended to diagnose HTN.[52-56] Another limitation of this study was that the researchers did not collect information on the type of BP-lowering medications taken by the population sample. This would have allowed the authors to assess the effects of medications in controlling SBP and/or DBP levels and provide pharmacologic linkage to management of HTN. Less than 10% (n=210) of participants indicated nonadherence to BP-lowering medications. Nonadherence to medications can be defined as not following clinically prescribed recommendations of regularly taking BP-lowering medications. We did not collect information if the participants were taking pills on alternate days or taking half the recommended dosage or were taking medications when he/she perceived symptoms related to high BP. It is quite possible that the number in our sample could have been higher if more accurate information was gathered concerning nonadherence.

Conclusions

During the past several decades, numerous studies have comprehensively evaluated the information regarding predictors of uncontrolled BP levels, such as demographic characteristics, self-reported comorbidities, and clinical correlates of hypertension that are consistent with the findings of this study. Age, race, and medication nonadherence are significant predictors of both isolated uncontrolled SBP and DBP levels. In addition, we found similar results for individuals

who were adherent with BP-lowering medications. This article intends to further support calls for strategies and interventions that focus on factors unique to the elderly and underrepresented populations to better control BP levels and eliminate disparities. Although the efforts of the NHBPEP have shown improvements in awareness, treatment, and control of BP, one third of the US population still has uncontrolled HTN. Black patients are more prone to experience uncontrolled HTN as compared with other racial/ethnic groups. This finding maintains recommendations that future research should tend to the minorities and consider the barriers specific to this group. Several studies have also shown that uncontrolled BP levels are mainly attributable to systolic pressure. JNC 7 has emphasized the need for practitioners and public health professionals to focus on controlling SBP levels among hypertensive populations. Further research and clinical trials may be warranted to support this plan of action. A total of 43% of our sample had uncontrolled systolic HTN. Future drug trials could elucidate the differential effects of BP-lowering medications on controlling isolated SBP or DBP levels. There is also a growing need for healthcare providers to better manage and target systolic HTN to achieve better overall control of HTN particularly in older populations. Finally, public health research and interventions for HTN and other correlated CVD risk factors should be designed to reduce sex and racial disparities.

Acknowledgments

CITIES team at Forsyth Medical Center, Moses Cone Health Systems, and the University of North Carolina at Greensboro.

Source of Funding

Office of Minority Health and the US Department of Health and Human Services.

Conflict of Interest

None.

References

1 Heron MP, Hoyert DL, Murphy SL, et al. Final data for 2006. National Center for Health Statistics. *Natl Vital Stat Rep.* 2009;**57**:1–134.

2 Lloyd-Jones D, Adams R, Carnethon M, et al. Heart disease and stroke statistics—2009 update a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation.* 2009;**119**:480–486.

3 The Centers for Disease Control and Prevention. *Health, United States, 2008, With Special Feature on the Health of Young Adults*.Hyattsville, MD: National Center for Health Statistics; 2009. Available at: http://www.cdc.gov/nchs/hus.htm. Accessed September 1, 2011.

4 Chobanian AV, Bakris GL, Black HR, et al; Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, National Heart, Lung, and Blood Institute, National High Blood Pressure Education Program Coordinating Committee. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure. *Hypertension.* 2003;**42**:1206–1252.

5 National Heart, Lung and Blood Institute. National High Blood Pressure Education Program: Program Description. Available at: http://www.nhlbi.nih.gov/about/nhbpep/nhbp_pd.htm. Accessed September 1, 2011.

6 Gu Q, Burt VL, Dillon CF, Yoon S. Trends in antihypertensive medication use and blood pressure control among united states adults with hypertensionclinical perspective the national health and nutrition examination survey, 2001 to 2010. *Circulation.*2012;**126**:2105–2114.

7 Angell SY, Garg RK, Gwynn RC, et al. Prevalence, awareness, treatment, and predictors of control of hypertension in New York City. *Circ Cardiovasc Qual Outcomes.* 2008;**1**:46–53.

8 Aronow WS, Fleg JL, Pepine CJ, et al. ACCF/AHA 2011 expert consensus document on hypertension in the elderly: a report of the American College of Cardiology Foundation Task Force on Clinical Expert Consensus Documents developed in collaboration with the American Academy of Neurology, American Geriatrics Society, American Society for Preventive Cardiology, American Society of Hypertension, American Society of Nephrology, Association of Black Cardiologists, and European Society of Hypertension. *J Am Coll Cardiol.* 2011;**57**:2037–2114.

9 Franklin SS, Larson MG, Khan SA, et al. Does the relation of blood pressure to coronary heart disease risk change with aging? The Framingham Heart Study. *Circulation.* 2001;**103**:1245–1249.

10 Nasir K, McClelland RL, Blumenthal RS, et al. Coronary artery calcium in relation to initiation and continuation of cardiovascular preventive medications the Multi-Ethnic Study of Atherosclerosis (MESA). *Circ Cardiovasc Qual Outcomes.* 2010;**3**:228–235.

11 Keyhani S, Scobie JV, Hebert PL, McLaughlin MA. Gender disparities in blood pressure control and cardiovascular care in a national sample of ambulatory care visits. *Hypertension.* 2008;**51**:1149–1155.

12 Olomu AB, Gourineni V, Huang JL, et al. Rate and predictors of blood pressure control in a Federal Qualified Health Center in Michigan: a huge concern? *J Clin Hypertens.* 2013;**15**:254–263.

13 Shirani S, Gharipour M, Khosravi A, et al. Gender differences in the prevalence of hypertension in a representative sample of Iranian population: the Isfahan Healthy Heart Program. *Acta Biomed.* 2011;**82**:223.

14 Krousel-Wood MA, Muntner P, Islam T, et al. Barriers to and determinants of medication adherence in hypertension management: perspective of the cohort study of medication adherence among older adults. *Med Clin North Am.* 2009;**93**:753–769.

15 Vawter L, Tong X, Gemilyan M, Yoon PW. Barriers to antihypertensive medication adherence among adults–United States, 2005. *J Clin Hypertens.* 2008;**10**:922–929.

16 Hyman DJ, Pavlik VN. Characteristics of patients with uncontrolled hypertension in the United States. *N Engl J Med.*2001;**345**:479–486.

17 Hyman DJ, Pavlik VN. Poor hypertension control: let's stop blaming the patients. *Cleve Clin J Med.* 2002;**69**:793–799.

18 Izzo JL, Levy D, Black HR. Importance of systolic blood pressure in older americans. *Hypertension.* 2000;**35**:1021–1024.

19 Burt VL, Cutler JA, Higgins M, et al. Trends in the prevalence, awareness, treatment, and control of hypertension in the adult US population: data from the health examination surveys, 1960 to 1991. *Hypertension.* 1995;**26**:60–69.

20 Franklin SS, Gustin W, Wong ND, et al. Hemodynamic patterns of age-related changes in blood pressure. The Framingham Heart Study. *Circulation.* 1997;**96**:308–315.

21 Degoulet P, Menard J, Vu H, et al. Factors predictive of attendance at clinic and blood pressure control in hypertensive patients.*BMJ.* 1983;**287**:88–93.

22 Kotchen TA. The search for strategies to control hypertension. *Circulation.* 2010;**122**:1141–1143.

23 Knight EL, Bohn RL, Wang PS, et al. Predictors of uncontrolled hypertension in ambulatory patients. *Hypertension.*2001;**38**:809–814.

24 Redon J, Erdine S, Boehm M, et al. Investigating the critical situation in hypertension management: is physician inertia putting patients at increased cardiovascular risk? (Share Survey): 4B. 06. *J Hypertens.* 2010;**28**:e210–e211.

25 Redon J, Erdine S, Böhm M, et al. Physician attitudes to blood pressure control: findings from the Supporting Hypertension Awareness and Research Europe-wide survey. *J Hypertens.* 2011;**29**:1633–1640.

26 Berlowitz DR, Ash AS, Hickey EC, et al. Inadequate management of blood pressure in a hypertensive population. *N Engl J Med.*1998;**339**:1957–1963.

27 Persell SD. Prevalence of resistant hypertension in the United States, 2003–2008. *Hypertension.* 2011;**57**:1076–1080.

28 Pimenta E, Calhoun DA. Resistant hypertension incidence, prevalence, and prognosis. *Circulation.* 2012;**125**:1594–1596.

29 Benetos A, Gautier S, Labat C, et al. Mortality and cardiovascular events are best predicted by low central/peripheral pulse pressure amplification but not by high blood pressure levels in elderly nursing home subjects: the PARTAGE (Predictive Values of Blood Pressure and Arterial Stiffness in Institutionalized Very Aged Population) study. *J Am Coll Cardiol.* 2012;**60**:1503–1511.

30 Ogedegbe G. Barriers to optimal hypertension control. *J Clin Hypertens.* 2008;**10**:644–646.

31 Wang TJ, Vasan RS. Epidemiology of uncontrolled hypertension in the United States. *Circulation.* 2005;**112**:1651–1662.

32 Fernandez S, Tobin JN, Cassells A, et al. The counseling African Americans to Control Hypertension (CAATCH) Trial: baseline demographic, clinical, psychosocial, and behavioral characteristics. *Implement Sci.* 2011;**6**:100.

33 Turner BJ, Hollenbeak C, Weiner MG, et al. Barriers to adherence and hypertension control in a racially diverse representative sample of elderly primary care patients. *Pharmacoepidemiol Drug Saf.* 2009;**18**:672–681.

34 Fletcher SW, Deliakis J, Schoch WA, Shapiro SH. Predicting blood pressure control in hypertensive patients: an approach to quality-of-care assessment. *Med Care.* 1979;**17**:285–292.

35 Cushman W, Ford C, Cutler J, et al. ALLHAT Collaborative Research Group: success and predictors of blood pressure control in diverse North American settings: the Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial (ALLHAT). *J Clin Hypertens.* 2002;**4**:393–404.

36 Levine DA, Lewis CE, Williams OD, et al. Geographic and demographic variability in 20-year hypertension incidence the CARDIA study. *Hypertension.* 2011;**57**:39–47.

37 Russell C, Conn V, Jantarakupt P. Older adult medication compliance: integrated review of randomized controlled trials. *Am J Health Behav.* 2006;**30**:636–650.

38 Miller E, Schulz MR, Bibeau DL, et al. Factors associated with misperceptions of weight in the stroke belt. *J Gen Intern Med.*2008;**23**:323–328.

39 Groh MR. *Access 2010 Bible*. Indianapolis, IN: Wiley Publishing Inc; 2010.

40 Norusis M, SPSS Inc. *PASW Statistics 18 Guide to Data Analysis*. Upper Saddle River, NJ: Pearson; 2011.

41 Bersamin A, Stafford RS, Winkleby MA. Predictors of hypertension awareness, treatment, and control among Mexican American women and men. *J Gen Intern Med.* 2009;**24**:521–527.

42 Morgado M, Rolo S, Macedo AF, et al. Predictors of uncontrolled hypertension and antihypertension medication adherence. *J Cardiovasc Dis Res.* 2011;**1**:196–202.

43 Fongwa MN, Evangelista LS, Hays RD, et al. Adherence treatment factors in hypertensive African American women. *Vasc Health Risk Manag.* 2008;**4**:157–166.

44 Ogedegbe G, Harrison M, Robbins L, et al. Barriers and facilitators of medication adherence in hypertensive African Americans: a qualitative study. *Ethn Dis.* 2004;**14**:3–12.

45 Clark LT. Improving compliance and increasing control of hypertension: needs of special hypertensive populations. *Am Heart J.*1991;**12**:664–669.

46 Boutin-Foster C, Ogedegbe G, Ravenell JE, et al. Ascribing meaning to hypertension: a qualitative study among African Americans with uncontrolled hypertension. *Ethn Dis.* 2007;**17**:29–34.

47 Doshi JA, Zuckerman IH, Picot SJ, et al. Antihypertensive use and adherence and blood pressure stress response among black caregivers and noncaregivers. *Appl Nurs Res.* 2003;**16**:266–277.

48 Krousel-Wood M, Hyre A, Muntner P, et al. Methods to improve medication adherence in patients with hypertension: current status and future directions. *Curr Opin Cardiol.* 2005;**20**:296–300.

49 Wong ND, Lopez VA, L'Italien G, et al. Inadequate control of hypertension in US adults with cardiovascular disease comorbidities in 2003–2004. *Arch Intern Med.* 2007;**167**:2431–2436.

50 Hyman D, Pavlik V, Vallbona C. Physician role in lack of awareness and control of hypertension. *J Clin Hypertens.*2000;**2**:324–330.

51 Nash DT. Systolic hypertension – combination therapy as one approach to treating a persistent condition. *Geriatrics.*2006;**61**:22–28.

52 Marshall TP. Blood pressure variability: the challenge of variation. *Am J Hypertens.* 2008;**21**:3–4.

53 Hajjar I, Kotchen JM, Kotchen TA. Hypertension: trends in prevalence, incidence and control. *Annu Rev Public Health.*2006;**27**:465–490.

54 Krum H, Jelinek MV, Stewart S, et al. Guidelines for the prevention, detection and management of people with chronic heart failure in Australia 2006. *Med J Aust.* 2006;**185**:549–556.

55 Taylor A, Pickering S, Grant J, et al. Comparing self-reported and measured high blood pressure and high cholesterol status using data from a large representative cohort study. *Aust N Z J Public Health.* 2010;**34**:394–400.

56 Turner MJ, van Schalkwyk JM. Blood pressure variability causes identification of hypertension in clinical studies: a computer simulation study. *Am J Hypertens.* 2008;**21**:85–91.