Rate and Predictors of Blood Pressure Control in a Federal Qualified Health Center in Michigan: A Huge Concern?

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Hypertension (HTN) is particularly burdensome in low-income groups. Federal-qualified health centers (FQHCs) provide care for low-income and medically underserved populations. To assess the rates and predictors of blood pressure (BP) control in an FQHC in Michigan, a retrospective analysis of all patients with HTN, coronary artery disease, and/or diabetes mellitus (DM) seen between January 2006 and December 2008 was conducted. Of 212 patients identified, 154 had a history of HTN and 122 had DM. BP control was achieved in 38.2% of the entire cohort and in 31.1% of patients with DM. The mean age was lower in patients with controlled BP in both the total population (*P*=.05) and the DM subgroup (*P*=.02). A logistic regression model found only female sex (odds ratio, 2.27; *P*=.02) to be associated with BP control and a trend towards an association of age with uncontrolled BP (odds ratio, 0.97; *P*=.06). BP control in nondiabetics was 47.8% vs 31.1% in diabetic patients (*P*=.02). We found that patients who attended the FQHC had a lower rate of BP control compared with the national average. Our study revealed a male sex disparity and significantly lower rate of BP control among DM patients. *J Clin Hypertens (Greenwich).* 2013;15:254–263. ©2013 Wiley Periodicals, Inc.

Hypertension (HTN) is a leading risk factor for cardiovascular disease morbidity and mortality. It is also one of the major modifiable risk factors.[1,2] Despite commonly available treatments, many hypertensive patients are not being treated optimally and do not attain well-controlled blood pressure (BP) levels.[1–5] Within the past few years, improvement in BP awareness and rates of treatment and control have been highly encouraging.[1,5,6] Nevertheless, with HTN affecting more than 65 million adult Americans,[2,3,5] it is imperative that continued attention be focused to achieve even better BP control.

The most recent National Health and Nutrition Examination Survey (NHANES) showed a promising trend of improved BP control in hypertensive patients of nearly 50% in recent years (2007–2008) when compared with 27.3% nearly 20 years ago (1988–1994).[5] When “Healthy People 2010” was developed a decade ago, achieving a 50% BP control by 2010 was thought to be an arduous yet achievable task by implementing aggressive measures in increasing awareness of HTN, ensuring treatment, and achieving control in treated patients.[5,7,8] The results of the NHANES study in 2010 show that BP goals can be reached with the right measures.[5,6] However, the study also pointed out the stark reality of racial and socioeconomic disparities in BP control.[5,6] Previous studies have also shown increased mortality rates in these vulnerable groups, with HTN-related cardiovascular and cerebrovascular disease being one of the major culprits.[9–14] Most of the above data from NHANES are from a nationally representative general population, and whether these rates are applicable to patients who receive care at safety-net clinics and free clinics is not clear.

Federally qualified health care centers (FQHCs), along with rural health clinics and free clinics, serve patients who live in medically underserved areas, have low income, have high rates of being uninsured or under-insured, live in rural areas, or have other characteristics that make it difficult to access care.[6,15–20] FQHCs provide preventive and primary health care services to these patients who would otherwise have difficulty in securing access to quality care.[16–19] Most of the prior studies of HTN control were done in primary care settings or large in-hospital populations, but very few studies have focused on degree of and factors affecting BP control in FQHCs.[6]

There is a higher prevalence of diabetes among the minority and low-income populations.[21–23] At the same time, prevalence of HTN in adults with diabetes is very high.[3,24,25] In spite of the recognition that persons with diabetes are at higher risk for cardiovascular disease, studies indicate that HTN is poorly controlled in patients with diabetes as compared with patients who do not have diabetes,[3,24,25] and, at the same time, HTN is more prevalent in patients with diabetes than nondiabetic patients.[26] Diabetes is associated with high cardiovascular mortality; however, a study of the

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Framingham cohort has revealed that much of this risk is due to coexisting HTN.[27] Both macrovascular and microvascular complications are increased in diabetics with HTN when compared with patients with diabetes mellitus (DM) who have normal BP.[26] In many patients with diabetes, HTN was the strongest determinant of cardiovascular outcomes.[27] With diabetics forming a significant percentage of the general population, analysis of the predictors of BP control in this group would potentially help improve cardiovascular outcomes and mortality.

While the associations of DM and coronary artery disease (CAD) with HTN are well known, the predictors of BP control are not known, particularly in low-income populations. In order to identify opportunities for interventions to improve secondary prevention, we sought to (1) determine the rate of BP control in an FQHC in Michigan and (2) determine the predictors of BP control in the FQHC.

METHODS

The study was conducted at Ingham County Healthcare Center, an FQHC in mid-Michigan. Ingham County is located in the south central portion of Michigan's Lower Peninsula and includes the capital city of Lansing. These healthcare centers deliver a comprehensive set of primary healthcare and diagnostic/screening services to citizens in mid-Michigan.[28] These services include general primary medical care, as well as preventive services targeted at specific clinical client groups with cancer, diabetes, cardiovascular disease, human immunodeficiency virus/acquired immune deficiency syndrome, and mental health conditions.[28]

All consecutive patients with a history of HTN, CAD, and/or DM seen in an FQHC in Michigan from January 1, 2006, to December 31, 2008, were evaluated for BP control. Uncontrolled HTN was defined as systolic BP (SBP) >140 mm Hg (>130 mm Hg in patients with DM) and diastolic BP (DBP) >90 mm Hg (>80 mm Hg in patients with DM) as per the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) guidelines.[29] We used the last clinic BP measurement to classify patients' BP control. CAD was defined as having an in-patient or out-patient or emergency department diagnosis of CAD manifested by acute myocardial infarction, unstable or stable angina, or history of coronary artery bypass surgery or percutaneous coronary intervention or angioplasty. Also included for CAD was a definitive diagnostic test, eg, cardiac catheterization, echocardiography or scintigraphy showing segmental abnormalities in the left ventricular wall, echocardiography demonstrating significant Q waves, or results of cardiac enzymes indicating acute myocardial injury.

Data Collection

Trained research assistants reviewed the charts of all patients who met the eligibility criteria. The data collected included demographic characteristics as well as medication use in the total cohort. BP recordings on different clinic visits, type of medications used, patient comorbidities, smoking histories, number of clinic and emergency department visits and hospital admissions were also abstracted from the charts. A person was considered a smoker when a patient self-reported "yes" or "current." A person was classified as a nonsmoker when the variable had responses of "no" or "exsmoker" in the last year. Each chart abstractor was supervised by two coinvestigators and used a standard data collection sheet and made reference to a chart abstraction manual concerning specific data fields and parameters. Team meetings were conducted frequently to review and refine chart audit processes and to maintain reliability of data entry. Institutional review board approved the study protocol.

Statistical Analysis

Sample descriptive statistics, including frequencies, percentages, means, and standard deviations, were calculated to summarize the sociodemographic and health status characteristics of the study cohort. Continuous variables were expressed as means and standard deviations (SDs) and categorical variables as percentages. Chi-square tests was used for categoric outcomes and Student *t* test for continuous outcomes using a two-tailed P value <.05 for statistical significance.

To investigate predictors of BP control, logistic regression models were created to obtain adjusted odds ratios (ORs). Both univariate and multivariate models were created. The initial full models with BP control as the outcome variable included the following set of covariates/predictor variables: age, race, sex, type of insurance, body mass index (BMI), smoking status, number of medications used for BP control, and number of clinic and emergency department visits. We created similar logistic regression models for each class (diuretics, angiotensin-converting enzyme [ACE] inhibitors/angiotensin receptor blockers [ARBs], β-blockers [BBs], calcium channel blockers [CCBs]) of BP medication use in both general population and diabetic population within the study group. SAS version 9.2 (SAS Institute, Cary, NC) was used for all statistical analyses.[30]

RESULTS

Patients' Demographic and Clinical Characteristics

A total of 212 patients were included in the study. Patient characteristics are detailed in Table I. Patient mean age was 51.5±12.3 years, 51.9% were men, and 55.2% were white; 74.5% had Medicaid (of which 60.2% had Ingham Health county–funded outpatient plan coverage); 12.7% did not have any insurance. A total of 122 patients (57. 6%) had diabetes, 72.6% had HTN, and 10.9% had CAD in their medical history. Of 159 patients who had smoking history available, 50.9% were smokers. Mean BMI was 33.8±10.6 and nearly 58% had BMI >30. Five percent of the population was

TABLE I. General Demographics

	Total Patients	Available, No.
Mean age, y	51.5 (12.3)	208
Men	51.9%	212
White	55.2%	212
Smokers	50.9%	159
Insurance		
Medicaid (includes 60.2% Ingham Health Plan)	74.5%	212
Medicare	11.3%	212
No insurance	12.7%	212
Homeless	5.2%	212
Cardiology care	13.2%	212
Medical history		
Diabetes mellitus	57.6%	212
Hypertension	72.6%	212
Coronary artery disease	10.9%	212
Hyperlipidemia	44.3%	212
Myocardial infarction	9.0%	212
Angina	25.9%	212
Peripheral vascular disease	5.2%	212
Cerebral vascular accident/stroke	4.7%	212
Congestive heart failure	8.3%	108
Chronic obstructive pulmonary disease	38.3%	120
Risk factors		
Body mass index, mean	33.8 (10.7)	185
Body mass index >30	57.8%	185
Body mass index >35	36.8%	185
Clinic visits, No.	7.2 (4.6)	188
Emergency department visits/hospitalizations, No.	0.7 (1.6)	212
Blood pressure medications, No.	1.7 (1.3)	212
Mean hemoglobin A_{1c} (diabetes mellitus)	8.0 (2.3)	101
Mean low-density lipoprotein	106.1 (32.8)	158
Medications		
β-Blocker	32.1%	212
Angiotensin-converting enzyme inhibitors/angiotensin receptor blocker	58.5%	212
Diuretics	34.4%	212
Calcium channel blocker	17.9%	212
Renin aldosterone inhibitors	3.3%	212
Aspirin	22.2%	212
Statin or other cholesterol medications	42.5%	212

homeless. The average number of clinic visits (over the study period) and number of antihypertensive medication prescribed were 7.2±4.6 and 1.7±1.3, respectively (Table I).

Of 212 patients, 81 (38.2%) had BP controlled (<140/90 mm Hg) and 131 (61.8%) had uncontrolled BP. Mean age of patients in the uncontrolled group was higher than in the controlled group (52.7±13.2 vs 49.5±10.5, *P*=.05). A larger proportion of the patients with controlled BP were women. BP control was seen in 29.1% in men (32 of 110) and 48% in women (49 of 102). The rate of BP control was significantly different across sexes (*P*=.01). The proportion of men in the uncontrolled group was higher than in the controlled group (59.5% vs 39.5%, *P*=.01) (Table II).

In our study, higher proportions of patients with DM were found in the uncontrolled BP group as compared with the controlled group (64.1% vs 46.9%, *P*=.02). The rate of BP control in nondiabetic patients was 47.8% (43 of 90) and the corresponding rate in DM patients was 31.1% (38 of 122). The difference was statistically significant (*P*=.02).

There was also a weak trend towards increased presence of history of cerebrovascular accident (CVA) in the uncontrolled group (6.9% vs 1.2%, *P*=.09). However, there were no differences between the controlled and uncontrolled BP groups with regards to race, BMI, smoking status, insurance type or absence of insurance, and homelessness. The mean hemoglobin A_{1c} level and mean low-density lipoprotein levels were not significantly different between the controlled and uncontrolled BP groups (Table II).

Types of Antihypertensive Medications Used in BP Control

Of the total population, 58.5% were taking ACE inhibitors/ARBs, 32.1% were taking BBs, and 34.4% were taking diuretics. Aspirin and lipid-lowering medications (statins and other cholesterol-reducing agents) were used in 22.2% and 42.5%, respectively (Table I). Analysis of the controlled and uncontrolled groups according to BP medication revealed a higher trend toward using ACE inibitors/ARBs (63.4% vs 50.6%, *P*=.09) in the uncontrolled vs controlled groups. However, there was no difference in the use of diuretics (38.2% vs 28.4%, *P*=.18), CCBs (21.4% vs 12.4%, *P*=.10), or BBs (30.5% vs 34.6%, *P*=.55) in patients with uncontrolled BP vs controlled BP (Table II).

Predictors of BP Control

After univariate analysis, only female sex was associated with a higher rate of BP control (OR, 2.25; *P*=.01) with increasing age showing a trend toward lower BP control (OR, 0.98; *P*=.06) (Table IIIa). After adjusting for all covariates, multivariate analysis also showed that female sex was a significant predictor of BP control when compared with male sex (OR, 2.27; *P*=.02). There was no other statistically significant predictor of BP control in multivariate analysis except for the trend toward lower (poorer) BP control with the increase of age (OR, 0.97; *P*=.06) (Table IIIb). Regression models predicting BP control according to type of antihypertensive medication used did not reveal any statistical significance (Table IIIc).

Predictors of Type of Antihypertensive Medication Use

Similar to earlier models, we examined the predictors of type of medication used (BBs, ACE inhibitors/ARBs,

TABLE II. Demographics According to Blood Pressure Control

	Blood Pressure Controlled	Available, No.	Blood Pressure Uncontrolled	Available, No.	*P* Value
Mean age, y	49.5 (10.5)	79	52.7 (13.2)	129	.05
Men	39.5%	81	59.5%	131	.01
White	56.8%	81	54.2%	131	.78
Smokers	55.6%	63	47.9%	96	.42
Insurance					
Medicaid (includes Ingham Health Plan)	79.0%	81	71.8%	131	.26
Medicare	8.6%	81	13.0%	131	.38
No insurance	9.9%	81	14.5%	131	.40
Homeless	4.9%	81	5.3%	131	1.00
Cardiology Care	8.6%	81	16.0%	131	.15
Medical history					
Diabetes mellitus	46.9%	81	64.1%	131	.02
Hypertension	71.6%	81	73.3%	131	.87
Coronary artery disease	11.1%	81	10.7%	131	1.00
Hyperlipidemia	40.7%	81	46.6%	131	.48
Myocardial infarction	9.9%	81	8.4%	131	.81
Angina	25.9%	81	26.0%	131	1.00
Peripheral vascular disease	3.7%	81	6.1%	131	.54
Cerebral vascular accident/stroke	1.2%	81	6.9%	131	.09
Congestive heart failure	11.8%	34	6.8%	74	.46
Chronic obstructive pulmonary disease	43.6%	39	35.8%	81	.43
Risk factors					
Body mass index, mean	33.1 (9.9)	72	34.2 (11.1)	113	.47
Body mass index >30	54.2%	72	60.2%	113	.45
Body mass index >35	40.3%	72	34.5%	113	.44
No. of clinic visits	7.7 (4.5)	71	6.9 (4.7)	117	.92
No. of emergency department visits/hospitalizations	0.6 (1.6)	81	0.7 (1.6)	131	.52
Blood pressure medications, No.	1.5 (1.3)	81	1.8 (1.3)	131	.09
Mean hemoglobin A_{1c} (diabetes mellitus)	8.3 (2.7)	33	7.9 (2.1)	68	.45
Mean low-density lipoprotein	104.4 (32.1)	59	107.1 (33.3)	99	.62
Medications					
β-Blocker	34.6%	81	30.5%	131	.55
Angiotensin-converting enzyme inhibitors or angiotensin receptor blocker	50.6%	81	63.4%	131	.09
Diuretics	28.4%	81	38.2%	131	.18
Calcium channel blocker	12.4%	81	21.4%	131	.10
Renin aldosterone inhibitors	3.7%	81	3.1%	131	1.00
Aspirin	14.8%	81	26.7%	131	.06
Statin	33.3%	81	38.2%	131	.56

CCBs, and diuretics) for control of HTN adjusting for age, race, sex, insurance, cardiologist care, smoking status, BMI, number of clinic visits, number of emergency department visits and hospitalizations, history of diabetes, and number of other antihypertensive medications used. Significant predictors for BB use in our total population were age (OR, 1.04; *P*=.03), having a Medicare/Medicaid insurance (OR, 9.24; *P*=.01), under a cardiologist's care (OR, 7.05; *P*=.01), history of diabetes (OR, 0.25; *P*<.001), and number of emergency department visits and hospitalizations (OR, 1.49, *P*<.001). Predictors for diuretic use were history of diabetes (OR, 0.43; *P*=.03), and BMI (OR, 1.05; *P*=.01). None of the predictors showed any significance in ACE inhibitor/ARB use except for a slightly higher trend of use in patients who had history of diabetes (OR, 2; *P*=.06) (Table IV).

BP Control and Predictors in the Diabetic Subgroup

Of the total cohort, 122 (57.5%) patients had diabetes and were selected for subgroup analysis. Of the people with diabetes, 38 patients (31.1%) had controlled BP (SBP <130 mm Hg and DBP <80 mm Hg) and 84 patients (68.9%) had uncontrolled BP (Table V). The mean age was 51.0±12.9 years in the diabetic subgroup; however, it was significantly lower in the patients with controlled BP when compared with patients with uncontrolled BP (42.0±10.2 vs 52.8±13.6, *P*=.02). Men constituted 42.1% of DM patients who had controlled BP compared with 58.3%

TABLE III. a. Univariate Logistic Regression Analysis for Factors Predicting Blood Pressure Control

Predictor	Odds Ratio	*P* Value	No. for Each Analysis
Age	**0.98**	**.06**	208
Race (white vs other)	1.11	.71	212
Sex (female vs male)	**2.25**	**.01**	212
Insurance (Medicaid/Medicare vs others)	0.78	.55	212
Smoker (not reported vs yes)	0.64	.38	211
Smoker (no vs yes)	0.74	.79	
Body mass index	0.99	.47	185
No. of clinic visits	1.04	.23	188
Emergency department or hospitalization	0.94	.52	212
No. of medications ($\geq$4 vs <4)	1.03	.95	212

b. Multivariate Logistic Regression Analysis for Factors Predicting Blood Pressure Control (n = 160)

Predictor	Odds Ratio	*P* Value
Age	**0.97**	**.06**
Race (white vs other)	1.18	.65
Sex (female vs male)	**2.27**	**.02**
Insurance (Medicaid/Medicare vs others)	1.22	.68
Smoker (not reported vs yes)	0.49	.29
Smoker (no vs yes)	0.56	.56
Body mass index	0.99	.58
No. of clinic visits	1.04	.29
Emergency department or hospitalization	0.91	.37
No. of medications ($\geq$4 vs <4)	1.01	.99

c. Additional Logistic Regression Analysis for Factors Predicting Blood Pressure Control According to Medication Use (n=212)

Predictor	Odds Ratio	*P* Value
β-Blockers (use vs not use)	1.27	.44
ACE inhibitor or ARB (use vs not use)	0.63	.11
Diuretics (use vs not use)	0.69	.23
CCB (use vs not use)	0.55	.15

Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; CCB calcium channel blocker. Bold values indicate significance or increasing trend towards significance.

in DM patients with uncontrolled BP (*P*=.12) (Table V).

There were no statistically significant differences between the controlled and uncontrolled BP groups among the diabetic population with regards to race, smoking status, BMI, medical history, or types of medication (Table V). Only age (OR, 0.96; *P*=.03) was significantly associated with BP control in the univariate analysis; however, this did not achieve any statistical significance (OR, 0.96; *P*=.07) in the multivariate analyses (Table VI).

Medication Use and Predictors of Type of Antihypertensive Use in Diabetic Patients

Among the diabetic patients, 24.6% were taking BBs, 27.9% taking diuretics, 65.6% taking ACE inhibitors/ARBs, 27.9% taking aspirin, and 37.7% were taking statins (Table V). Age (OR, 1.06; *P*=.02) and emergency department visits and hospitalizations (OR, 1.5; *P*=.04) were significant predictors of BB use in DM patients (Table VII). The use of ACE inhibitors/ARBs in DM patients was associated with having insurance (Medicaid/Medicare) (OR, 0.11; *P*=.02), cardiologist care (OR, 0.19; *P*=.04), and use of other major antihypertensive medications (OR, 2.45; *P*=.03) (Table VII).

DISCUSSION

Our study was performed in a busy FQHC in Michigan and sheds light on the degree of BP control in safety-net clinics and diabetic populations. Although there has been considerable improvement nationally in this regard, our study revealed that BP control remains a problem in FQHCs, which are lagging behind national improvement in the rate of BP control.

BP control was achieved in only 38.2% of the total cohort and in 31.1% of patients with diabetes. This is much lower than the levels found in previous studies performed both in the general population and in primary care clinics.[5,6,14,31–33] Recently, the National Health and

TABLE IV. Multivariate Logistic Regression Analysis for Factors Predicting Use of Each Type of Antihypertensive Medication in the Total Population

All Patients	β-Blockers (n=160)		ACE Inhibitor or ARB (n=160)		Diuretics (n=160)		CCB (n=160)	
Predictor	OR	*P* Value	OR	*P* Value	OR	*P* Value	OR	*P* Value
Age	**1.04**	**.03**	1.02	.28	1.02	.28	**1.08**	**.00**
Race (white vs other)	1.19	.68	1.66	.16	1.33	.46	1.22	.69
Sex (female vs male)	0.50	.11	0.84	.63	1.46	.32	**0.32**	**.03**
Insurance (Medicaid/ Medicare vs others)	**9.24**	**.01**	0.93	.89	0.68	.47	1.76	.48
Cardiologist (yes vs no)	**7.05**	**.01**	0.40	.10	0.29	.09	0.63	.52
Smoker (not reported vs yes)	0.45	.11	0.94	.58	1.52	.72	1.80	.28
Smoker (no vs yes)	1.05	.32	1.36	.37	1.71	.41	1.00	.58
Body mass index	1.01	.76	1.03	.10	**1.05**	**.01**	1.03	.18
No. of clinic visits	1.01	.85	1.00	.93	1.04	.33	1.07	.22
Emergency department or hospitalization	**1.49**	**.00**	1.24	.10	1.05	.69	**1.37**	**.01**
History of diabetics	**0.25**	**.00**	**2.00**	**.06**	**0.43**	**.03**	1.36	.55
Other major medications in use	0.76	.32	1.18	.51	1.16	.57	0.96	.89

Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; CCB, calcium channel blocker; OR, odds ratio. Bold values indicate significance or increasing trend towards significance.

Nutrition Examination Survey (NHANES) study has shown that BP control is 50.1% in a nationally representative general population, which indicated progress toward the "Healthy People 2010" national objective of controlling BP in 50% of all individuals with HTN.[1,5] In a large study involving 4 FQHCs affiliated with Open Door Family Medical Centers (Open Door) located in New York, Shelley and colleagues[6] showed BP control of 49% among hypertensive patients. Our low rates are thus a considerable problem.

Some well-documented barriers to HTN control include patients' unawareness of HTN and poor adherence and access to medical care.[1,2,4–7] Our earlier studies in an FQHC revealed that educational sessions highlighting cardiovascular disease and its burden helped to improve patient knowledge and understanding about prevention and adherence to the medications.[34] Many studies have shown that BP control is influenced by multiple factors, of which sex, race, age, socioeconomic status, and patient education are major predictors.[3,4,6,7,9–13,35–39]

When comparing controlled and uncontrolled BP groups in our study population, a larger proportion of patients with controlled BP were women. BP control was achieved in 29.1% of men compared with 48% of women (*P*=.01). Past studies of the association between sex and BP control have had varied results, with some studies showing male sex as a predictor of poor BP control[6,31,36,40] and some showing opposite results.[33,37,41] Looking at past NHANES population studies, male sex was found to be associated with uncontrolled BP (NHANES III 1988–1994)[36]; however, with significant increases in treatment and control in men in later NHANES (1999–2000), a sex difference did not play a significant role in BP control.[38,42] In a large sex-based study of cardiovascular risk factors and BP control using NHANES 1999–2004, Ong and colleagues[38] showed that BP control rates were not significantly lower in women; however women tend to have more cardiovascular risk factors such as central obesity and total cholesterol.[38] A recent NHANES study examining BP trends showed that awareness and treatment of HTN was higher in women when compared with men, but the proportion of patients treated and controlled was low in women.[5] Some of the sex differences in HTN vary according to age and menopausal status in women and were attributed to sex hormones, which are thought to play a role in BP regulation.[38,43] Women were also found to have higher mean SBP but lower mean DBP than men.[38] Nevertheless, awareness needs to be increased and steps toward control should be undertaken irrespective of sex disparities.

Increasing age showed a trend toward lower BP control (OR, 0.98; *P*=.06) in our study. Elderly patients are at a higher risk for cardiovascular disease and attention should be given to BP control in this group. In the recent NHANES study, although awareness and treatment was high in elderly patients, control of BP in treated patients was significantly lower when compared with younger age groups.[5] Similar findings were documented by several previous studies, which showed that elderly patients had lower rates of BP control.[24,33,36–38]

In our study, the proportion of patients with diabetes was significantly higher in the uncontrolled group compared with the controlled group (64.1% vs 46.9%, *P*=.02). The rate of BP control in nondiabetic patients was nearly 48% compared with 31% in

TABLE V. Demographics of DM Patients According to BP Control (n=122)

	DM	Available, No.	BP Controlled	Available, No.	BP Uncontrolled	Available, No.	*P* Value
Mean age, y	51.0 (12.9)	120	42.0 (10.3)	37	52.8 (13.6)	83	**.02**
Men	53.3%	122	42.1%	38	58.3%	84	.12
White	52.5%	122	52.6%	38	52.4%	84	1.00
Smokers	46.4%	122	53.3%	30	43.3%	67	.39
Insurance							
Medicaid (includes Ingham Health Plan)	73.0%	122	79.0%	38	70.2%	84	.38
Medicare	13.9%	122	10.5%	38	15.5%	84	.58
No insurance	13.1%	122	10.5%	38	14.3%	84	.77
Homeless	6.6%	122	7.9%	38	6.0%	84	.70
Cardiology care	13.9%	122	7.9%	38	16.7%	84	.26
Medical history							
Coronary artery disease	6.6.%	122	5.3%	38	7.1%	84	1.00
Hyperlipidemia	49.2%	122	52.6%	38	47.6%	84	.70
Myocardial infarction	4.9%	122	2.6%	38	6.0%	84	.66
Angina	22.1%	122	21.1%	38	22.6%	84	1.00
Peripheral vascular disease	5.7%	122	5.3%	38	6.0%	84	1.00
Cerebral vascular accident/stroke	7.4%	122	2.6%	38	9.5%	84	.27
Congestive heart failure	3.4%	59	6.7%	15	2.3%	44	.45
Chronic obstructive pulmonary disease	40.6%	64	47.1%	17	38.3%	47	.57
Risk factors							
Body mass index, mean	34.4 (11.3)	106	33.2 (11.5)	34	34.9 (11.2)	72	.47
Body mass index >30	61.3%	106	50.0%	34	65.3%	72	.14
Body mass index >35	38.7%	106	38.2%	34	37.5%	72	1.00
No. of clinic visits	6.8 (4.2)	115	7.1 (4.3)	37	6.7 (4.2)	78	.64
Emergency department visit/hospitalization	0.6 (1.4)	122	0.4 (1.4)	38	0.7 (1.4)	84	.25
BP medications	1.6 (1.3)	122	1.3 (1.2)	38	1.7 (1.4)	84	.09
Mean hemoglobin A_{1c} (DM)	8.0 (2.3)	101	8.3 (2.7)	33	7.9 (2.1)	68	.45
Mean low-density lipoprotein	106.4 (35.5)	98	101.2 (40.1)	32	109.0 (33.1)	66	.31
Medications							
β-Blocker	24.6%	122	23.7%	38	25.0%	84	1.00
ACE inhibitors or angiotensin receptor blocker	65.6%	122	57.9%	38	69.1%	84	.30
Diuretics	27.9%	122	26.3%	38	28.6%	84	.83
Calcium channel blocker	18.0%	122	7.9%	38	22.6%	84	.07
Renin aldosterone inhibitors	3.3%	122	2.6%	38	3.6%	84	1.00
Aspirin	27.9%	122	18.4%	38	32.1%	84	.13
Statin	37.7%	122	39.5%	38	36.9%	84	.84

Abbreviations: ACE, angiotensin-converting enzyme; BP, blood pressure; DM, diabetes mellitus. Bold values indicate significance or increasing trend towards significance.

patients with DM (*P*=.02). This is consistent with findings from previous studies that showed a lack of tight control[25] and higher predilection for uncontrolled BP in diabetic patients.[1,6,33,35,37,41] One large study done in general medicine clinics has shown that diabetic patients with an annual visit to the subspecialist physicians were more likely to have BP control, emphasizing the importance of coordinated care for DM patients with HTN.[24]

Race was not a predictor of BP control in our study group. Previous studies have shown that BP control was achieved less often in African American patients when compared with white patients.[33,44] Numerous studies have shown that racial differences play a significant role in BP control[3,5,6,37]; however, some studies argue that the impact of race is quite complex and interacts with other factors such as access to care and socioeconomic status.[32,35] Our study was comprised of a minority population, with whites constituting 55% of our total population and nonwhites 45%, with both races having equal access and similar health plan insurance. However, the recent NHANES survey emphasizes the race disparities and their significance in BP control and highly encourages improvement of awareness in a minority population.[1,2,5]

More than 58% of our total study population was obese and there was a high incidence of smoking. Although none of these variables played a role in predicting BP control, this is still a critical concern. Obesity and smoking have been documented as risk factors for HTN and cardiovascular diseases,[45,46] and healthy lifestyle and diet recommendations are simple

TABLE VI. a. Univariate Logistic Regression Analysis for Factors Predicting Blood Pressure Control in Patients With DM (n=122)

Predictor	Odds Ratio	*P* Value	No. for Each Analysis
Age	**0.96**	**.03**	120
Race (white vs other)	1.01	.98	122
Sex (female vs male)	1.93	.10	122
Insurance (Medicaid/Medicare vs others)	1.42	.57	122
Smoker (not reported vs yes)	0.85	.93	122
Smoker (no vs yes)	0.67	.43	122
Body mass index	0.99	.46	106
No. of clinic visits	1.02	.67	115
Emergency department or hospitalization	0.82	.26	122
No. of medications ($\geq$4 vs <4)	0.23	.17	122
Hemoglobin A_{1c}	1.07	.45	101

b. Multivariate Logistic Regression Analysis for Factors Predicting Blood Pressure Control in Patients With DM (n=83)

Predictor	Odds Ratio	*P* Value
Age	0.96	.07
Race (white vs other)	1.09	.87
Sex (female vs male)	1.12	.83
Insurance (Medicaid/Medicare vs others)	2.24	.33
Smoker (not reported vs yes)	0.74	.87
Smoker (no vs yes)	0.45	.26
Body mass index	0.98	.55
No. of clinic visits	1.01	.83
Emergency department or hospitalization	0.91	.59
No. of medications ($\geq$4 vs <4)	0.49	.55
Hemoglobin A_{1c}	1.15	.21

c. Additional Logistic Regression Analysis for Factors Predicting Blood Pressure Control in Patients With DM According to Medication Use (n=122)

Predictor	Odds Ratio	*P*
β-Blockers (use vs not use)	1.06	.91
ACE inhibitor or ARB (use vs not use)	0.65	.31
Diuretics (use vs not use)	1.13	.80
CCB (use vs not use)	0.30	.07

Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; CCB, calcium channel blocker; DM, diabetes mellitus. Bold values indicate significance or increasing trend towards significance.

ways to improve BP control in safety-net clinics and in the general population.

Self-pay or free care was associated with decreased BP control in a large study performed on HTN-related clinic visits to community health centers and community practices.[37] Studies on inner city populations have also shown similar influence of socioeconomic status on BP control.[39] In contrast, having optimal medical insurance has not been shown to improve BP control. A recent NHANES study (2005–2008) showed that uncontrolled HTN was more prevalent in patients with no access to medical care and insurance.[2] In that study, however, nearly 86% of the study patients with uncontrolled HTN had some sort of medical insurance, either public or private.[2] Our study did not show any influence of insurance on BP control; however, an insurance variable was studied as having a "Medicaid/Medicare" vs others, which might have masked some of the effect. The Affordable Health Care Act (ACA) will help to increase insurance coverage, improve access to preventive and quality care,[2] and reduce out-of-pocket costs for prescription drugs.[1,2] Whether this will improve HTN control remains to be seen.

ACE inhibitors were shown to reduce risk of major cardiovascular outcomes in a broad range of high-risk DM patients and were also found to lower risk of diabetic nephropathy.[47] In addition, they were also shown to be beneficial in patients with DM even without any cardiovascular disease.[48] Our study showed that nearly 59% of the total population were taking ACE inhibitors/ARBs and only 34% were taking diuretics. The higher use of ACE inhibitors/ARBs could be the result of the higher number of diabetics in our study (ACE inhibitor/ARB use was nearly 65% in diabetic population). However, none

TABLE VII. Multivariate Logistic Regression Analysis for Factors Predicting Use of Each Antihypertensive Medication in Patients With Diabetes Mellitus

Diabetics Only	β-Blockers (n=97)		ACE Inhibitor or ARB (n=97)		Diuretics (n=97)		CCB (n=97)	
Predictor	OR	*P* Value	OR	*P* Value	OR	*P* Value	OR	*P* Value
Age	**1.06**	**.02**	1.01	.54	1.02	.43	**1.11**	**.00**
Race (white vs other)	0.85	.78	2.69	.06	2.23	.15	0.60	.44
Sex (female vs male)	0.65	.46	0.59	.33	**4.99**	**.01**	0.34	.10
Insurance (Medicaid/Medicare vs other)	NA[a]	NA[a]	**0.11**	**.02**	2.45	.37	1.94	.56
Cardiologist (yes vs no)	**3.79**	**.07**	**0.19**	**.04**	0.18	.09	0.82	.81
Smoker (not reported vs yes)	0.48	.55	1.37	.73	1.19	.74	1.82	.23
Smoker (no vs yes)	0.53	.67	2.84	.12	2.11	.23	0.61	.25
Body mass index	1.02	.62	**1.08**	**.02**	1.02	.41	1.06	.07
No. of clinic visits	0.95	.40	0.98	.75	1.07	.24	1.06	.43
Emergency department and hospitalization	**1.50**	**.04**	1.53	.08	1.01	.97	1.27	.22
Other major medications in use	0.80	.54	**2.45**	**.03**	**2.21**	**.05**	1.19	.68

Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; CCB, calcium channel blocker; NA, not applicable; OR, odds ratio.

[a]Model could not converge with insurance as a predictor/insurance was not a significant univariate predictor. Bold values indicate significance or increasing trend towards significance.

of the studied predictors were associated with use of ACE inhibitors/ARBs in our population, except for a slightly higher trend of their use as expected in patients who had history of diabetes (OR, 2; *P*=.06). In a separate analysis of patients with DM, use of other antihypertensive medications (BBs, CCBs, diuretics) has been shown to be an influencing factor on the use of ACE inhibitors/ARBs (OR, 2.45; *P*=.03). This is in accordance with previous studies that showed that people taking ACE inhibitors have significantly higher use of other cardiovascular and antihypertensive medications both in primary and secondary prevention.[48,49] BB use in our study was strongly influenced by having Medicaid/Medicare insurance and being under a cardiologist's care. This is consistent with findings from a previous study performed in diverse cardiology practice, where the most commonly prescribed antihypertensive medication was a BB.[32]

When Healthy People 2010 was formulated, many experts suggested that aggressive BP control can only be achieved by increasing patient awareness and improving adherence to treatment of aware patients.[5,7] In a large study performed in a cardiology practice,[32] patients' knowledge had a direct role in BP control. This demonstrates that strategies to improve patient knowledge and awareness can result in better realization of BP control targets.

The lower levels of BP control in our population could be secondary to the clinic's serving a high rate of minority patients, those with low socioeconomic status and higher incidence of diabetes, and smokers and obese patients, which are poor predictors of BP control. One of the objectives of the Million Hearts initiative, which aims at preventing 1 million heart attacks and strokes in a 5-year period, was consistent use of antihypertensive medications and increasing public awareness about lifestyle modification and improving access to care.[1] Major challenges remain in improving BP control, especially in vulnerable patients at highest risk in federally qualified health centers.

Limitations

Several limitations exist in our study. Race was coded in mutually exclusive categories. More recent guidelines recognize that individuals may consider themselves part of multiple races and differentiate race from ethnicity. The category of nonwhites was not further differentiated. This fails to adequately portray full race/ethnicity delineation. However, the majority (81%) of nonwhites were black patients and race was not a predictor of BP control in our study. We used the last clinic BP measurement to classify patients' BP control and this potentially may misclassify some proportion of patients. We had small numbers of patients with CAD in our study population; however, it is to be noted that most of the patients attending this safety-net clinic had minimal or no insurance and many had limited access to specialty care, limiting our CAD group. Finally, our study was conducted at an FQHC in Michigan and our results may not be generalizable to other communities.

CONCLUSIONS

Our study revealed that patients who attend the study FQHC have significantly lower rates of BP control compared with the national average. Furthermore, we found a male sex disparity and significantly lower BP control, especially among diabetic patients. Our findings underscore the need to improve BP control in FQHCs.

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References

1. Yoon PW, Gillespie CD, George MG, Wall HK. Control of hypertension among adults - national health and nutrition examination survey, United States, 2005-2008. *MMWR Morb Mortal Wkly Rep*. 2012;61:19–25.
2. Centers for Disease Control (CDC). Vital signs: prevalence, treatment, and control of hypertension – United States, 1999–2002 and 2005–2008. *MMWR Morb Mortal Wkly Rep*. 2011;60:103–108.
3. Wang JT, Vasan RS. Epidemiology of uncontrolled hypertension in the United States. *Circulation*. 2005;112:1651–1662.
4. Lloyd-Jones DM, Evans JC, Larson MG, et al. Differential control of systolic and diastolic blood pressure: factors associated with lack of blood pressure control in the community. *Hypertension*. 2000;36: 594–599.
5. Egan BM, Zhao Y, Axon RN. US trends in prevalence, awareness, treatment, and control of hypertension, 1988-2008. *JAMA*. 2010; 303:2043–2050.
6. Shelley D, Tseng TY, Andrews H, et al. Predictors of blood pressure control among hypertensive in community health centers. *Am J Hypertens*. 2011;24:1318–1323.
7. Egan BM, Basile JN. Controlling blood pressure in 50% of all hypertensive patients. *J Investig Med*. 2003;51:373–385.
8. US Department of Health and Human Services. *Healthy People 2010. Understanding and Improving Health*, 2nd ed. Washington, DC: US Government Printing Office; November 2000.
9. Mensah GA, Mokdad AH, Ford ES, et al. State of disparities in cardiovascular health in the United States. *Circulation*. 2005;111:1233–1241.
10. Wei M, Mitchell BD, Haffner SM, Stern MP. Effects of cigarette smoking, diabetes, high cholesterol, and hypertension on all-cause mortality and cardiovascular disease mortality in Mexican Americans. The San Antonio Heart Study. *Am J Epidemiol*. 1996;144:1058–1065.
11. Fiscella K, Holt K. Racial disparity in hypertension control: tallying the death toll. *Ann Fam Med*. 2008;6:497–502.
12. Thomas AJ, Eberly LE, Smith GD, et al. Race/ethnicity, income, major risk factors, and cardiovascular disease mortality. *Am J Public Health*. 2005;95:1417–1423.
13. Roger VL, Go AS, Lloyd-Jones DM, et al. Heart disease and stroke statistics – 2012 update: a report from the American Heart Association. *Circulation*. 2012;125:e2–e220.
14. Wong MD, Shapiro MF, Boscardin WJ, Ettner SL. Contribution of major diseases to disparities in mortality. *N Engl J Med*. 2002;347:1585–1592.
15. Darnell JS. Free clinics in the United States: a nationwide survey. *Arch Intern Med*. 2010;170:946–953.
16. US Department of Health and Human Services, Health Resources and Services Administration, Bureau of Primary Health Care. *Health Centers: America's Primary Care Safety Net, Reflections on Success, 2002–2007*. Rockville, MD; June 2008.
17. *Quality Incentives for Federally Qualified Health Centers, Rural Health Clinics and Free Clinics: A Report to Congress*. Washington, DC: Department of Health Policy School of Public Health and Health Service; 2012.
18. Dievler A, Giovannini T. Community health centers: promise and performance. *Med Care Res Rev*. 1998;55:405–431.
19. Politzer RM, Yoon J, Shi L, et al. Inequality in America: the contribution of health centers in reducing and eliminating disparities in access to care. *Med Care Res Rev*. 2001;58:234–248.
20. Gale J, Coburn A. *The Characteristics and Roles of Rural Health Clinics in the United States: A Chartbook*. Portland, ME: University of Southern Maine, Muskie School of Public Service, Maine Rural Health Research Center; 2003.
21. Centers for Disease Control and Prevention. *National Diabetes Fact Sheet: National Estimates and General Information on Diabetes and Prediabetes in the United States, 2011*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention; 2011.
22. Rabi DM, Edwards AL, Southern DA, et al. Association of socio-economic status with diabetes prevalence and utilization of diabetes care services. *BMC Health Serv Res*. 2006;6:124–130.
23. Agardh E, Allebeck P, Hallqvist J, et al. Type 2 diabetes incidence and socio-economic position: a systematic review and meta-analysis. *Int J Epidemiol*. 2011;40:804–818.
24. Duggirala MK, Cuddihy RM, Cuddihy MT, et al. Predictors of blood pressure control in patients with diabetes and hypertension seen in primary care clinics. *Am J Hypertens*. 2005;18:833–838.
25. Borzecki AM, Wong AT, Hickey EC, et al. Hypertension control: how well are we doing? *Arch Intern Med*. 2003;163:2705–2711.
26. Ferrannini E, Cushman WC. Diabetes and hypertension: the bad companions. *Lancet*. 2012;380:601–610.
27. Chen G, McAlister FA, Walker RL, et al. Cardiovascular outcomes in Framingham participants with diabetes: the importance of blood pressure. *Hypertension*. 2011;57:891–897.
28. *2010 Annual Report: Ingham County Health Department*. http://hd.ingham.org/Portals/HD/Home/Documents/Publications/2010%20Annual%20Report%20Web%20Version.pdf. Accessed July 18, 2012.
29. Chobanian AV, Bakris GL, Black HR, et al. The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC-7 report. *JAMA*. 2003;289:2560–2572.
30. SAS Institute Inc. *Base SAS 9.2 Procedures Guide*. Cary, NC; 2009.
31. Ornstein SM, Nietert PJ, Dickerson LM. Hypertension management and control in primary care: a study of 20 practices in 14 states. *Pharmacotherapy*. 2004;24:500–507.
32. DeVore AD, Sorrentino M, Arnsdorf MF, et al. Predictors of hypertension control in a diverse general cardiology practice. *J Clin Hypertens (Greenwich)*. Aug 2010;12:570–577.
33. Cushman WC, Ford CE, Cutler JA, et al. 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.
34. Olomu A, Gourineni V, Pandya N, et al. Office-Guidelines Applied in Practice (Office-GAP) Program in a federally qualified health center increased patient knowledge and medication use. *Circulation*. 2011;124:A12338.
35. Hicks L, Shaykevich S, Bates D, Ayanian J. Determinants of racial/ethnic differences in blood pressure management among hypertensive patients. *BMC Cardiovasc Disord*. 2005;5:16.
36. Hyman DJ, Pavlik VN. Characteristics of patients with uncontrolled hypertension in the United States. *N Engl J Med*. 2001;345:479–486.
37. Hicks LS, Fairchild DG, Horng MS, et al. Determinants of JNC VI guideline adherence, intensity of drug therapy,and blood pressure control by race and ethnicity. *Hypertension*. 2004;44:429–434.
38. Ong KL, Tso AW, Lam KS, Cheung BM. Gender difference in blood pressure control and cardiovascular risk factors in Americans with diagnosed hypertension. *Hypertension*. 2008;51:1142–1148.
39. Ahluwalia JS, McNagny SE, Rask KJ. Correlates of controlled hypertension in indigent, inner-city hypertensive patients. *J Gen Intern Med*. 1997;12:7–14.
40. Stockwell DH, Madhavan S, Cohen H, et al. The determinants of hypertension awareness, treatment, and control in an insured population. *Am J Public Health*. 1994;84:1768–1774.
41. Majernick TG, Zacker C, Madden NA, et al. Correlates of hypertension control in a primary care setting. *Am J Hypertens*. 2004;17:915–920.
42. Hajjar I, Kotchen TA. Trends in prevalence, awareness, treatment, and control of hypertension in the United States, 1988–2000. *JAMA*. 2003;290:199–206.
43. Reckelhoff JF. Gender differences in the regulation of blood pressure. *Hypertension*. 2001;37:1199–1208.
44. Bosworth HB, Dudley T, Olsen MK, et al. Racial differences in blood pressure control: potential explanatory factors. *Am J Med*. 2006;119:70.e9–70.e15.
45. Poirier P, Giles TD, Bray GA, et al. Obesity and cardiovascular disease: pathophysiology, evaluation, and effect of weight loss: an update of the 1997 American Heart Association Scientific Statement on Obesity and heart disease from the Obesity Committee of the Council on Nutrition, Physical activity, and Metabolism. *Circulation*. 2006;113:898–918.
46. Halperin RO, Gaziano JM, Sesso HD. Smoking and the risk of incident hypertension in middle-aged and older men. *Am J Hypertens*. 2008;21:148–152.
47. Effects of ramipril on cardiovascular and microvascular outcomes in people with diabetes mellitus: results of the HOPE study and MICRO-HOPE substudy. Heart Outcomes Prevention Evaluation Study Investigators. *Lancet*. 2000;355:253–259.
48. Eurich DT, Majumdar SR, Tsuyuki RT, Johnson JA. Reduced mortality associated with the use of ACE inhibitors in patients with type 2 diabetes. *Diabetes Care*. 2004;27:1330–1334.
49. Barron HV, Michaels AD, Maynard C, et al. Use of antiotensin-converting enzyme inhibitors at discharge in patients with acute myocardial infarction in the United States: data from the National Registry of Myocardial Infarction 2. *J Am Coll Cardiol*. 1998;32:360–367.