Hypertension Control and Its Correlates Among Adults Attending a Hypertension Clinic in Tanzania

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Hypertension control rates are low in sub-Saharan Africa. Population-specific determinants of blood pressure (BP) control have not been adequately described. The authors measured BP and conducted interviews to determine factors associated with BP control among adults attending a hypertension clinic in Tanzania. Three hundred adults were enrolled. BP was controlled in 47.7% of patients at the study visit but only 28.3% over three consecutive visits. Demographic and socioeconomic factors were not associated with control. Obesity and higher medication cost were associated with decreased control. Their effect was mediated through adherence. Good knowledge of (odds ratio [OR], 2.5; 95% confidence interval [CI], 1.0–6.1; P=.047), attitudes towards (OR, 2.7; 95% CI, 1.0–7.1; P=.04), and practices concerning (OR, 5.4; 95% CI, 2.3–13.0; P<.001) hypertension were independently associated with increased control, even after adjusting for mediation through adherence. Good adherence had the strongest association with control (OR, 14.6; 95% CI, 5.8–37.0; P<.001). Strategies to reduce hypertension-related morbidity and mortality in sub-Saharan Africa should target these factors. Interventional studies of such strategies are needed. *J Clin Hypertens (Greenwich).* 2016;18:207–216.

The prevalence of hypertension (HTN) has rapidly risen in sub-Saharan Africa (SSA), likely related to the effects of urbanization on lifestyle and diet. The estimated prevalence of HTN among adults in SSA quadrupled from 2005 to 2008 and is projected to affect 125.5 million African adults by 2025.[1] The World Health Organization estimates that the age-adjusted prevalence of HTN in SSA is now the highest of any region in the world.[2] In our own region of Tanzania, HTN-related diseases are the second most common cause of hospital admission and mortality.[3]

Meanwhile, HTN control rates in SSA are low.[4] Studies of HTN control in Africa have found that urban and rural Tanzanians have some of the lowest rates of control, ranging between 5% and 15% for all patients who started treatment.[4–6] In one community-based study in Tanzania, only two of six adults with HTN were aware of their diagnosis, one of six of those diagnosed were on treatment, and only one of six who were being treated were adequately controlled.[5]

Despite the high prevalence of HTN in Africa and the low rates of control, factors associated with HTN control in patients receiving treatment have not been described. These factors may differ from those in developed nations. Therefore, we conducted a cross-sectional study to investigate factors associated with both blood pressure (BP) control at a single clinic visit and BP control over three consecutive clinic visits. We included demographic and socioeconomic correlates as well as knowledge, attitudes, practices, and adherence in order to determine the best potential targets for interventions to improve BP control in this population.

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METHODS

Study Location and Population

This cross-sectional study was conducted at the HTN clinic at Bugando Medical Centre (BMC), a regional hospital in Mwanza that serves the Lake Zone of northwestern Tanzania. In this study, we consecutively screened all adults attending the HTN clinic during the study period. Participants were 18 years and older, previously diagnosed with HTN, had attended at least two prior clinic encounters, and had been prescribed antihypertensive medications. Individuals were excluded from the study if they had cognitive impairment that made it impossible to conduct a reliable and private interview.

Study Procedures

After explaining the purpose of the study, written informed consent was obtained from patients who agreed to participate. A 15- to 20-minute face-to-face interview was conducted in Swahili using a pretested, structured questionnaire of mostly close-ended questions designed to assess knowledge, attitudes, practices, and financial impact related to HTN. The questionnaire

was written in English and translated to Swahili by the principal investigator. To ensure translation accuracy, the Swahili version was translated back to English by a professional translator. A trained interviewer administered the questionnaire using a standard script of common words and phrases that could easily be understood by all study participants.

Demographic factors of age, sex, educational background, marital status, occupational status, urban or rural residence, and self-reported duration of HTN were recorded. Medication adherence was assessed using the four-point Morisky Medication-Taking Adherence Scale (MMAS-4), as is frequently used in studies of HTN.[7,8] The MMAS-4 questions are listed in Table S1. Questions were also asked to assess knowledge, attitudes, and practices related to HTN, as described below.

For study participants who reported never taking their medications as prescribed, the reason for nonadherence was recorded. The financial impact of HTN was assessed by recording the number of antihypertensive medications per participant, monthly cost for these medications, and medication payment method. Cost could not be ascertained for study participants with health insurance or whose employers paid for medications.

BPs were obtained in two ways. During the study visit, BP was measured manually after at least 5 minutes of sitting using a mercury sphygmomanometer according to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) guidelines.[9] BP was measured three times (before, during, and after the interview). An average of the last two readings was recorded as the BP. BPs from the last two prior visits were obtained through chart review. The interval between each prior clinic visit was 1 to 2 months. Patients with systolic BPs <140 mm Hg and diastolic BP <90 mm Hg were considered controlled. BPs were further staged according to JNC 7 guidelines.[9] Weight and height were measured and used to calculate body mass index (BMI).

Scoring of HTN Knowledge, Attitudes, and Practices

The questions asked concerning knowledge, attitudes, and practices related to HTN among study participants are listed in Table S1.

Participants' knowledge of HTN was assessed with eight questions. Seven questions asked participants to identify risk factors and interpret a BP value using multiple choice format. Each correct answer was given one point. Zero points were given if the participant did not know the answer or answered incorrectly. The eighth question was open-ended and asked participants to name three complications of HTN. Each correct complication named was given one point. Knowledge was scored from zero to 10 points with higher scores indicating better knowledge. Participants were categorized as having good (≥8 points), moderate (5–7 points), or poor (<5 points) knowledge.

Participants' attitudes regarding HTN were assessed by asking whether they agreed, did not know, or disagreed with eight statements. For positive attitude statements such as "You are ready to change your eating habits when you are advised," two points were given if they answered "agree," one for "don't know," and zero for "disagree." For the one negative attitude statement "alternative (traditional) medicines treat high BP," zero points were allotted if they answered "agree," one for "don't know," and two for "disagree." Attitudes were scored from zero to 16 points with higher scores indicating a more positive attitude. Participants were categorized as having good (16 points), moderate (14–15 points), or poor (<14 points) attitudes.

Participants' practices were assessed by asking the degree to which they engaged in eight positive or negative behaviors. For behaviors indicating patient engagement in HTN management such as medication adherence and keeping appointments, two points were given if they reported "always," one for "rarely," and zero for "never" engaging in these behaviors. Scoring was reversed for negative behaviors such as smoking, drinking alcohol, and adding salt to food. Practices were scored from zero to 16 points with higher scores indicating engagement in positive behaviors. Participants were categorized as having good (15–16 points), moderate (12–14 points), or poor (<12 points) practices.

Statistical Analysis

The primary study outcome was BP control at the enrollment visit. Secondary outcomes include BP control over three consecutive visits (the study visit plus two prior visits), medication adherence, and knowledge, attitudes, and practices related to HTN. Possible explanatory variables for BP control included demographic factors, BMI, knowledge, attitude, practice and adherence index scores, individual questions in the knowledge, attitudes, practices and MMAS-4 questionnaires, number of medications, cost of medications, and insurance status.

We structured our conceptual framework such that the determinants of BP control were organized in a hierarchical relationship by their proximity to the outcome. The most distal variables in our study were demographic factors such as age and sex. These could influence socioeconomic factors (level of education, employment, urban residence), which, in turn, could influence a participant's knowledge, attitudes, and practices regarding HTN. These variables ultimately impact medication adherence, the most proximal determinant in our study, as it has the most direct effect on BP control.

All data were double-entered, and analysis was conducted using Stata version 13 (StataCorp LP, San Antonio, TX). Continuous variables were reported as medians and interquartile ranges (IQRs). Categorical variables were reported as proportions and percentages. Fisher's exact test and the Wilcoxon rank-sum test were used to compare differences between sexes for

TABLE I. Baseline Characteristics of 300 Adults With HTN Attending the Bugando Medical Centre Hypertension Clinic

Characteristics	No. (%) or Median (IQR)
Age, y	54 (50–61)
Sex	
Male	104 (34.7)
Female	196 (65.3)
Education level	
Never went to school	28 (9.3)
Primary school	192 (64.0)
Secondary/university/college	80 (26.7)
Marital status	
Married	244 (81.3)
Widow	34 (11.3)
Single	11 (3.7)
Divorced	7 (2.3)
Separated	4 (1.3)
Occupation	
Public sector employee	77 (25.7)
Self-employed	64 (21.3)
Student/volunteer/homemaker	57 (19.0)
Agricultural worker	37 (12.3)
Retired	36 (12.0)
Private sector employee	24 (8.0)
Unemployed	5 (1.7)
Place of residence	
Urban area	218 (72.7)
Rural area	82 (27.3)
Duration of HTN diagnosis, y	
<1	40 (13.3)
1–5	122 (40.7)
>5	138 (46.0)
Body mass index, kg/m^2	
Underweight (<18.9)	1 (0.3)
Normal (19–24.9)	70 (23.3)
Overweight (25–29.9)	123 (41.0)
Obese (30–34.9)	69 (23.0)
Severe obesity (35–39.9)	26 (8.7)
Morbid obesity (≥40)	11 (3.7)
Medications, No.	
1	33 (11.0)
2	119 (39.7)
3	99 (33.0)
≥4	49 (16.3)
Median cost of medications (TZS in 10,000s)[a]	2.8 (2.0–4.2)
Cost of medications by category (TZS in 10,000s)[a]	
<2.5	50 (33.1)
2.5–3.5	53 (35.1)
>3.5	48 (31.8)
Insurance status	
Uninsured	189 (63.0)
Insured	111 (37.0)
Medication payment method	
Self-pay	122 (40.7)
Health insurance	111 (37.0)
Relatives	48 (16.0)
Other	19 (6.3)

Abbreviations: HTN, hypertension; IQR, interquartile range; TZS, Tanzanian shillings. [a]Available for 151 study participants who self-paid for medications, had relatives pay, or used other payment methods.

categorical and continuous variables, respectively. Univariable and multivariable logistic regression was used to analyze the relationship between each explanatory variable and HTN control at the study visit.

In addition, univariable and multivariable ordinal logistic regression was used to analyze the relationship between the explanatory variables and HTN control trends over three consecutive clinic visits, described as being controlled at zero of three visits, one or two of three visits, or three of three visits. This ordinal logistic regression analysis was performed to confirm that the factors associated with BP control at the study visit were the same as the factors associated with BP control over time. We tested for proportional odds assumption using the Brant test. A priori, we had decided that all multivariable analyses would be adjusted for age, sex, education, insurance status, and place of residence, as we thought that these would be the most likely confounders. We also performed multilevel analysis in which knowledge, attitude and practice index scores, cost, and BMI were adjusted for adherence, and in which adherence was adjusted for knowledge, attitudes, and practices. The significance threshold for all tests was a two-sided $P<.05$. Because this was an exploratory analysis, we chose not to correct for multiple comparisons.

Ethics

The research proposal was approved by the ethical committees of both BMC and Weill Cornell Medical College. Written informed consent in Swahili was obtained from all participants. All clinic attendees, regardless of study participation, received equal services including HTN education and counseling after the interview visit.

RESULTS

Study Enrollment

Three hundred thirty-nine consecutive clinic patients were invited to participate in the study between June and August 2013. Twenty-seven were excluded because of cognitive impairment (prior stroke, dementia, or mental retardation), and 12 did not give consent. A total of 300 participants were enrolled.

Baseline Characteristics

Sociodemographic information for participants is summarized in Table I. The median age was 54 (IQR, 50–61) years and a majority were female (196 of 300, 65.3%). One quarter (80 of 300, 26.7%) had academic achievement beyond primary level education. A majority (244 of 300, 81.3%) were married, employed (202 of 300, 67.3%), and lived in an urban area (218 of 300, 72.7%).

Almost half of participants (138 of 300, 46%) had HTN for more than 5 years, and 229 of 300 (76.3%) were overweight or obese. Those living in urban areas were more likely to be obese (88 of 218, 40.4%) than those living in rural areas (18 of 82, 22.0%). Many patients reported taking two antihypertensive medications (119 of 300, 39.7%), and 49 of 300 (16.3%) reported taking four or more medications. The average monthly cost of medications was 28,000 Tanzanian shillings (TZS) per month (IQR, 20,000–42,000) equivalent to $17 US dollars (USD) per month (IQR, 12–25.5). A majority of patients (189 of 300, 63.0%) were uninsured.

Outcomes

Nearly half of patients (143 of 300, 47.7%) had controlled HTN at the study visit (Table II). Control was not significantly different between men and women. Of those who were uncontrolled at the time of interview, equal proportions had stage 1 (85 of 157, 54%) and stage 2 (72 of 157, 46%) HTN. Over the last three clinic visits, 85 of 300 (28.3%) were controlled at all three visits, compared with 114 of 300 (38.0%) who were uncontrolled at all three visits. A majority of patients (168 of 300, 56.0%) had high adherence to medication on the MMAS-4. Most patients had moderate scores for knowledge (123 of 300, 41.0%), attitudes (136 of 300, 45.3%) and practices (148 of 300, 49.3%). Only the knowledge index score (P=.03) was significantly different between men and women. Men were more likely to have good knowledge than women (38 of 104 [36.5%] vs 44 of 196 [22.5%]).

Factors Associated With HTN Control

The factors associated with BP control at the study visit by univariable and multivariable logistic regression are

TABLE II. Total and Sex-Specific Outcomes of 300 Adults With HTN Attending the Bugando Medical Centre Hypertension Clinic

Outcome	Total (N=300), No. (%)	Male (n=104), No. (%)	Female (n=196), No. (%)	*P* Value
HTN at time of interview				
Controlled[a]	143 (47.7)	52 (50.0)	91 (46.4)	.63
Uncontrolled	157 (52.3)	52 (50.0)	105 (53.6)	
HTN stage at interview				
Controlled[a]	143 (47.7)	52 (50.0)	91 (46.4)	.23
Stage 1[b]	85 (28.3)	33 (31.7)	52 (26.5)	
Stage 2[c]	72 (24.0)	19 (18.3)	53 (27.0)	
HTN control over time				
HTN controlled at 3/3 visits	85 (28.3)	26 (25.0)	59 (30.1)	.35
HTN controlled at 2/3 visits	52 (17.3)	21 (20.2)	31 (15.8)	
HTN controlled at 1/3 visits	49 (16.3)	21 (20.2)	28 (14.3)	
HTN controlled at 0/3 visits	114 (38.0)	36 (34.6)	78 (39.8)	
Knowledge index score				
Poor	95 (31.7)	26 (25.0)	69 (35.2)	**.03**
Moderate	123 (41.0)	40 (38.5)	83 (42.4)	
Good	82 (27.3)	38 (36.5)	44 (22.5)	
Attitudes index score				
Poor	38 (12.7)	8 (7.7)	30 (15.3)	.1
Moderate	136 (45.3)	46 (44.2)	90 (45.9)	
Good	126 (42.0)	50 (48.1)	76 (38.8)	
Practices index score				
Poor	75 (25.0)	28 (26.9)	47 (23.9)	.29
Moderate	148 (49.3)	45 (43.3)	103 (52.6)	
Good	77 (25.7)	31 (29.8)	46 (23.5)	
Adherence index score				
Low (MMAS-4: 3–4)	55 (18.3)	24 (23.1)	31 (15.8)	.32
Medium (MMAS-4: 1–2)	77 (25.7)	25 (24.0)	52 (26.5)	
High (MMAS-4: 0)	168 (56.0)	55 (52.9)	113 (57.7)	

Abbreviations: HTN, hypertension; MMAS, Moriksy Medication-Taking Adherence Scale. [a]Controlled HTN: SBP <140 mm Hg and DBP <90 mm Hg. [b]Stage 1: 140–159 mm Hg or 90–99 mm Hg. [c]Stage 2: ≥160 mm Hg or ≥100 mm Hg. Bold values indicate significance.

TABLE III. Univariable and Multivariable Logistic Regression Analyses of Determinants of Blood Pressure Control at Study Visit Among 300 Adults With HTN Attending the Bugando Medical Centre Hypertension Clinic

	HTN Controlled at Study Visit				
	No. (%) or Median (IQR)		Univariable		Adjusted for Age, Sex, Education, Residence, and Insurance Status
	Yes (n=143)	No (n=157)	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Age, y	54 (51–60)	54 (49–61)	1.0 (.98–1.02)	.97	1.0 (0.98–1.02)	.91
Sex						
Male	52 (50.0)	52 (50.0)	1		1	
Female	91 (46.4)	105 (53.6)	0.9 (0.5–1.4)	.56	0.9 (0.6–1.5)	.75
Education level						
No school/primary school	104 (47.3)	116 (52.7)	1		1	
Secondary/above	39 (48.8)	41 (51.2)	1.1 (0.6–1.8)	.82	1.1 (0.6–1.9)	.84
Marital status						
Non-married	23 (41.1)	33 (58.9)	1		1	
Married	120 (49.2)	124 (50.8)	1.4 (0.8–2.5)	.27	1.3 (0.7–2.4)	.45
Occupation						
Unemployed[a]	43 (43.9)	55 (56.1)	1		1	
Self-employed[b]	47 (46.5)	54 (53.5)	1.1 (0.6–1.9)	.71	1.2 (0.6–2.3)	.66
Employed[c]	53 (52.5)	48 (47.5)	1.4 (0.8–2.5)	.23	1.5 (0.7–3.2)	.26
Place of residence						
Urban area	98 (45.0)	120 (55.0)	1		1	
Rural area	45 (54.9)	37 (45.1)	1.5 (0.9–2.5)	.13	1.5 (0.9–2.5)	.15
Duration of HTN diagnosis, y						
<1	15 (37.5)	25 (62.5)	1		1	
1–5	62 (50.8)	60 (49.2)	1.7 (0.8–3.6)	.15	1.7 (0.8–3.7)	.15
>5	66 (47.8)	72 (52.2)	1.5 (0.7–3.1)	.25	1.6 (0.7–3.6)	.26
Body mass index, kg/m^2						
Normal/underweight (<25)	42 (59.2)	29 (40.9)	1		1	
Overweight (25–29.9)	65 (52.9)	58 (47.2)	0.8 (0.4–1.4)	.4	0.7 (0.4–1.3)	.31
Obese (≥30)	36 (34.0)	70 (66.0)	0.4 (0.2–0.7)	**.001**	0.3 (0.2–0.6)	**.001**
Medications, No.						
1	16 (48.5)	17 (51.5)	1		1	
2–3	97 (44.5)	121 (55.5)	0.9 (0.4–1.8)	.67	0.8 (0.4–1.8)	.65
≥4	30 (61.2)	19 (38.8)	1.7 (0.7–4.1)	.26	1.6 (0.6–4.0)	.31
Median cost of medications (TZS in 10,000s)[d]	2.5 (1.8–3.7)	3.0 (2.2–5.0)	0.8 (0.7–0.98)	**.03**	0.8 (0.7–0.95)	**.01**
Cost of medications by category (TZS in 10,000s)[d]						
<2.5	29 (58.0)	21 (42.0)	1		1	
2.5–3.5	25 (47.2)	28 (52.8)	0.6 (0.3–1.4)	.27	0.7 (0.3–1.6)	.38
>3.5	19 (39.6)	29 (60.4)	0.5 (0.2–1.1)	.07	0.4 (0.2–1.0)	.06
Insurance status						
Uninsured	88 (46.6)	101 (53.4)	1		1	
Insured	55 (49.5)	56 (50.5)	1.1 (0.7–1.8)	.62	1.1 (0.6–1.8)	.82
Knowledge index score						
Poor	37 (39.0)	58 (61.1)	1		1	
Moderate	63 (51.2)	60 (48.8)	1.6 (0.96–2.8)	.07	1.8 (1.01–3.2)	**.046**
Good	43 (52.4)	39 (47.6)	1.7 (0.95–3.1)	.07	2.1 (1.00–4.5)	**.049**
Attitudes index score						
Poor	10 (26.3)	28 (73.7)	1		1	
Moderate	68 (50.0)	68 (50.0)	2.8 (1.3–6.2)	**.01**	2.8 (1.2–6.4)	**.02**
Good	65 (51.6)	61 (48.4)	3.0 (1.3–6.7)	**.01**	3.0 (1.3–7.0)	**.01**
Practices index score						
Poor	14 (18.7)	61 (81.3)	1		1	
Moderate	76 (51.3)	72 (48.7)	4.6 (2.4–8.9)	**<.001**	4.8 (2.4–9.4)	**<.001**
Good	53 (68.8)	24 (31.2)	9.6 (4.5–20.5)	**<.001**	11.0 (5.0–24.2)	**<.001**
Adherence index score						
Low (MMAS-4: 3–4)	7 (12.7)	48 (87.3)	1		1	

TABLE III. (Continued)

	HTN Controlled at Study Visit		Univariable		Adjusted for Age, Sex, Education, Residence, and Insurance Status	
	No. (%) or Median (IQR)					
	Yes (n=143)	No (n=157)	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Medium (MMAS-4: 1–2)	15 (19.5)	62 (80.5)	1.7 (0.6–4.4)	.31	1.7 (0.6–4.5)	.31
High (MMAS-4: 0)	121 (72.0)	47 (28.0)	17 (7.5–41.8)	**<.001**	18.8 (7.8–45.4)	**<.001**

Abbreviations: CI, confidence interval; HTN, hypertension; IQR, interquartile range; MMAS, Moriksy Medication-Taking Adherence Scale; OR, odds ratio; TZS, Tanzanian shillings. [a]Student/volunteer/homemaker, retired, and unemployed (unable to work). [b]Self-employed and agricultural worker. [c]Public sector employee and private sector employee. [d]Available for 151 study participants who self-paid for medications, had relatives pay, or used other payment methods. Bold values indicate significance.

listed in Table III. Results for multivariable analysis are described here. No sociodemographic factors were associated with BP control. Both obesity and higher cost of medication were associated with decreased odds of BP control at the study visit. Individuals with a BMI of ≥30 and those who had higher cost of medications had respective odds ratios (ORs) of 0.3 (95% confidence interval [CI], 0.2–0.6; *P*=.001) and 0.8 (95% CI, 0.7–0.95; *P*=.01). Odds of control decreased by 20% for every 10,000 TZS spent on medication (OR, 0.8; 95% CI, 0.7–0.95; *P*=.01).

Study participants with moderate and good knowledge of HTN had increased odds of control (OR, 1.8; 95% CI, 1.01–3.2; *P*=.046, and OR, 2.1; 95% CI, 1.00–4.5; *P*=.049, respectively). Those with moderate and good attitudes had increased odds of control (OR, 2.8; 95% CI, 1.2–6.4; *P*=.02, and OR, 3.0; 95% CI, 1.3–7.0; *P*=.01, respectively). Those who had moderate and good practices also had increased odds of control (OR, 4.8; 95% CI, 2.4–9.4; *P*<.001, and OR, 11.0; 95% CI, 5.0–24.2; *P*<.001, respectively). Patients with high medication adherence by the MMAS-4 had increased odds of control relative to those with low adherence at the study visit (OR, 18.8; 95% CI, 7.8–45.4; *P*<.001). This benefit was not shown for those with medium adherence (OR, 1.7; 95% CI, 0.6–4.5; *P*=.31).

In multilevel logistic regression analysis, knowledge, attitudes, and practices remained significantly associated with increased HTN control even after adjusting for medication adherence, indicating that the effect of knowledge, attitudes, and practices on HTN control is only partially mediated by the effect of adherence: good knowledge had an OR of 2.5 (95% CI, 1.0–6.1; *P*=.047), good attitudes had an OR of 2.7 (95% CI, 1.0–7.1; *P*=.04), and good practices had an OR of 5.4 (95% CI, 2.3–13.0; *P*<.001). In addition, when association between adherence and BP control was adjusted for knowledge, attitudes, and practices indices, the OR decreased only slightly to 14.6 (95% CI, 5.8–37.0; *P*<.001). When the multivariable logistic regression models for the association of cost and BMI with BP control were adjusted for adherence, the association was no longer significant, suggesting that the effect of cost and BMI on control is mediated through adherence (OR, 0.9; 95% CI, 0.7–1.1; *P*=.38, and OR, 0.5; 95% CI, 0.2–1.1; *P*=.10, respectively).

Factors Associated With HTN Control Over Three Consecutive Visits

The factors associated with BP control over three consecutive study visits are listed in Table IV. Results for multivariable analysis are described. This ordinal logistic regression confirmed that the determinants of BP control over three consecutive clinic visits were similar to the factors associated with HTN control at the study visit. All *P* values for Brant's test were >.05, indicating that the proportional odds assumption was not violated.

No sociodemographic variables were significantly associated with BP control over time. Being overweight (BMI 25–29.9) and being obese (BMI ≥30) were associated with decreased odds of control over three consecutive clinic visits (OR, 0.5; 95% CI, −0.3 to 0.9; *P*=.01, and OR, 0.2; 95% CI, 0.1–0.4; *P*<.001, respectively). Higher cost of medications was also associated with decreased odds of control over three visits (OR, 0.8; 95% CI, 0.6–0.9; *P*=.001). Paying more than 35,000 TZS per month was associated with a 70% decrease in odds of control compared with those who paid <25,000 TZS per month (OR, 0.3; 95% CI, 0.2–0.7; *P*=.006). However, when cost was adjusted for adherence, we found that the effect of cost on control was again mediated through adherence (OR, 0.8; 95% CI, 0.7–1.0; *P*=.06). Good knowledge (OR, 2.8; 95% CI, 1.4–5.7; *P*=.003) increased odds of control. Moderate and good attitudes (OR, 2.7; 95% CI, 1.3–5.7; *P*=.01, and OR, 2.2; 95% CI, 1.02–4.6; *P*=.045, respectively) and moderate and good practices (OR, 4.2; 95% CI, 2.4–7.5; *P*<.001, and OR, 8.9; 95% CI, 4.6–17.4; *P*<.001, respectively) also increased odds of HTN control over three visits. Lastly, medium and high adherence increased odds of control over three visits (OR, 2.2; 95% CI, 1.1–4.6; *P*=.04, and OR, 14.3; 95% CI,1.1–28.7; *P*<.001, respectively).

Individual Questionnaire Items Associated With HTN Control

Analysis of the individual questions on the knowledge component of the study showed that not knowing that parental history of HTN increases personal risk of

TABLE IV. Univariable and Multivariable Ordinal Logistic Regression Analyses of Determinants of HTN Control Over Three Consecutive Clinic Visits Among 300 Adults With HTN Attending the Bugando Medical Centre Hypertension Clinic

	HTN Control Over Time						
	No. (%) or Median (IQR)			Univariable		Adjusted for Age, Sex, Education, Residence, and Insurance Status	
	0 of 3 Visits	1 or 2 of 3 Visits	3 of 3 Visits	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Age, y	55 (49–62)	54 (50–61)	54 (51–61)	1.0 (0.97–1.01)	.53	1.0 (0.97–1.01)	.43
Sex							
Male	36 (34.6)	42 (40.4)	26 (25.0)	1		1	
Female	78 (39.8)	59 (30.1)	59 (30.1)	0.98 (0.6–1.5)	.93	1.0 (0.7–1.6)	.84
Education level							
No school/primary school	83 (37.7)	75 (34.1)	62 (28.2)	1		1	
Secondary/above	31 (38.8)	26 (32.5)	23 (28.9)	0.99 (0.6–1.6)	.96	1.2 (0.7–2.0)	.59
Marital status							
Non-married	24 (42.9)	17 (30.4)	15 (26.8)			1	
Married	90 (36.9)	84 (34.4)	70 (28.7)	1.2 (0.7–2.1)	.49	1.2 (0.7–2.1)	.61
Occupation							
Unemployed[a]	41 (41.8)	31 (31.6)	26 (26.5)	1		1	
Self-employed[b]	35 (34.7)	35 (34.7)	31 (30.7)	1.3 (0.8–2.2)	.32	1.2 (0.6–2.2)	.61
Employed[c]	38 (37.6)	35 (34.7)	28 (27.7)	1.1 (0.7–1.9)	.62	1.1 (0.6–2.1)	.84
Place of residence							
Urban area	26 (31.7)	30 (36.6)	26 (31.7)	1		1	
Rural area	88 (40.4)	71 (32.6)	59 (27.1)	1.4 (0.9–2.2)	.2	1.5 (0.9–2.4)	.13
Duration of HTN diagnosis, y							
<1	14 (35.0)	17 (42.5)	9 (22.5)	1		1	
1–5	45 (36.9)	37 (30.3)	40 (32.8)	1.2 (0.6–2.3)	.6	1.1 (0.6–2.2)	.70
>5	55 (39.9)	47 (34.1)	36 (26.1)	0.96 (0.5–1.8)	.89	1.0 (0.5–2.0)	.97
Body mass index, kg/m^2							
Normal/underweight (<25)	15 (21.1)	27 (38.0)	29 (40.9)	1		1	
Overweight (25–29.9)	43 (35.0)	45 (36.6)	35 (20.5)	0.6 (0.3–0.9)	**.03**	0.5 (0.3–0.9)	**.01**
Obese (≥30)	56 (52.8)	29 (27.4)	21 (19.8)	0.3 (0.2–0.5)	**<.001**	0.2 (0.1–0.4)	**<.001**
Medications, No.							
1	12 (36.4)	10 (30.3)	11 (33.3)	1		1	
2–3	86 (39.5)	72 (33.0)	60 (27.5)	0.8 (0.4–1.6)	.56	0.8 (0.4–1.6)	.55
≥4	16 (32.7)	19 (38.8)	14 (28.6)	1.0 (0.4–2.2)	.96	1.0 (0.4–2.2)	.95
Median cost of medications (TZS in 10,000s)[d]	3.5 (2.5–5.6)	2.5 (1.8–3.7)	2.6 (2.0–3.3)	0.8 (0.7–0.9)	**.002**	0.8 (0.6–0.9)	**.001**
Cost of medications by category (TZS in 10,000s)[d]							
<2.5	13 (26.0)	18 (36.0)	19 (38.0)	1		1	
2.5–3.5	14 (26.4)	20 (37.7)	19 (35.9)	0.9 (0.5–1.9)	.87	1.0 (0.5–2.1)	.96
>3.5	25 (52.1)	13 (27.1)	10 (20.8)	0.4 (0.2–0.8)	**.007**	0.3 (0.2–0.7)	**.006**
Insurance status							
Uninsured	71 (37.6)	60 (31.8)	58 (30.7)	1		1	
Insured	43 (38.7)	41 (36.9)	27 (24.3)	0.9 (0.6–1.3)	.46	0.8 (0.5–1.2)	.28
Knowledge index score							
Poor	43 (45.3)	31 (32.6)	21 (22.2)	1		1	
Moderate	46 (37.4)	40 (32.5)	37 (30.1)	1.4 (0.9–2.4)	.15	1.7 (0.99–2.8)	.05
Good	25 (30.5)	30 (36.6)	27 (32.9)	1.8 (1.04–3.1)	**.04**	2.8 (1.4–5.7)	**.003**
Attitudes index score							
Poor	22 (57.9)	9 (23.7)	7 (18.4)	1		1	
Moderate	44 (32.4)	47 (34.6)	45 (33.1)	2.7 (1.3–5.5)	**.01**	2.7 (1.3–5.7)	**.01**
Good	48 (38.1)	45 (35.7)	33 (26.2)	2.0 (1.003–4.1)	**.049**	2.2 (1.02–4.6)	**.045**
Practices index score							
Poor	48 (64.0)	21 (20.0)	6 (8.0)	1		1	
Moderate	51 (34.5)	51 (34.5)	46 (31.1)	3.7 (2.1–6.5)	**<.001**	4.2 (2.4–7.5)	**<.001**
Good	15 (19.5)	29 (37.7)	33 (42.9)	7.0 (3.7–13.1)	**<.001**	8.9 (4.6–17.4)	**<.001**

TABLE IV. (Continued)

	HTN Control Over Time			Univariable		Adjusted for Age, Sex, Education, Residence, and Insurance Status	
	No. (%) or Median (IQR)						
	0 of 3 Visits	1 or 2 of 3 Visits	3 of 3 Visits	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Adherence index score							
Low (MMAS-4: 3–4)	40 (72.2)	14 (25.5)	1 (1.8)	1		1	
Medium (MMAS-4: 1–2)	43 (55.8)	25 (32.5)	9 (11.7)	2.2 (1.1–4.6)	**.03**	2.2 (1.1–4.6)	**.04**
High (MMAS-4: 0)	31 (18.5)	62 (36.9)	75 (44.6)	13.3 (6.7–26.4)	**<.001**	14.3 (1.1–28.7)	**<.001**

Abbreviations: CI, confidence interval; HTN, hypertension; IQR, interquartile range; MMAS, Moriksy Medication-Taking Adherence Scale; OR, odds ratio; TZS, Tanzanian shillings. [a]Student/volunteer/homemaker, retired, and unemployed (unable to work). [b]Self-employed and agricultural worker. [c]Public sector employee and private sector employee. [d]Available for 151 study participants who self-paid for medications, had relatives pay, or used other payment methods. Bold values indicate significance.

HTN (OR, 0.5; 95% CI, 0.3–0.9; *P*=.01) or that HTN is a chronic lifelong condition (OR, 0.3; 95% CI, 0.2–0.5; *P*<.001) were associated with decreased HTN control at the study visit using multivariable analysis (Table S1). Among questions asked on the attitude questionnaire, disagreeing with the statement "I can enjoy my life with a healthy lifestyle modification" (OR, 0.3; 95% CI, 0.2–0.8; *P*=.01) was associated with decreased HTN control using multivariable analysis. Regarding specific practices, drinking alcohol (OR, 0.3; 95% CI, 0.1–0.7; *P*=.006), adding salt to meals (OR, 0.4; 95% CI, 0.2–0.6; *P*=.001), rarely or never adhering to normal weight advice (OR, 0.4; 95% CI, 0.2–0.6; *P*<.001), and rarely or never taking medications as prescribed (OR, 0.1; 95% CI, 0.5–0.2; *P*<.001) were associated with decreased HTN control at the study visit using multivariable logistic analysis. For the individual questions on the MMAS-4, a response of "yes" to any question was associated with decreased HTN control using multivariable analysis (*P*<.001).

Reasons for Nonadherence

Among those who reported never taking prescribed antihypertensive medication, the most common reasons cited for nonadherence were not taking medications when feeling well (28.0%), being unable to afford medication (24.0%), and forgetting to take medication (22.7%). Men were more likely than women to list not taking medications when feeling well as the reason for nonadherence (*P*=.02) (Table V).

DISCUSSION

At the study visit, approximately half of patients had controlled BPs (47.7%), while rates of control over time were much less, with 28.3% of patients demonstrating consistent BP control over three consecutive clinic visits. These rates of control among hypertensive adults on treatment are similar to those described in the United States (29–53%) and European (30%–50%) populations,[10,11] and much higher compared with prior studies in Tanzania (5%–14.9%).[5,6] The significantly higher rates of control in our study population are likely the result of patients having regular checkups at a tertiary referral hospital with a dedicated HTN clinic. Our rates were comparable to a study performed at a tertiary teaching hospital in Ethiopia in which 46.6% of 384 hypertensive patients had controlled HTN.[12]

Surprisingly, no demographic or socioeconomic factors were associated with BP control. There was no difference in rates of control between men and women, in comparison to other studies that show women in African countries have better rates of control and that Tanzanian women are 50% less likely to have HTN.[4,13] In addition, while living in an urban area significantly increases risk of HTN, in our study there was no

TABLE V. Total and Sex-Specific Reasons Cited for Nonadherence Among 75 Adults With Hypertension Attending the Bugando Medical Centre Hypertension Clinic Who Reported Never Taking Prescribed Antihypertensive Medications

Reason	Total (N=75), No. (%)	Men (n=23), No. (%)	Women (n=52), No. (%)	*P* Value
I don't take my medication when I feel well	21 (28.0)	11 (47.8)	10 (19.2)	.02
I can't afford my medications	18 (24.0)	6 (26.1)	12 (23.1)	.78
I forget to take my medication	17 (22.7)	3 (13.0)	14 (26.9)	.24
I am afraid of side effects	5 (6.7)	1 (4.4)	4 (7.7)	1.0
I dislike taking medications	4 (5.3)	1 (4.4)	3 (5.8)	1.0
I am prescribed too many medications	2 (2.7)	0 (0.0)	2 (3.9)	1.0
I prefer to use alternative therapy	1 (1.3)	0 (0.0)	1 (1.9)	1.0
Other	7 (9.3)	1 (4.4)	6 (11.5)	.43

difference in control between those who lived in urban and rural settings.[14,15] We also expected that having health insurance would increase rates of control. Studies in the United States have shown that among patients receiving treatment for HTN, uninsured individuals are at a lower odds of continued medication use[16] and adequate BP control[17] than privately insured individuals. However, in our study, insurance status did not have a significant association with BP control. Prospective studies are needed to describe the relationship between socioeconomic factors and BP control in other rural and urban regions of African and to determine whether providing insurance could improve medication use and BP control in uninsured Africans.

We found that good knowledge, attitudes, and practices were strongly associated with HTN control and remained significantly associated even when adjusted for adherence. Similar studies have been conducted in SSA populations, but with mixed results.[18–22] In our study, we specifically found that not knowing that HTN is a heritable condition, not knowing that it is a chronic condition, and not agreeing that it is possible to enjoy life while making healthy lifestyle modifications were the three knowledge and attitudes questionnaire items associated with poor control. This suggests an opportunity for directed intervention by clinicians to educate patients on the chronicity and hereditability of HTN. As education level did not have an effect on control rates, all patients, including well-educated ones, should receive targeted education. Further research is needed to understand how to effectively improve attitude towards lifestyle change in hypertensive patients.

Any current alcohol use, adding salt to meals, failing to adhere to normal weight advice, and not taking medications as prescribed were associated with decreased HTN control. These factors are also associated with decreased control in developed countries, but the interventions that are used in those settings may not necessarily work in SSA populations.[23,24] In particular, there is a lower rate of tobacco and alcohol use in our study population compared with developed nations and even other SSA populations.[25] However, in urban Tanzania, the prevalence of obesity is >13% in men and >35% in women.[1,13,26] Therefore, while interventions should promote reduction of all HTN risk factors, particular emphasis must be placed on decreasing obesity rates and researching interventions that target obese patients with HTN, as this group is especially vulnerable to poor HTN control. Interventions will need to address cultural context; for example, in Tanzania, as in many other developing countries, a heavier body is preferred and many are unaware that they are obese.[26] In addition, since African populations may be more salt-sensitive than other populations, more focus may be needed on reducing salt intake.[27]

A perfect adherence score of zero on the MMAS-4 was associated with a nearly 20-fold increased odds of BP control at the study visit as well as over the three consecutive visits. Antihypertensive medication adherence is a well-documented factor associated with BP control in other populations and the foundation for medical treatment of HTN.[12] In addition, each individual question on the MMAS-4 was associated with decreased control: forgetting to take medication, being careless about taking medications, stopping medications when feeling well, and not taking medications when feeling poorly because of medication, all decreased the odds of control by 80% to 90%. Thus, strategies to improve adherence in this population should involve patient education that antihypertensive medications should be taken daily and consistently even when feeling well. Prior studies also support this approach, as a systemic review of interventions to improve antihypertensive medication adherence found that improving patient knowledge of medications posed the greatest clinical value.[28] Interventions to improve adherence should also aim to lower the out-of-pocket cost of medications for patients by prescribing generic brands and less-expensive regimens. Furthermore, studies have shown that medication adherence is associated with lower rates of hospitalization and healthcare costs and emphasizes the need to create and test targeted interventions to increase adherence.[29]

Cost was also a significant predictor of BP control. The odds of control over time decreased by 20% for every 10,000 TZS increase ($6 USD) and decreased by 70% when costs exceeded 35,000 TZS compared with <25,000 TZS. The negative impact of cost on medication adherence has been previously described in other populations.[30] The effect of cost on control seems to be mediated through adherence, with lower cost leading to increased adherence and increased BP control. Providers should consider and assess the financial impact of prescriptions and tailor regimens that are cost-effective and feasible for the patient. On a systemic level, governments and health organizations should negotiate for better prices, and further randomized control trials are needed to compare the efficacy of different cost-effective drug regimens in SSA.

STUDY LIMITATIONS

One limitation of our study is that it was a single-center, hospital-based study. Still, our results may be generalizable to many sites in SSA, since our prior research has demonstrated that the majority of HTN care in Tanzania occurs in hospital clinics and that very little HTN management currently occurs in health centers or clinics.[31] We also did not record whether prescribed drugs were generic or brand name. This important variable should be included in future studies.

CONCLUSIONS

In this study of hypertensive adults in Tanzania, BP was controlled in almost half the study population at one time point but in less than a third throughout three consecutive clinic visits, with no difference between men

and women. Good knowledge, attitudes, and practices increased control, while high BMI and high medication cost decreased control. Of all factors analyzed, high medication adherence was associated with the greatest odds of control. This study demonstrates that it is possible to achieve high rates of HTN control in a resource-limited setting if medication costs are low and adherence is high. At our own hospital, we are now trying to improve BP control by implementing standard treatment protocols of low-cost, generic antihypertensive drugs. Prospective studies are needed to determine the best interventions for improving knowledge, attitudes, and practices and achieving normal body weight in hypertensive SSA populations.

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References

1. Twagirumukiza M, De Bacquer D, Kips JG, et al. Current and projected prevalence of arterial hypertension in sub-Saharan Africa by sex, age and habitat: an estimate from population studies. *J Hypertens*. 2011;29:1243–1252.
2. World Health Organization. *A Global Brief on Hypertension: Silent Killer, Global Public Health Crisis*. Geneva, Switzerland: World Health Organization; 2013.
3. Peck RN, Green E, Mtabaji J, et al. Hypertension-related diseases as a common cause of hospital mortality in Tanzania: a 3-year prospective study. *J Hypertens*. 2013;31:1806–1811.
4. Kayima J, Wanyenze RK, Katamba A, et al. Hypertension awareness, treatment and control in Africa: a systematic review. *BMC Cardiovasc Disord*. 2013;13:54.
5. Dewhurst MJ, Dewhurst F, Gray WK, et al. The high prevalence of hypertension in rural-dwelling Tanzanian older adults and the disparity between detection, treatment and control: a rule of sixths? *J Hum Hypertens*. 2013;27:374–380.
6. Hendriks ME, Wit FWNM, Roos MTL, et al. Hypertension in sub-Saharan Africa: cross-sectional surveys in four rural and urban communities. *PLoS One*. 2012;7:e32638.
7. Shalansky SJ, Levy AR, Ignaszewski AP. Self-reported Morisky score for identifying nonadherence with cardiovascular medications. *Ann Pharmacother*. 2004;38:1363–1368.
8. Morisky DE, Green LW, Levine DM. Concurrent and predictive validity of a self-reported measure of medication adherence. *Med Care*. 1986;24:67–74.
9. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension*. 2003;42:1206–1252.
10. Go AS, Mozaffarian D, Roger VL, et al. Heart disease and stroke statistics–2013 update: a report from the American Heart Association. *Circulation*. 2013;127:e6–e245.
11. Kearney PM, Whelton M, Reynolds K, et al. Worldwide prevalence of hypertension: a systematic review. *J Hypertens*. 2004;22:11–19.
12. Ambaw A, Alemie G, W/Yohannes S, Mengesha Z. Adherence to antihypertensive treatment and associated factors among patients on follow up at University of Gondar Hospital, Northwest Ethiopia. *BMC Public Health*. 2012;12:282.
13. Njelekela MA, Mpembeni R, Muhihi A, et al. Gender-related differences in the prevalence of cardiovascular disease risk factors and their correlates in urban Tanzania. *BMC Cardiovasc Disord*. 2009;9:30.
14. Riha J, Karabarinde A, Ssenyomo G, et al. Urbanicity and lifestyle risk factors for cardiometabolic diseases in rural Uganda: a cross-sectional study. *PLoS Med*. 2014;11:e1001683.
15. Seedat YK. Perspectives on research in hypertension. *Cardiovasc J Afr*. 2009;20:39–42.
16. Gai Y, Gu NY. Association between insurance gaps and continued antihypertension medication usage in a US national representative population. *Am J Hypertens*. 2009;22:1276–1280.
17. Duru OK, Vargas RB, Kermah D, et al. Health insurance status and hypertension monitoring and control in the United States. *Am J Hypertens*. 2007;20:348–353.
18. Spencer J, Phillips E, Ogedegbe G. Knowledge, attitudes, beliefs, and blood pressure control in a community-based sample in Ghana. *Ethn Dis*. 2005;15:748–752.
19. Iyalomhe GBS, Iyalomhe SI. Hypertension-related knowledge, attitudes and life-style practices among hypertensive patients in a sub-urban Nigerian community. *J Public Health Epidemiol*. 2010;2:71–77.
20. Osman EM, Suleiman I, Elzubair AG. Patients knowledge of hypertension and its control in eastern Sudan. *East Afr Med J*. 2007;84:324–328.
21. Katibi IA, Olarinoye JK, Kuranga SA. Knowledge and practice of hypertensive patients as seen in a tertiary hospital in the middle belt of Nigeria. *Niger J Clin Pract*. 2010;13:159–162.
22. Azubuike S, Kurmi R. Awareness, practices, and prevalence of hypertension among rural Nigerian women. *Arch Med Heal Sci*. 2014;2:23.
23. Cutler JA. Combinations of lifestyle modification and drug treatment in management of mild-moderate hypertension: a review of randomized clinical trials. *Clin Exp Hypertens*. 1993;15:1193–1204.
24. Calhoun DA, Jones D, Textor S, et al. Resistant hypertension: diagnosis, evaluation, and treatment: a scientific statement from the American Heart Association Professional Education Committee of the Council for High Blood Pressure Research. *Circulation*. 2008;117:e510–e526.
25. Ng M, Freeman MK, Fleming TD, et al. Smoking prevalence and cigarette consumption in 187 countries, 1980-2012. *JAMA*. 2014;311:183–192.
26. Muhihi AJ, Njelekela MA, Mpembeni R, et al. Obesity, overweight, and perceptions about body weight among middle-aged adults in Dar es Salaam, Tanzania. *ISRN Obes*. 2012;2012:368520.
27. Ibrahim MM, Damasceno A. Hypertension in developing countries. *Lancet*. 2012;380:611–619.
28. Gwadry-Sridhar FH, Manias E, Lal L, et al. Impact of interventions on medication adherence and blood pressure control in patients with essential hypertension: a systematic review by the ISPOR medication adherence and persistence special interest group. *Value Health*. 2013;16:863–871.
29. Sokol MC, McGuigan KA, Verbrugge RR, Epstein RS. Impact of medication adherence on hospitalization risk and healthcare cost. *Med Care*. 2005;43:521–530.
30. Eaddy MT, Cook CL, O'Day K, et al. How patient cost-sharing trends affect adherence and outcomes: a literature review. *P T*. 2012;37:45–55.
31. Peck R, Mghamba J, Vanobberghen F, et al. Preparedness of Tanzanian health facilities for outpatient primary care of hypertension and diabetes: a cross-sectional survey. *Lancet Glob Health*. 2014;2:e285–e292.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Univariate and multivariate logistic regression analyses of knowledge, attitude, practice, and adherence questions associated with hypertension control among 300 adults with hypertension attending the Bugando Medical Centre hypertension clinic.