Title: Prevalence and quality of antihypertensive therapy among hypertension patients enrolled in the Ghana National Health Insurance Scheme.

Short title: *Patterns of antihypertensive therapy in Ghana*

Macarius M. Donneyong[a], Teng-Jen Chang[a], Anton Pottegård[b,c], Daniel Ankrah[d], Francis Asenso-Boadi[e], Vivian Addo-Cobbiah[e], Lydia Dsane-Selby[e], Jesper Hallas[b,f].

   a. Pharmacy Practice and Science, College of Pharmacy, The Ohio State University, Columbus, OH, USA
   b. Clinical Pharmacology and Pharmacy, University of Southern Denmark
   c. Hospital Pharmacy, Odense University Hospital, Denmark
   d. Korle-Bu Teaching Hospital, Accra, Ghana.
   e. Ghana National Health Insurance Authority, Accra, Ghana.
   f. Clinical Biochemistry and Pharmacology, Odense University Hospital, Denmark

Conflict of interest: None

Corresponding author:
Macarius M. Donneyong, PhD, MPH
Pharmacy Practice and Science,
College of Pharmacy, The Ohio State University
Riffe Building, Room 404
496 W. 12th Ave
Columbus, OH 43210
USA

Word count: 2,732

KEY POINTS

- Antihypertensive medication use is very high among hypertension patients enrolled in the Ghana National Health Insurance Scheme.
- CCBs were the most frequently used antihypertensive agents either as monotherapy (60%) or in combination with another antihypertensive agent (42%).
- In terms of dosage of consumed antihypertensive agents, ARBs were consumed at the highest dosages of 120 (Interquartile Range [IQR]: 60, 180) DDDs over a year.
- The quality of antihypertensive therapy was suboptimal; only a third (32%) of hypertension patients received guideline-concordant therapy.

ABSTRACT

Background: Hypertension is a leading cause of morbidity in Ghana. However, there is insufficient data on the prevalence and quality of antihypertensive therapy.

Objectives: To describe the prevalence of use and quality of antihypertensive therapy.

Methods: A cross-sectional study design was used to analyze the 2015 Ghana National Health Insurance Scheme (NHIS) electronic claims data. Hypertension diagnosis was defined using ICD-10 codes. The primary outcomes assessed were the prevalence of use and quality of antihypertensive therapy. Quality of antihypertensive therapy was defined as the use of antihypertensive agents recommended for treating hypertension patients with comorbid heart failure, myocardial Infarction/Coronary Artery Disease, diabetes, chronic kidney disease or stroke. We used multivariable logistic regression models to identify predictors of antihypertensive use and quality of therapy.

Results: Antihypertensive medication use was very high (86%) among the 161,873 hypertension patients covered under the Ghana NHIS. Only a third (32%) of hypertension patients received guideline-concordant therapy. Angiotensin receptor blockers were consumed at the highest dosages of 120 (Interquartile Range [IQR]: 60, 180) daily defined doses over a year. Males (odds ratio [OR] = 0.60; 95% Confidence Interval [CI]:0.58, 0.61) and those with comorbid stroke (OR = 0.91, 95% CI:0.84, 0.99), diabetes (OR = 0.72; 95% CI:0.69, 0.74) and stroke (OR = 0.74, 95%CI:0.68, 0.80) were less likely to use antihypertensives, all other predictors were associated with higher use.

Conclusion: Antihypertensive medication use was very high among hypertension patients covered under the Ghana NHIS. However, there was indication of suboptimal quality of the antihypertensive therapy provided.

Key Words: Antihypertensive, hypertension treatment, Ghana National Health Insurance Scheme, Africa

3

INTRODUCTION

Hypertension is now the second leading cause of morbidity in Ghana [1]. As a risk factor, hypertension is a major cause of cardiovascular diseases (CVD) and stroke that accounted for nearly 22% of mortality among patients at the Korle-Bu Teaching hospital, a large urban teaching-hospital in Ghana [2]. Hypertension awareness, treatment and control remain poor [2-4]. A meta-analysis of population-based studies in Ghana reported that between 7.2% - 31.3% of hypertension patients reported using antihypertensive medications [3]. A more recent analysis of the 2014 Ghana Demographic and Health Survey (GDHS) reported that 32.6% of hypertension patients reported using antihypertensive medications [2]. Hypertension has thus been found to be under-treated in Ghana. What is unknown is the quality of pharmacologic treatment received by those who reported using antihypertensive medications. None of the existing published reports were able to investigate beyond a binary response to self-reported use of antihypertensive medications. Further, because all existing studies are based on self-reported antihypertensive medication use, the authors were unable to assess the doses, types and total number of unique antihypertensive medications used [5-9]. Yet this information is critical for understanding the quality of treatment provided to hypertensive patients.

To address this lack of data on how patients are treated with antihypertensive medications in Ghana, we leveraged prescribed medication use data from the Ghana National Health Insurance Scheme (NHIS) electronic claims database to: 1) measure the prevalence and identify the predictors of antihypertensive medication use among hypertension patients; 2) assess the quality of antihypertensive treatment (based on dose, drug regime and types of medications used) and identify the predictors of these quality indicators.

METHODS

4

Data source

Through a data access request process, the National Health Insurance Authority (NHIA) provided us with the 2015 NHIS claims data, drawn from a random sample of 54 providers across the country. The content and structure of this database has been previously described [10]. Briefly, the Ghana NHIS is a universal health coverage plan that has been in existence since 2004 and currently covers about 10.4 million insured lives (~40% of the Ghanaian population). This database captures information on drugs dispensed, medical diagnosis, procedures, clinical investigations/tests, the associated costs of all services provided, etc. Because the NHIS uses a local unique drug naming convention (a nine alpha-numeric code for identifying unique drugs), we reviewed the names of drugs included in the NHIS essential medicines list to identify all antihypertensive drugs that were covered under this health plan [10,11]. Based on this list of identified antihypertensive drugs, we mapped each drug to its corresponding Anatomical Therapeutic Chemical (ATC) code.

Study population

Hypertension diagnosis was defined using the ICD-10 codes for hypertension diagnosis: I10-13. We restricted our analysis to patients aged 12 years or older because the NHIS classifies hypertension patients based on an age cut-off of 12 years [12]. Only participants with non-missing ICD-10 codes were included in the analysis.

Outcomes

The primary outcomes for this study were the prevalence of antihypertensive use and quality of therapy among hypertension patients.

Antihypertensive use: This was defined as a prescription for at least a single antihypertensive agent from any therapeutic class (angiotensin-converting enzyme inhibitor [ACEI], angiotensin-receptor blocker [ARB], beta-blocker [BB], calcium channel blocker [CCB] or diuretic) among

5

patients with a hypertension diagnosis at any time during 2015. Hypertension patients who had at least one record of ATC corresponding to ACEI, ARB, BB, CCB, and diuretic were classified as antihypertensive users; all others, including those missing data for the NHIS' local code (5%) were classified as non-users of antihypertensive medications.

Most hypertension patients require at least 2 different agents to control their blood pressure [13,14], therefore, we also measured the prevalence of combination therapy and the total dose of antihypertensive medications consumed as:

a. Combination therapy: this was defined as use of at least two or more single or fixed-dose combinations of antihypertensive medications from different therapeutic classes. We also identified the 10 most frequently used two-drug combination regimen among those using at least two antihypertensive medications.

b. Dose of antihypertensive used: We calculated the one-year dispensed quantity for each drug for each patient. As a common unit of quantity across all drug substances, we used the Defined Daily Dose (DDD), developed by WHO for drug utilization statistics. According to WHO, one DDD is the assumed daily maintenance dose when the drug is used for its main indication in an adult[15]. This allowed us to meaningfully express quantities across a wide range of drugs that have different potency. For example, one DDD is 5 mg for amlodipine and 25 mg for hydrochlorothiazide.. Because DDDs are drug specific, we calculated separate DDDs for each antihypertensive agent used by patients. For fixed combination products (e.g. lisinopril/hydrochlorothiazide), each component was included separately, i.e., a person using a combination product would contribute equally as using each component by separate prescriptions. We chose this procedure to simplify the description of the used regimes and since focus was on the substances used and their quantities and not on whether they were given as fixed dose combinations or not.

6

The Quality of antihypertensive therapy was assessed based on the Ghana Ministry of Health's Standard Treatment Guidelines and the American Medical Association's Eighth Joint National Committee (JNC 8) clinical guidelines [1,14]. Two measures for quality of antihypertensive therapy were operationally defined as follows:

a. Use of a thiazide diuretic or CCB, with or without other agents. These two medications are the recommended drugs for initial treatment of hypertension among Blacks [14].

b. Guideline-concordant antihypertensive use by comorbidities: Guideline concordant treatment was defined as the use of specific antihypertensive medications among hypertension patients with compelling indications based on the presence of comorbidities [14]. We created the following disease-drug pairs as indicators of guideline-concordant treatment; 1) heart failure (ICD-10: I50, I50.0, I50.1, I50.9): use of ACEI or ARB plus BB; 2) myocardial infarction (MI) (ICD-10: I21-23)/Coronary Artery Disease (CAD) (ICD-10: I25); use of ACEI/ARB and BB. For those with only CAD, use of ACEI, BB, diuretic or CCB will be considered guideline-concordant treatment; 3) Diabetes (ICD-10: E08-E11, E13): use of ACEI/ARB, CCB or diuretic; 4) Chronic kidney disease (CKD) (ICD-10: N18): ACEI/ARB; 5) stroke (ICD-10: I63): ACEI, diuretic.

Candidate predictors: We defined several demographic, clinical and healthcare utilization factors based on literature and availability of information in the 2015 NHIS claims data. These variables are listed in Table 1 and include: age, sex, region of healthcare provider, compelling chronic conditions for antihypertensive therapy, contraindications for antihypertensive therapy and use of other medications, cost of medications and overall healthcare service utilization. We also included other comorbidities that may be contraindicated for some antihypertensive therapy; asthma, chronic obstructive pulmonary disease (COPD), or heart block. Comorbidities were defined based on the corresponding ICD-10 codes of each condition. ATC codes were

7

used to define use of other medications. Cost of medicines and healthcare system utilization were measured directly from reimbursement information in the 2015 claims dataset.

Statistical analysis

The Pearson Chi-square test was used to assess the distribution of candidate predictors between users and non-users of antihypertensive medications among patients diagnosed with hypertension. We also described antihypertensive use in terms of overall prevalence of use by therapeutic classes and total dose consumed. Further, we described the frequency of use and defined daily dose (DDD) of the top-most frequently used single and two-drug combination antihypertensive regimen. The quality of antihypertensive therapy was also described. The rest of the analysis focused on identifying predictors of each outcome; use, annual consumptions and quality of antihypertensive therapy. We used logistic regression models to assess the associations between prespecified candidate predictors and antihypertensive treatment use and quality as binary outcomes. The odds ratios (OR) and corresponding 95% confidence intervals (CI) of each predictor was extracted from these models. We assessed bivariate associations between each candidate predictor and outcomes through unadjusted logistic regression models. The multivariable-adjusted associations between each candidate predictor and outcomes were adjusted for all other candidate predictors included in the model.

Missing data for candidate predictors

About 19% of the sample was missing data for age. Because age was not missing at random between antihypertensive users (62%) and non-users (38%), we used the hot deck method to impute these missing ages [16]. The propensity of missing age was calculated as the probability of missing age conditional on all other predictors (except antihypertensive medication use) [17]. Missing ages were then replaced by ages from participants who had similar propensity scores as those with missing ages [17]. Because only participants with valid ICD-10 codes were included in the analysis, there were no missing data for all chronic condition variables given that these

8

were defined from ICD-10 codes. All patients included in our analysis had valid data for sex, geographical region and cost of healthcare utilization.

RESULTS

The 2015 Ghana NHIS dataset contained 16,490,013 electronically processed claims from 54 medical providers located in the then 10 regions of Ghana. There were 161,873 enrollees (out of 1,424,656; 11%) with a hypertension diagnosis in 2015. The prevalence of comorbid compelling indications for antihypertensive therapy among these hypertension patients were, 23%, 14%, 4%, 4%, 3% for diabetes, CKD, stroke, MI/CAD and heart failure respectively. The majority of the hypertension patients, 86%, were using at least one antihypertensive agent during 2015. The mean age of the hypertension patients was 59 (standard deviation [SD], 15) years.

Characteristics of hypertension patients by antihypertensive medications use status

 The characteristics of antihypertensive users and non-users are compared in **Table 1**. The antihypertensive users were older than non-users; 60 (SD, 15) vs. 56 (SD, 17) years. More female patients (74%) used an antihypertensive agent compared to male patients (36%) (P <0.01). The proportion of hypertension patients who used antihypertensive agents also differed by geographic region of residence; residents in the Ashanti region were most likely to use antihypertensives (25%) whereas those in Greater Accra (33%), the capital region of Ghana, were most likely to be non-users (33%) (P <0.01). Users and non-users of antihypertensive agents were also different on several clinical characteristics and co-medication use variables except for anticoagulant use, diabetes, peripheral artery disease (PAD).

Patterns of antihypertensive medication use

9

Table 2 is a rank order of the top-most frequently used single and two-drug antihypertensive regimen among hypertension patients. CCBs were the most frequently used antihypertensive agents either as monotherapy (60%) or in combination with another antihypertensive agent (42%). In terms of dosage of consumed antihypertensive agents, ARBs were consumed at the highest dosages of 120 (Interquartile Range [IQR]: 60, 180) DDDs over a year. Both combinations of CCB plus diuretics and ACE plus CCBs were consumed at the highest dosages (240 [120, 450] DDD, when including both drugs) among all two-drug antihypertensive regimen.

Predictors of overall antihypertensive medication use

The associations, odds ratios (OR) with 95% confidence intervals (CI), between predictors and antihypertensive medication use from univariable and multivariable-adjusted models are presented in **Table 3**. Females were more likely than males to use antihypertensive medications. Compared to older adults (>60 years old), younger patients were less likely to use antihypertensive medications. Significant geographic variation in antihypertensive use was observed; patients were more likely to use antihypertensive medication in any region compared to the capital region, Greater Accra (GR). Antihypertensive medication use also increased with cost of outpatient and inpatient service utilization. Patients with comorbid HF (OR = 1.57, 95%CI: 1.41, 1.75) and CKD (OR = 1.14, 95%CI: 1.09, 1.19) were more likely to use antihypertensive medications whereas those with comorbid diabetes (OR = 0.72, 95% CI: 0.69, 0.74) or stroke (OR = 0.91, 95% CI: 0.84, 0.99) were less likely to use antihypertensive medications. The presence of comorbid MI/CAD was not associated with antihypertensive use.

The quality of antihypertensive therapy based on concordance with clinical guideline recommendations

Overall, only about a third (32% [18,346 out of 56,815]) of the hypertension patients received treatment in accordance with clinical guidelines as described in the methods section. By

10

individual compelling indications, guideline-concordant antihypertensive therapy was highest among those with comorbid CKD (use of ACEI/ARB), 59% (11,940 out of 20,359). A quarter of those with stroke (1,467 out of 5,776) also received guideline concordant therapy (ACEI or diuretic). Only 20% (6,391 out of 32,736), 10% (541 out of 5,166) and 8% (430 out of 5,720) of hypertension patients with comorbid diabetes, heart failure or MI/CAD used a guideline-concordant antihypertensive therapy.

Predictors of guideline-concordant antihypertensive therapy

The multivariable logistic regression analysis identified majority of the variables assessed to be significantly associated with guideline-concordant therapy except the presence of other chronic comorbid conditions (PAD, thyroid disease, asthma, COPD, arthritis and heart block
), **Table 4a**. Guideline-concordant therapy increased with increasing cost of both medications and overall healthcare (outpatient and inpatient services) utilization. The predictors of guideline concordant therapy by each compelling indication varied slightly from those observed in the overall population (**Tables 4a** and **4b**). The only exception was cost that was consistently associated with higher odds of guideline-concordant therapy.

DISCUSSION

Use of antihypertensive therapy was very high among hypertension patients who had health insurance coverage from the Ghana NHIS. Nearly half of the patients used both CCBs and diuretics. However, the overall quality of antihypertensive therapy in terms of guideline-concordant therapy was suboptimal especially among patients who had diagnosis of chronic conditions that indicate for antihypertensive therapy. Only a third of the patients who had a comorbid diagnosis of heart failure, MI/CAD, diabetes, CKD or stroke received antihypertensive therapy according to the JCN 8 clinical guidelines [14]. For all substances, we found surprisingly small quantities dispensed over a year for each user.

11

The prevalence of hypertension (11%) observed from the NHIS database is comparable to the national data from the 2014 GDHS data [2]. However, the prevalence of antihypertensive use observed among NHIS enrollees (86%) in our study was two times larger than the most recent data from the 2014 GDHS data [2]. Older studies reported even smaller proportions (18% – 31%) of use of antihypertensive therapy among hypertension patients [5-9]. Our study design involved only patients with health insurance coverage and antihypertensive use was defined from claims data, in contrast, previously published studies involved the general population and defined prevalence of antihypertensive medication use based on self-reports. These self-reported medication use were not verified by the authors.

The predictors of antihypertensive use from claims data have not been previously investigated in Ghana. The majority of the factors assessed as potential predictors in our analysis were significantly associated with antihypertensive use. Nonetheless, it is concerning that MI/CAD, diabetes and stroke - chronic conditions that indicate for antihypertensive therapy – were rather associated with non-use of antihypertensive medications. Further research is needed to better understand the drivers of these associations.

The overall quality of antihypertensive therapy was suboptimal despite the near universal use of antihypertensive medications; only about a third of the hypertension patients received clinical guideline-concordant antihypertensive therapy. The quality of treatment varied across subgroups of patients with compelling chronic indications for antihypertensive therapy. While the quality of antihypertensive therapy was moderate (59%) among patients with comorbid CKD, the quality was poor for all other subgroups. Guideline-concordant therapy was hardly followed for treating patients with comorbid heart failure or MI/CAD. This is very concerning because

12

uncontrolled hypertension is a major risk factor of death among patients with these comorbid conditions.

Implications of findings

Our analysis suggests that the NHIS coverage has positively impacted access to antihypertensive medication because the proportions of patients using antihypertensive medications among the NHIS enrollees is significantly higher compared to that in the general population. However, our data also highlights major gaps in the quality of pharmacologic management of hypertension in Ghana. Specifically, there needs to be concerted efforts to adequately treat patients who are at most risk of adverse hypertension outcomes because of comorbid compelling indications (heart failure, MI/CAD, diabetes, stroke or CKD), other chronic conditions and male sex. Additional research is needed, however, to address the gaps in the quality of antihypertensive therapy identified in this analysis. We propose further be conducted to understand antihypertensive prescribing practices by clinicians and identify barriers that can be intervened on to improve the quality of antihypertensive therapy. Longitudinal NHIS claims data as well as other primary cohort data would be required to successfully carry out this type of study.

Strength and limitations

Our study features several strengths in spite of the aforementioned limitations. First, this is the single largest study of antihypertensive use and quality of therapy among 161,873 adults with hypertension in Ghana. The major limitation of our study is that we had access to only cross-sectional NHIS claims data to implement our objectives. Because of this we are unable to infer any causal associations between measured predictors and antihypertensive medication use and quality of treatment. Additionally, because our analysis involved prevalent hypertension

13

diagnosis and antihypertensive use, we could not assess the potential impact of prior adverse reactions on the quality of antihypertensive therapy. We were also unable to assess the impact of critical determinants of access to medications such as socioeconomic status (SES) because the NHIS claims data did not capture this variable. However, we would not expect our results to change significantly had we included SES in our analysis because antihypertensive medications are provided at no cost to the patient. Baseline blood pressure level is a major predictor of antihypertensive therapy, however, this variable is not present in the NHIS claims data. Other variables that are related to need for antihypertensive therapy include non-pharmacologic complementary treatment such as diet and exercise, however, these were also not captured in the dataset. Although the NHIS claims data have been audited for reimbursement purposes, we have not independently validated the accuracy of the ICD-10 diagnosis codes and ATCs for defining diseases and medication use in our analysis. Lastly, this data does not fully represent the entire Ghana population because data was available for only hospitals that submitted electronic claims for reimbursement in 2015.

CONCLUSION

The majority of hypertension patients covered under the Ghana NHIS received antihypertensive medications. This demonstrates the benefits of this national health insurance plan to hypertension patients. However, treatment patterns were indicative of suboptimal quality of antihypertensive therapy provided. Providers need to adhere better with antihypertensive treatment guidelines especially among hypertension patients with compelling indications for antihypertensive medication use.

14

TABLES

Table 1: Description of the characteristics of hypertension patients by antihypertensive medication use status in the 2015 Ghana National Health Insurance Scheme database.

Predictors	Overall, N=161,873	Antihypertensive medication use (%)		P-value
		Did not use, n=22,535	Used, n=139,337	
Demographics				
Age (mean [SD]), years		56.08 (16.51)	59.88 (14.97)	
Age groups, years				0.00
12 - 29	4,486	10.96	6.62	
30 - 39	11,742	17.10	15.61	
40 - 49	25,203	22.53	24.73	
50 - 59	39,812	43.21	50.61	
≥60	80,630	6.20	2.42	
Sex				
Female	117,546	63.96	74.02	0.00
Provider region	161,873			0.00
Ashanti	38,808	20.95	24.46	
Brong Ahafo	27,499	19.28	16.62	
Central	14,973	6.66	9.67	
Eastern	19,090	6.48	12.65	
Greater Accra	28,942	32.55	15.51	
Northern	10,070	5.79	6.29	
Upper East	5,731	2.47	3.71	
Upper West	2,774	1.40	1.76	
Volta	3,635	1.25	2.41	
Western	10,351	3.16	6.92	
Clinical factors				
Medications				
Statin	7,260	1.59	4.95	0.00
Aspirin	25,726	4.46	17.74	0.00
Antidiabetics	29,770	11.10	19.57	0.00
Anticoagulant	86	0.04	0.06	0.22
Compelling chronic conditions				
Heart failure	5,554	1.72	3.71	0.00
MI/CAD	6,363	2.85	4.11	0.00
Diabetes	37,984	23.29	23.49	0.50
Stroke	6,546	3.42	4.15	0.00
CKD	23,034	11.87	14.61	0.00
Other chronic conditions				
PAD	77	0.05	0.05	0.67
Thyroid disease	953	0.71	0.57	0.01
Asthma	2,601	1.26	1.66	0.00
COPD	150	0.04	0.10	0.01
Arthritis	431	0.14	0.29	0.00
Heart block	977	0.61	0.60	0.85

Cost of healthcare utilization (Ghana cedis)				0.00
≤8.91 (1st quartile)	40,634	30.53	24.22	
8.92 – 20.26 (2nd quartile)	41,392	43.88	22.61	
20.7 - 53.46 (3rd quartile)	40,172	17.33	26.03	
>53.46 (4th quartile)	39,675	8.26	27.14	

Abbreviations: MI, myocardial infarction; CAD, coronary artery disease; CKD, chronic kidney disease; PAD, peripheral arterial disease; COPD, chronic obstructive pulmonary disease.

Accepted Article

Table 2: The frequency and defined daily dose (DDD) of the top most frequently used single and two-drug regimens among the overall hypertension patients in enrolled in the Ghana National Health Insurance Scheme.

Rank-order	Regimen type	Frequency of use		Total DDD dispensed for drug regime	
		Counts	%	Median	IQR
		Single-therapy			
1	CCB	20791	59.8	74	59, 180
2	ACEI	5131	14.8	60	30, 120
3	Diuretics	3897	11.22	30	30, 60
4	ARB	2357	6.8	120	60, 180
5	BB	1123	3.2	20	10, 40
		Two-drug therapy			
1	CCB + DIU	27441	42.1	240	120, 450
2	ACE + CCB	15804	24.2	240	120, 450
3	ARB + CCB	7616	11.7	150	300, 540
4	BB + CCB	3557	5.5	180	80, 360
5	ACE + DIU	2476	3.8	126	62, 267
6	CCB + ACE/DIU*	2453	3.8	224	120, 450
7	ARB + DIU	1450	2.2	235	120, 367
8	BB + DIU	759	1.2	105	53, 240
9	ACE + BB	408	0.6	110	50, 240
10	ACE + ARB	239	0.4	158	90, 240

* Fixed-dose combination

Abbreviations: MI, myocardial infarction; CAD, coronary artery disease; CKD, chronic kidney disease; PAD, peripheral arterial disease; COPD, chronic obstructive pulmonary disease.

Table 3: Predictors of antihypertensive medication use among hypertension patients enrolled in the Ghana National Health Insurance Scheme.

Predictors	Unadjusted associations		Multivariable-adjusted associations	
	Odds ratio (OR)	95% confidence interval (CI)	OR	95% CI
Demographics				
Age (years)				
12 - 29	0.33	0.31, 0.35	0.31	0.28, 0.33
30 - 39	0.52	0.50, 0.55	0.53	0.50, 0.56
40 - 49	0.8	0.77, 0.84	0.82	0.79, 0.86
50 - 59	0.93	0.90, 0.97	0.93	0.90, 0.97
≥60	Referent	N/A	Referent	N/A
Sex				
Female	Referent	N/A	Referent	N/A
Male	0.62	0.60, 0.64	0.60	0.58, 0.61
Provider-related factors				
Provider region				
Greater Accra	Referent	N/A	Referent	N/A
Ashanti	2.45	2.36, 2.55	3.41	3.26, 3.56
Brong Ahafo	1.81	1.74, 1.89	1.89	1.81, 1.98
Central	3.05	2.87, 3.23	2.76	2.60, 2.94
Eastern	4.10	3.86, 4.35	3.73	3.51, 3.97
Northern	2.28	2.14, 2.43	2.01	1.87, 2.15
Upper East	3.15	2.88, 3.46	3.93	3.57, 4.32
Upper West	2.64	2.34, 2.98	2.87	2.54, 3.24
Volta	4.04	3.57, 4.57	4.05	3.57, 4.60
Western	4.60	4.24, 4.98	5.26	4.83, 5.72
Compelling chronic conditions				
Heart failure	2.20	1.98, 2.44	1.57	1.41, 1.75
MI/CAD	1.46	1.34, 1.58	0.94	0.87, 1.03
Diabetes	1.01	0.98, 1.05	0.72	0.69, 0.74
Stroke	1.22	1.13, 1.32	0.91	0.84, 0.99
CKD	1.27	1.22, 1.33	1.14	1.09, 1.19
Other chronic conditions				
PAD	0.88	0.47, 1.62	0.45	0.23, 0.86
Thyroid disease	0.80	0.68, 0.95	0.60	0.50, 0.72
Asthma	1.32	1.17, 1.50	1.05	0.92, 1.20
COPD	2.53	1.29, 4.97	2.00	1.02, 3.90
Arthritis	2.09	1.45, 3.01	1.40	0.96, 2.04
Heart block	0.98	0.82, 1.18	0.70	0.58, 0.85
Cost of healthcare utilization (Ghana cedis)				
≤8.91 (1st quartile)	Referent	N/A	Referent	N/A
8.92 – 20.26 (2nd quartile)	0.65	0.63, 0.67	0.82	0.79, 0.85
20.7 - 53.46 (3rd quartile)	1.89	1.82, 1.97	2.30	2.20, 2.40
>53.46 (4th quartile)	4.14	3.93, 4.37	5.41	5.10, 5.74

Abbreviations: MI, myocardial infarction; CAD, coronary artery disease; CKD, chronic kidney disease; PAD, peripheral arterial disease; COPD, chronic obstructive pulmonary disease.

Table 4a: Factors associated with the use of guideline-concordant antihypertensive medication therapy among subgroups of hypertension patients with compelling conditions for antihypertensive therapy (Overall, Heart failure, and MI/CAD)

Predictors	Overall (n=56815)		Heart failure (n=5166)		MI/CAD (n=5720)	
	OR	95% CI	OR	95% CI	OR	95% CI
Demographics						
Age (years)						
12 - 29	1.13	0.97, 1.32	0.82	0.35, 1.95	0.41	0.09, 1.79
30 - 39	0.84	0.76, 0.94	2.07	1.38, 3.10	0.87	0.52, 1.45
40 - 49	1.04	0.98, 1.11	2.11	1.59, 2.80	1.27	0.94, 1.71
50 - 59	1.01	0.96, 1.06	1.22	0.96, 1.56	1.02	0.80, 1.30
≥60	Referent	N/A	Referent	N/A	Referent	N/A
Sex						
Female	Referent	N/A	Referent	N/A	Referent	N/A
Male	1.27	1.21, 1.33	1.04	0.85, 1.27	1.22	0.97, 1.53
Provider-related factors						
Provider region						
Greater Accra	Referent	N/A	Referent	N/A	Referent	N/A
Ashanti	1.09	1.01, 1.17	0.41	0.26, 0.63	0.53	0.28, 1.02
Brong Ahafo	0.63	0.58, 0.68	0.95	0.66, 1.36	1.17	0.72, 1.91
Central	0.89	0.81, 0.97	1.46	0.98, 2.19	0.82	0.51, 1.32
Eastern	0.65	0.60, 0.71	0.77	0.53, 1.12	0.43	0.26, 0.72
Northern	0.75	0.66, 0.84	1.19	0.77, 1.85	0.95	0.55, 1.65
Upper East	0.99	0.85, 1.15	1.09	0.61, 1.97	*	*
Upper West	1.33	1.13, 1.57	0.64	0.27, 1.50	0.26	0.10, 0.69
Volta	1.02	0.87, 1.20	0.47	0.27, 0.82	1.50	0.51, 4.42
Western	1.30	1.18, 1.44	0.69	0.40, 1.19	0.68	0.41, 1.11
Compelling chronic conditions						
Heart failure	2.52	2.31, 2.74	N/A	N/A	1.33	0.94, 1.89
MI/CAD	1.15	1.05, 1.25	0.76	0.54, 1.08	N/A	N/A
Diabetes	2.71	2.55, 2.88	1.16	0.94, 1.44	1.04	0.83, 1.31
Stroke	3.06	2.81, 3.33	1.01	0.72, 1.41	0.88	0.58, 1.32
CKD	21.16	19.83, 22.58	0.93	0.74, 1.16	1.09	0.85, 1.40
Other chronic conditions						
PAD	1.05	0.48, 2.30	*	*	*	*
Thyroid disease	0.97	0.75, 1.26	1.67	0.69, 4.03	1.59	0.79, 3.21
Asthma	1.02	0.88, 1.19	1.39	0.96, 2.02	0.86	0.49, 1.48
COPD	1.36	0.79, 2.33	1.20	0.47, 3.08	2.33	0.46, 11.77
Arthritis	0.71	0.47, 1.08	*	*	*	*
Heart block	0.97	0.75, 1.26	0.42	0.18, 0.95	1.15	0.51, 2.61
Cost of healthcare utilization (Ghana cedis)						
≤8.91 (1st quartile)	1.34	1.24, 1.45	1.19	0.68, 2.08	0.40	0.19, 0.88
8.92 – 20.26 (2nd quartile)	1.31	1.22, 1.40	1.29	0.80, 2.10	1.02	0.60, 1.73
20.7 - 53.46 (3rd quartile)	2.04	1.91, 2.19	2.65	1.68, 4.19	1.44	0.87, 2.39
Cost of antihypertensive medications (Ghana cedis)						
≤16.50 (1st quartile)	2.93	2.68, 3.20	5.27	2.49, 11.15	2.48	1.29, 4.76

16.51 – 45.61 (2nd quartile)	5.48	5.02, 5.99	9.83	4.71, 20.51	2.91	1.54, 5.49
45.62 - 105.60 (3rd quartile)	12.18	11.13, 13.32	13.03	6.26, 27.13	6.27	3.39, 11.61

*Dropped because of collinearity or no variation

Abbreviations: MI, myocardial infarction; CAD, coronary artery disease; CKD, chronic kidney disease; PAD, peripheral arterial disease; COPD, chronic obstructive pulmonary disease.

Table 4b: Factors associated with the use of guideline-concordant antihypertensive medication therapy among subgroups of hypertension patients with compelling conditions for antihypertensive therapy (Diabetes, Stroke, and CKD)

Predictors	Diabetes (n =32736)		Stroke (n=5776)		CKD (n=20359)	
	OR	95% CI	OR	95% CI	OR	95% CI
Demographics						
Age (years)						
12 - 29	1.03	0.74, 1.42	0.47	0.23, 0.99	1.16	0.95, 1.40
30 - 39	0.83	0.69, 0.99	0.76	0.54, 1.07	0.82	0.72, 0.93
40 - 49	0.88	0.80, 0.97	0.97	0.79, 1.19	1.15	1.05, 1.26
50 - 59	0.87	0.82, 0.94	0.91	0.78, 1.06	1.21	1.11, 1.32
≥60	Referent	N/A	Referent	N/A	Referent	N/A
Sex						
Female	Referent	N/A	Referent	N/A	Referent	N/A
Male	1.11	1.04, 1.19	1.32	1.16, 1.51	1.48	1.38, 1.59
Provider-related factors						
Provider region						
Greater Accra	Referent	N/A	Referent	N/A	Referent	N/A
Ashanti	0.97	0.86, 1.09	1.44	1.06, 1.96	1.25	1.12, 1.38
Brong Ahafo	0.65	0.58, 0.73	1.25	0.98, 1.58	0.50	0.44, 0.56
Central	1.00	0.89, 1.13	1.77	1.31, 2.40	0.70	0.61, 0.81
Eastern	0.90	0.80, 1.02	1.83	1.45, 2.31	0.39	0.34, 0.44
Northern	0.46	0.38, 0.56	1.44	1.08, 1.92	0.86	0.73, 1.02
Upper East	2.22	1.73, 2.83	6.35	4.27, 9.44	0.68	0.58, 0.81
Upper West	1.03	0.80, 1.34	5.06	2.77, 9.24	1.83	1.43, 2.33
Volta	1.16	0.90, 1.49	4.14	3.03, 5.65	0.68	0.53, 0.87
Western	2.37	2.09, 2.70	2.26	1.64, 3.11	0.55	0.47, 0.65
Compelling chronic conditions						
Heart failure	4.92	4.32, 5.60	3.22	2.51, 4.14	2.43	2.05, 2.88
MI/CAD	1.20	1.07, 1.35	1.06	0.82, 1.38	0.96	0.83, 1.12
Diabetes	N/A	N/A	1.01	0.87, 1.17	2.82	2.59, 3.06
Stroke	1.49	1.31, 1.69	N/A	N/A	1.33	1.14, 1.55
CKD	1.30	1.20, 1.40	1.19	1.01, 1.40	N/A	N/A
Other chronic conditions						
PAD	1.53	0.64, 3.69	*	*	3.32	0.41, 26.83
Thyroid disease	1.22	0.87, 1.71	0.84	0.42, 1.68	0.90	0.64, 1.26
Asthma	1.05	0.83, 1.33	0.86	0.51, 1.43	1.15	0.90, 1.46
COPD	0.32	0.06, 1.81	1.12	0.24, 5.16	1.80	0.76, 4.28
Arthritis	0.89	0.45, 1.76	1.11	0.33, 3.75	0.84	0.49, 1.43
Heart block	1.52	1.02, 2.26	1.16	0.54, 2.49	0.88	0.61, 1.27
Cost of healthcare utilization (Ghana cedis)						
≤8.91 (1st quartile)	1.08	0.93, 1.26	1.66	1.18, 2.34	1.00	0.89, 1.11
8.92 – 20.26 (2nd quartile)	1.40	1.25, 1.57	1.49	1.10, 2.01	0.86	0.78, 0.96
20.7 - 53.46 (3rd quartile)	2.73	2.46, 3.03	2.40	1.81, 3.17	1.01	0.91, 1.12
Cost of antihypertensive medications (Ghana cedis)						
≤16.50 (1st quartile)	7.57	5.62, 10.20	2.61	1.94, 3.51	2.80	2.53, 3.10
16.51 – 45.61 (2nd quartile)	15.78	11.79,	4.29	3.21, 5.71	5.17	4.66, 5.75

		21.13				
45.62 - 105.60 (3rd quartile)	27.45	20.52, 36.71	7.57	5.69, 10.07	17.84	15.77, 20.19

*Dropped because of collinearity or no variation

Abbreviations: MI, myocardial infarction; CAD, coronary artery disease; CKD, chronic kidney disease; PAD, peripheral arterial disease; COPD, chronic obstructive pulmonary disease.

References

1. Ministry of Health RoG. Dietary and Physical Activity Guidelines for Ghana. In:2010.
2. Sanuade OA, Boatemaa S, Kushitor MK. Hypertension prevalence, awareness, treatment and control in Ghanaian population: Evidence from the Ghana demographic and health survey. *PLoS One.* 2018;13(11):e0205985.
3. Bosu WK. Epidemic of hypertension in Ghana: a systematic review. *BMC Public Health.* 2010;10:418.
4. Kushitor MK, Boatemaa S. The double burden of disease and the challenge of health access: Evidence from Access, Bottlenecks, Cost and Equity facility survey in Ghana. *PLoS One.* 2018;13(3):e0194677.
5. Agyemang C, Bruijnzeels MA, Owusu-Dabo E. Factors associated with hypertension awareness, treatment, and control in Ghana, West Africa. *J Hum Hypertens.* 2006;20(1):67-71.
6. Cappuccio FP, Micah FB, Emmett L, et al. Prevalence, detection, management, and control of hypertension in Ashanti, West Africa. *Hypertension.* 2004;43(5):1017-1022.
7. Addo J, Smeeth L, Leon DA. Prevalence, detection, management, and control of hypertension in Ghanaian civil servants. *Ethn Dis.* 2008;18(4):505-511.
8. Addo J, Amoah AG, Koram KA. The changing patterns of hypertension in Ghana: a study of four rural communities in the Ga District. *Ethn Dis.* 2006;16(4):894-899.
9. Amoah AG. Hypertension in Ghana: a cross-sectional community prevalence study in greater Accra. *Ethn Dis.* 2003;13(3):310-315.
10. Ankrah D, Hallas J, Odei J, Asenso-Boadi F, Dsane-Selby L, Donneyong M. A review of the Ghana National Health Insurance Scheme claims database: possibilities and limits for drug utilization research. *Basic Clin Pharmacol Toxicol.* 2019;124(1):18-27.
11. Authority GNHI. NHIS Medicines List 2021. http://www.nhis.gov.gh/files/Main%20Medicines%20List%202021%20March%20Version%20(003).pdf. Published 2021. Accessed 03/23/2021, 2021.
12. Dsane-Selby HWNOL. *Ghana National Health Insurance Scheme: Improving Financial Sustainability Based on Expenditure Review.*
13. Ministry of Health RoG. Standard Treatment Guidelines. In. Seventh ed2017.
14. James PA, Oparil S, Carter BL, et al. 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). *Jama.* 2014;311(5):507-520.
15. Methodology WCCfDS. Definition and general considerations. https://www.whocc.no/ddd/definition_and_general_considera/. Published 2021. Accessed 03/19/2021, 2021.
16. Ford B. Incomplete data in sample surveys. *New York Academic Pr.* 1983;185:207.
17. Little RJ. Survey nonresponse adjustments for estimates of means. *International Statistical Review/Revue Internationale de Statistique.* 1986:139-157.