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RESEARCH ARTICLE

Multilevel modeling, prevalence, and predictors of hypertension in Ghana: Evidence from Wave 2 of the World Health Organization's Study on global AGEing and adult health

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Abstract

Background and aims: Hypertension is a major public health issue, an important risk factor for cardiovascular diseases and stroke, especially in developing countries where the rates remain unacceptably high. In Africa, hypertension is the leading driver of cardiovascular disease and stroke deaths. Identification of critical risk factors of hypertension can help formulate targeted public health programs and policies aimed at reducing the prevalence and its associated morbidity, disability, and mortality. This study attempts to develop multilevel regression, an in-depth statistical model to identify critical risk factors of hypertension.

Methods: This study used data on 4667 individuals aged ≥18 years from the nationally representative World Health Organization Study on global AGEing and adult health (SAGE) Ghana Wave 2 conducted in 2014/2015. Multilevel regression modeling was employed to identify critical risk factors for hypertension based on systolic blood pressure (SBP) (ie, SBP > 140 mmHg). Of the 4667, 27.3% were hypertensive. Final data on 4381 individuals residing in 3790 households were analyzed using multilevel models, and results were presented as adjusted odds ratios (aOR) and their associated 95% confidence intervals (CI).

Results: Risk factors for hypertension identified were age (aOR) = 5.4, 95% CI: 4.11-7.09), obesity (aOR = 1.51, 95% CI: 1.19-1.91), marital status (aOR = 0.75, 95% CI: 0.64-0.89), perceived health state (moderate; aOR = 1.38, 95% CI: 1.15-1.65 and bad/very bad; aOR = 1.35, 95% CI: 1.0-1.83), and difficulty with self-care (aOR = 1.64, 95% CI: 1.1-2.44). We found unobserved significant differences in the likelihood of hypertension prevalence between different households.

Conclusion: Addressing the problem of obesity, targeting specific interventions to those aged over 50 years, and improvement in the general health of Ghanaians are paramount to reducing the prevalence and its associated morbidity, disability, and mortality. Lifestyle modification in the form of dietary intake, knowledge provision

Abbreviations: AIC, Akaike Information Criterion; BIC, Bayesian information criterion; BMI, body mass index; LRT, likelihood ratio test; NCDs, noncommunicable diseases; SBP, systolic blood pressure; GVIF, generalized variance inflation factor; VPC, variance partitioning coefficient.

supported with strong public health message, and political will could be beneficial to the management and prevention of hypertension.

KEYWORDS
AGEing and adult health, developing countries, hypertension, hypertension predictors, multilevel modeling, sub-Saharan Africa

1 | BACKGROUND

Hypertension remains one of the biggest threats to public health globally, especially in the low- and middle-income countries where the prevalence is the highest as a result of more people residing in these countries, and with greater priority and interest in infectious diseases.[1,2] It contributes significantly to the global burden of cardiovascular and its related illnesses like stroke, kidney, and heart failures, and their resultant premature morbidity, disability, and mortality. Hypertension is responsible for 51% of deaths from stroke and at least 45% from heart diseases. Overall, it is responsible for about 50% of deaths from stroke and heart disease.[3,4] The Global Burden of Disease Study Group reported that in 2017, cardiovascular diseases were the leading cause of death in Africa and were responsible for 1.42 million deaths or 16.4% of the total deaths in all ages.[5] High blood pressure, one of the noncommunicable diseases (NCDs), is the leading risk factor for deaths in Africa, responsible for nearly two-thirds of the cardiovascular deaths in the region. Globally, Africa has the highest prevalence of high blood pressure (27%)[6] and a common cause of medical hospitalization in the region[7] and responsible for over 50% of first-time acute stroke.[8,9] Previous studies reported that with the aging population and the rising urbanization and its associated stress, sedentary lifestyle, and "Western" diet, high blood pressure will continue to rise.[2,6,9,10]

Previous studies observe that older age, race, cigarette smoking, high salt intake, high body mass index (BMI), alcohol use, female sex, urban residence, physical inactivity, and genetics are among the main factors associated with hypertension.9,11-16 Although not a significant problem previously in groups like young and rural populations, hypertension is now a critical public health problem in these groups.[9,17-19]

There is a renewed political will to address NCDs as a result of the third high-level meeting of the United Nations General Assembly in October 2018, during which Heads of State and Governments committed to reorienting health systems to respond to the needs of the rapidly aging population in relation to NCDs.[9,20,21] However, sound statistical methods are required to analyze the barriers and facilitators of hypertension in order to achieve this ambitious goal. Furthermore, there is paucity of data on whether individuals belonging to a particular household are more or less likely to be hypertensive compared with individuals belonging to a different household and what factors might account for this. It is against this background that this study attempts to estimate the prevalence and to employ a multilevel regression model to identify correlates of hypertension to inform sound and targeted policies aimed at improving cardiovascular health outcomes in this group of adults.

2 | METHODS

2.1 | Study population

This work was based on the nationally representative World Health Organization Study on global AGEing and adult health (SAGE) Ghana Wave 2 conducted in the period 2014/2015, which is a household-based survey.[22] This is a nationwide representative household survey that employed multistage cluster sampling strategies where clusters were systematically sampled and households residing in the selected clusters identified/listed and individuals in those selected households selected for interview. The multistage cluster sampling strategy employed was to allow each household and individual respondent to be assigned a known nonzero selection probability. From the list of individuals listed from each household, all persons aged 50 years and older were selected from households classified as those with individuals aged "≥50 years households" and one person aged 18 to 49 years was selected from a household classified as those with individuals aged "18–49 years households" to complete the individual interview. Trained field officers visited sampled households for individual and household interviews. SAGE is a multicountry study that collects data to complement existing aging data sources to inform policy and programs. Two separate questionnaires (individual and household) were used during the survey. In the present study, we merge the individual- and household-level datasets using a unique individual and household identification number. Information on subjective well-being, risk factors and preventive health behaviors, quality of life and health care utilization, perceived health status, household characteristics, sociodemographic and social cohesion were collected from individuals aged ≥50 years. WHO SAGE surveys primarily focus on older adults (≥50), but for the purpose of comparison, a smaller sample of those aged 18 to 49 years was also included in the study. Detailed description of the methods is published elsewhere.[23] The data in this study were used in previous studies.[24-26]

2.2 | Outcome variable

The outcome variable of interest in the study is hypertension status based on systolic blood pressure measurement (SBP > 140 mmHg).

The blood pressure readings were taken three times between rest periods with 1 minute between each measurement using an oscillometric device, and the measures are standardized as required of such exercise. This study always adopts international standards and procedures in the data collection and analysis, and used the recommended threshold of SBP > 140 mmHg to declare the hypertension status[27] (ie, SBP > 140 mmHg = hypertensive coded as 1, and 0 otherwise).

2.3 | Covariates

This study considered several covariates based on the literature on factors influencing hypertension, including other potential health variables yet to be established in the literature as risk factors. These include age (<50 vs ≥50), obesity according to WHO standards[28] (ie, BMI≥30 (obese) vs BMI < 30 (not obese)), ethnicity (Akan, Ewe, Ga-Adangbe, Guan and Northern dialect), sex (male vs female), marital status (not currently married vs currently married), type of toilet facility in household (flush toilets vs non-flush toilets), perceived health state at the time of the interview (good/very good, moderate and bad/very bad) and difficulty with self-care (good/very good, mild, moderate and severe/extreme), alcohol consumption (no vs yes), type of cooking fuel (gas/electric: advanced fuel; coal/charcoal/kerosene: transition fuel; and wood: primitive fuel), household wall (durable materials vs nondurable materials) and floor types (hard floor vs earth floor).[2,11-14,29-31]

For toilet facilities, the survey asked, "What type of toilet facility do members of your household usually use?" and we grouped the responses as indicated earlier. For the perceived health state today variable, the survey asked, "In general, how would you rate your health today?" and responses were recorded. In case of difficulty with self-care, the survey asked, "Overall in the last 30 days, how much difficulty did you have with self-care, such as bathing/washing or dressing yourself?". Regarding alcohol consumption, the survey asked, "Have you ever consumed a drink that contains alcohol (such as beer, wine, spirits)?" with yes or no responses as indicated earlier. For household cooking fuel, the survey asked, "What type of fuel does your household mainly use for cooking?" and we grouped the responses according to primitive, transition, and advanced fuels. The survey also collected data on household wall type through the question "What type of wall does your dwelling have?" and we combined the responses as presented earlier. Finally, floor types of households were measured through the question "What type of floor does your dwelling have?" and responses recorded as presented above.

2.4 | Statistical analysis

Descriptive statistics were used to summarize the distribution of selected background characteristics of respondents. Further analyses were conducted to examine individual and household-level factors that might be significantly associated with hypertension and explored unobserved household-level effects on the outcome. We extract data on a total of 4667 individuals with valid measurements on systolic blood pressure. Due to missingness in some critical covariates, a final sample of 4381 individuals was used in our final models. Both single-level and multilevel (mixed effects) logistic regression models were applied on 4381 individuals residing in 3790 households with complete measurements on hypertension as well as complete measurements on potential explanatory variables considered in the final models. The minimum and the maximum number of individuals living in household were one (1) and seven (7), respectively. The extension of the single-level logistic regression model to the multilevel logistic regression model is warranted because of the hierarchical structure of the SAGE dataset, where we have individuals nested within households. Specifically, we applied a multilevel logistic regression model to examine possible differences in hypertension among individuals across households while simultaneously identifying potential risk factors. Thus, the multilevel modeling approach[32] placed particular emphasis on household-level differences in the risk of hypertension among individuals and the extent of nesting of hypertension within a household, which cannot be achieved through a single-level logistic regression model.

We present the binary multilevel model formulation in which we allowed for clustering (ie, individuals nested within households) in the data. Let P_{ij} be the probability that individual i from household j is hypertensive, $P_{ij} = \left(\frac{P_{ij}}{1-P_{ij}}\right)$ is the odds of being hypertensive by individual i living in household j. Our model formulation is given as follows:

$$\log\left(\frac{P_{ij}}{1-P_{ij}}\right) = \alpha + \boldsymbol{d}(\boldsymbol{x_{ij}})'\beta + h_{0j},$$

where α is the overall mean probability of being hypertensive shared by all households, $d(.)$ is a vector of risk factors, β is a vector of regression coefficients, h_{0j} is the household-level residual assumed to follow a normal distribution with mean zero (0) and variance τ^2.

To quantify the proportion of total variation attributable to within-households differences, the household-level variance partitioning coefficient (VPC)[33] was employed, which is estimated as VPC = $(\tau^2/(\tau^2 + \text{individual-level variance})) \times 100$. The individual-level residual is assumed to follow standard logistic distribution with mean zero and variance $\pi^2/3$, where $\pi = 3.14$.[34] However, the VPC lacks physical interpretation or is difficult to interpret because it is estimated on the log-odds scale. To address this, we computed the median odds ratio (MOR) as a measure of household-level variation or heterogeneity. The MOR is preferred because it is easier to interpret and understand as it is expressed in terms of inter-household variance on the odds ratio scale based on which the effects of risk factors are also interpreted.[35,36] Specifically, the MOR converted the household-level variance to a measure of spread on the odds ratio scale, providing information about the average difference between two random households. Given the household-level variance as τ^2, the MOR is estimated as follows:

TABLE 1 Distribution of hypertension status by selected background characteristics of the respondents

Variable	Hypertensive status		*P* value
	No n (%)	Yes n (%)	
Age			
<50	1039 (91.1)	101 (8.9)	<.001
≥50	2355 (66.8)	1172 (33.2)	
Sex			
Male	1457 (75.6)	471 (24.4)	<.001
Female	1937 (70.7)	802 (29.3)	
Ethnicity			
Akan	1649 (72.8)	615 (27.2)	<.001
Ewe	182 (66.9)	90 (33.1)	
Ga-Adangbe	390 (67.1)	191 (32.9)	
Guan	148 (77.1)	44 (22.9)	
Northern dialect	1025 (75.5)	333 (24.5)	
Marital status			
Currently not married	1430 (69.1)	639 (30.9)	<.001
Currently married	1964 (75.6)	634 (24.4)	
Father's education			
No formal education	2483 (71.9)	970 (28.1)	.049
Primary or less	421 (73.3)	153 (26.7)	
Secondary or higher	490 (76.6)	150 (23.4)	
Obesity			
No	2911 (74.4)	1002 (25.6)	<.001
Yes	367 (65.8)	191 (34.2)	
Vigorous activity			
None	1600 (78.6)	437 (21.4)	<.001
Mild	524 (73.5)	189 (26.5)	
Moderate	645 (72.5)	245 (27.5)	
Severe	273 (60.3)	180 (39.7)	
Extreme	344 (61.3)	217 (38.7)	
Use tobacco			
Yes	190 (67.6)	91 (32.4)	.047
No	3193 (73.1)	1177 (26.9)	
Ever use alcohol			
No	2406 (73.0)	892 (27.0)	.605
Yes	977 (72.2)	376 (27.8)	
Perceived health state			
Good/very good	2451 (77.1)	727 (22.9)	<.001
Moderate	702 (63.8)	398 (36.2)	
Bad/very bad	235 (61.8)	145 (38.2)	
High salt diet can cause health problems			
Yes	2085 (72.0)	812 (28.0)	.723
No	1017 (72.5)	386 (27.5)	

TABLE 1 (Continued)

Variable	Hypertensive status		*P* value
	No n (%)	Yes n (%)	
Problem with self-care			
None	2769 (74.2)	961 (25.8)	<.001
Mild	479 (71.0)	196 (29.0)	
Moderate	115 (57.5)	85 (42.5)	
Severe/extreme	26 (46.4)	30 (53.6)	
Wall			
Durable materials	2073 (71.2)	838 (28.8)	.005
Nondurable materials	1297 (75.0)	432 (25.0)	
Drinking water			
Piped source	1680 (72.0)	655 (28.0)	.291
Non-piped source	1691 (73.3)	615 (26.7)	
Toilets			
Flush toilets	485 (67.5)	234 (32.5)	.001
Non-flush toilets	2883 (73.7)	1030 (26.3)	
Cooking fuel			
Gas/electric/kerosene	403 (70.1)	172 (29.9)	.249
Coal/charcoal	1133 (72.2)	436 (27.8)	
Wood	1815 (73.4)	657 (26.6)	
Shared toilets			
No	631 (68.7)	288 (31.3)	.010
Yes	2191 (73.0)	809 (27.0)	
Floor			
Hard floor	2882 (72.0)	1118 (28.0)	.026
Earth floor	483 (76.3)	150 (23.7)	

$$\mathrm{MOR} = \exp\left(\sqrt{2\times\tau^2}\times\varphi^{-1}(0.75)\right) \cong \exp\left(0.945\times\sqrt{\tau^2}\right)$$

Model parameters were obtained using maximum likelihood. Identity covariance structure provided a good fit to the data in the multilevel logistic model. The goodness of fit for the fitted models was examined using a likelihood ratio test (LRT), Akaike information criterion (AIC), and Bayesian information criterion (BIC). Generalized variance inflation factor (GVIF) was used to check multicollinearity, and a GVIF value below 10 was considered acceptable (ie, no multicollinearity).[37] All the analyses were performed using Stata 14.0.[38] Backward elimination was employed to select candidate set of risk factors for multivariable logistic regression analysis. *P* value < .05 was used to declare statistical significance.

2.5 | Ethics statement

SAGE was approved by the World Health Organization's Ethical Review Board (reference number RPC149) and the Ethical and Protocol Review Committee, College of Health Sciences, University of Ghana, Accra, Ghana. Written informed consent was obtained from all study participants. All methods were performed in accordance with the relevant guidelines and regulations.

3 | RESULTS

3.1 | Sample characteristics

Of the 4667 individual respondents, 1273 (27.3%) were hypertensive (92.1% for ≥50 and 7.9% for <50 years old). Of 3527 individuals aged ≥50 years, 1172 (33.2%) were hypertensive, and of 1140 individuals aged <50 years, 101 (8.9%) were hypertensive. Prevalence of hypertension was higher among females (29.3%), those currently not married (30.9%), individuals who are obese (34.2%), persons with severe vigorous activity (39.7%), and persons who use tobacco (32.4%). The prevalence is also higher among those who perceived their health state to be bad/very bad (38.2%) and those who rated themselves as having severe/extreme problems with self-care (53.6%). Age, sex, ethnic group, marital status, and father's educational level of the study participants were associated with hypertension status in the cross-

TABLE 2 Risk factors for hypertension from single-and multilevel logistic regression models

Variables	Single-level logistic uOR (95% CI)	aOR (95% CI)	Multilevel logistic aOR (95% CI)
Age			
<50 y	Ref	Ref	Ref
50 or more	5.12 (4.13-6.35)***	4.85 (3.85-6.11)***	5.40 (4.11-7.09)***
Obesity			
No	Ref	Ref	Ref
Yes	1.51 (1.25-1.83)***	1.47 (1.19-1.83)***	1.51 (1.19-1.91)**
Sex			
Male	Ref	Ref	Ref
Female	1.28 (1.12-1.46)***	1.11 (0.94-1.31)	1.11 (0.94-1.33)
Marital status			
Not currently married	Ref	Ref	Ref
Currently married	0.72 (0.63-0.82)***	0.76 (0.66-0.89)***	0.75 (0.64-0.89)**
Toilet facility			
Flush toilets	Ref	Ref	Ref
Non-flush toilets	0.74 (0.62-0.88)***	0.79 (0.63-0.99)*	0.79 (0.62-1.01)
Perceived health state			
Good/very good	Ref	Ref	Ref
Moderate	1.91 (1.65-2.22)***	1.34 (1.14-1.58)***	1.38 (1.15-1.65)***
Bad/very bad	2.08 (1.66-2.6)***	1.32 (1-1.73)*	1.35 (1.00-1.83)*
Difficulty with self-care			
Good/ very good	Ref	Ref	Ref
Mild	1.18 (0.98-1.41)	1.05 (0.86-1.28)	1.06 (0.85-1.32)
Moderate	2.13 (1.59-2.85)***	1.57 (1.09-2.25)*	1.64 (1.1-2.44)*
Severe/extreme	3.32 (1.96-5.65)***	1.78 (0.77-4.13)	1.88 (0.74-4.73)
Alcohol			
No	Ref	Ref	Ref
Yes	1.04 (0.9-1.2)	1.09 (0.92-1.28)	1.1 (0.92-1.31)
Cooking fuel			
Gas/electric	Ref	Ref	Ref
Coal/charcoal/kerosene	0.96 (0.77-1.18)	0.97 (0.75-1.26)	0.96 (0.73-1.28)
Wood	0.88 (0.72-1.09)	0.87 (0.66-1.13)	0.84 (0.63-1.14)
Walls			
Durable materials	Ref		
Nondurable material	0.82 (0.72-0.94)**		
Floor			
Hard floor	Ref		
Earth floor	0.8 (0.66-0.97)*		
Ethnicity			
Akan	Ref		
Ewe	1.33 (1.01-1.74)*		
Ga-Adangbe	1.31 (1.08-1.6)**		
Guan	0.8 (0.56-1.13)		
Northern dialect	0.87 (0.75-1.02)		
Random effect parameters			Estimates
Individual-level variance			$\pi^2/3 \approx 3.29$

TABLE 2 (Continued)

Variables	Single-level logistic uOR (95% CI)	aOR (95% CI)	Multilevel logistic aOR (95% CI)
Household-level variance (τ^2)			0.46 (0.15-1.48)
Variance partitioning coefficient			12.27%
Median odds ratio			1.90

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; Ref, reference category; uOR, unadjusted odds ratio.
*Significant at 5%; **Significant at 1%;***Significant at 0.1%.

tabulation results. Other factors associated with hypertension status include obesity, vigorous activity, use of tobacco, perceived health state, problem with self-care, wall, type of toilet, toilet shared, and floor type (Table 1).

3.2 | Predictors of hypertension

The univariable analyses identified age, obesity, sex, marital status, toilet facility, health state, difficulty with self-care, wall type, floor type, and ethnicity as significant predictors of hypertension. Significant predictors of hypertension in the multivariable model include age, obesity, marital status, toilet facility, perceived health state, and difficulty with self-care.

Comparing the single-level multivariable logistic regression to the multilevel logistic regression model (Table 2), the multilevel model provided a good fit to the data. Thus, the multilevel logistic regression is preferred to the single-level multivariable model.

Significant predictors of hypertension in the multilevel model include age, obesity, marital status, perceived health state, and difficulty with self-care.

Significant unobserved household-level variations in hypertension were found. The results from the variation analyses showed that over 12% of variance in hypertension could be attributable to residual household-level variations after adjusting for individual- and household-level factors considered in the multilevel model. The estimated median odds ratio (MOR) on the other hand was estimated as 1.90, suggesting that hypertension varied significantly between households because MOR is 90% higher than the reference (MOR = 1).

Individuals aged ≥50 years had increased odds of hypertension compared with those aged 18 to 49 years (aOR) = 5.4, 95% CI: 4.11-7.09). There is a 51% increase in the odds of hypertension among individuals who are obese compared with their counterparts who are not obese (aOR = 1.51, 95% CI: 1.19-1.91). Individuals who are currently married had 25% less odds of having hypertension compared with those who are not currently married (aOR = 0.75, 95% CI: 0.64-0.89), suggesting that unmarried persons had 33% increased odds of having hypertension. Individuals who rated their perceived health state as moderate or bad/very bad had 38% and 35% higher odds of having hypertension, respectively, compared with those who rated themselves as good/very good (aOR = 1.38, 95% CI: 1.15-1.65 and aOR = 1.35, 95% CI: 1.0-1.83). Those who rated themselves as having moderate difficulty with self-care had 64% higher odds of having hypertension compared with those who rated themselves as having no difficulty (aOR = 1.64, 95% CI: 1.1-2.44) (Table 2).

4 | DISCUSSION

4.1 | Principal findings

The study sets out to estimate hypertension prevalence and to develop a novel multilevel logistic regression model to identify critical risk factors of hypertension to help in formulating targeted policies that could improve cardiovascular health among Ghanaian adults. Data on 4381 individuals were analyzed to identify critical risk factors of hypertension. In this study, a hypertension prevalence of 27.3% was observed, suggesting that hypertension among Ghanaian adults is still a serious public health issue. Critical risk factors independently associated with hypertension were age, obesity, marital status, health state, and difficulty with self-care. We observed strong residual household-level variations in hypertension, and over 12% of variation in hypertension in adults could be attributable to unobserved household-level differences. The estimated MOR, which is 90% higher than the reference (MOR = 1), suggests that hypertension prevalence significantly varied across households in Ghana.

4.2 | Interpretation

The estimated hypertension prevalence in this study was 27.3%. This prevalence exceeded the 18% prevalence observed in her neighboring country Burkina Faso,[31] and other African countries with prevalence of 24.5% in Kenya[14] and 8% in Tanzania[39] but lower than the 31% observed in Nigeria.[40] These differences could be attributable to the setting and study designs. Critical risk factors independently associated with hypertension while adjusting for the unobserved household-level effects were age, obesity, marital status, perceived health state, and difficulty with self-care.

Of critical importance to this study is the quantification of residual household-level effects on hypertension among adults, which represent differences in household-level hypertension outcomes that cannot be explained by the available household-level covariates.

Generally, the health and the general well-being of individuals is heavily reliant on the households they belong to. Thus, the households determine the resources, opportunities, and risks available to the individual over their life course.[41-43] We observed strong residual household-level variations in hypertension, and over 12% of variation in hypertension in adults could be attributable to unobserved household-level variations after adjusting for the risk factors in the model. The MOR of 1.90, which is 90% higher than the reference (MOR = 1), indicates that hypertension prevalence substantially varied from one household to another in Ghana. This could be attributable to household-level, social, and environmental factors not considered in our model. Recognizing the hierarchical nature of the data via multilevel modeling in this study helps avoid spurious statistical significance and misleading conclusion that is commonly associated with using single-level models in the presence of clustered data due to underestimation of standard errors for the regression coefficients.

The study broadly supports earlier studies that examined determinants of hypertension in developing countries. For instance, older age group, obesity, rating perceived health state as moderate or bad/very bad, and rating level of difficulty for self-care as moderate were associated with increased odds of hypertension in adults, and those who were currently married had reduced odds of hypertension.[3,11-15,31,40,44,45] The association between hypertension and the older age group observed in this study could be attributable to variations in the arterial structure and function, notably arterial stiffening with adverse consequences on cardiac structure and function.[40,46,47] Individuals who were currently unmarried had increased odds of hypertension compared with those who were currently married. Protective effects for marriage on health have been established in previous studies.[48,49] However, this finding is not consistent with a previous study that observed that married women had increased odds of hypertension, but no such association was found in men in the same study.[3] It also contradicts a previous study[50] that did not find an association between marital status and hypertension, but this could be as a result of the setting or how the variable marital status was categorized. Marital status is a critical social characteristic that is well known to predict a range of health outcomes such as cardiovascular illnesses[51,52] and mortality in general.[49,53]

Obesity, which is one of the modifiable risk factors considered in this study, showed an association with hypertension. Individuals who were obese had higher odds of hypertension compared with their counterparts who were not obese, a finding that is consistent with previous studies.[14,31,39,40,45,54] The association between hypertension and obesity had been established and well known, and reducing BMI is part of the advice provided in the treatment of hypertension.[31,55] This could be attributable to metabolic and endocrine disorders as a result of increasing BMI.[56]

Individuals who rated their perceived health state as moderate or bad/very bad on the day of the interview had increased odds of hypertension compared with those who rated their perceived health state as good/very good. Also, those who rated their difficulty with self-care as moderate had increased odds of hypertension compared with their counterparts who rated themselves as having no difficulty. These findings are plausible because, in a previous study, a hypertensive group had significantly lower age-adjusted health status scores compared with the non-hypertensive group.[57] To the best of our knowledge, this is the first study to have established an association between hypertension and health variables like self-reported perceived health state and difficulty with self-care. The significant association between hypertension and these health variables suggests the need to improve the overall health of Ghanaian adults to reduce and prevent the high prevalence of hypertension among this group.

One of the major public health issues in Ghana presently is the rise in the prevalence of NCDs.[58,59] The findings in the present study provided vital and current information on prevalence and critical risk factors for hypertension that can be used by policymakers and health practitioners for better understanding of hypertension and its prevention and management, which could lead to more effective prevention approaches, patient management, and improved cardiovascular outcomes. The study highlights the need to address the problem of obesity, targeting specific interventions to those aged over 50 years, and improvement in the general health of the Ghanaian population as a primary intervention is warranted as part of an overall strategy to reduce the hypertension prevalence and its resultant premature morbidity, disability, and mortality.

4.3 | Strengths of the study

The strengths of this study include the fact that it utilized data from a nationally representative population-based survey, which is globally respected for its sound survey methods and sound data quality on individuals, their households, and communities in which they reside. The large samples drawn nationwide permit generalization of findings to the population of adults in Ghana and that of adults from other similar populations globally. The study also used a novel multilevel modeling approach, permitting the study of unobserved household-level effects on hypertension. Thus, providing much more information about why individuals from certain households are more likely to be hypertensive while others are not and at the same time investigating underlying associations between hypertension and the risk factors, which could not have been possible using a single-level logistic regression approach.

4.4 | Limitation of the data

Despite these strengths, the study has limitations, and so the findings should be interpreted with caution. For example, the cross-sectional nature of the survey and the analytical techniques employed in the analysis of the data could not establish cause and effect relationship between hypertension and the risk factors considered. Also, some of the risk factors such as perceived health state and difficulty with self-care were based on self-reports and so could introduce reporting bias. The variation in hypertension prevalence among those aged <50 and

≥50 years should be interpreted with caution because the WHO SAGE surveys primarily focus on older adults and so always sample more older adults (≥50 years) compared with younger adults (18-49 years). Finally, as with all studies of this nature, our study could not measure all factors that might be associated with hypertension status.

5 | CONCLUSION

Findings from the study show that the prevalence of hypertension remains high among Ghanaian adults. This study developed a novel multilevel binary logistic regression model, which captures unobserved household-level effects and identified critical risk factors of hypertension that can aid formulation of health policies and intervention strategies that will improve cardiovascular health outcomes of the Ghanaian adults. Lifestyle modification in the form of dietary intake, knowledge provision supported with strong public health messages, and political will could be beneficial to the management and prevention of hypertension. Active screening for hypertension should be encouraged to identify undiagnosed cases to minimize the danger of stroke and cardiovascular diseases, but there is a need to improve the health systems and services in the country to reap the full benefits of such interventions. There is also the need to target younger populations to minimize their risk of developing hypertension during adulthood/old age. Further study to identify as-yet unidentified risk factors that might account for the substantial unexplained household-level variations in adult hypertension is warranted.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTIONS

Conceptualization: Justice Moses K. Aheto
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Formal analysis: Justice Moses K. Aheto
Investigation: Justice Moses K. Aheto
Funding acquisition: Justice Moses K. Aheto
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All authors have read and approved the final version of the manuscript.

Justice Moses K. Aheto had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

CONSENT FOR PUBLICATION

Not applicable.

TRANSPARENCY STATEMENT

Justice Moses K. Aheto, affirm that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

DATA AVAILABILITY STATEMENT

Data are freely available upon making official request to WHO-SAGE Team through the WHO website at http://www.who.int/healthinfo/sage/cohorts/en/. However, registration is required for access to the data files.

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