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ORIGINAL ARTICLE

Prevalence, risk factors, and self-awareness for hypertension and diabetes: rural–urban and male–female dimensions from a cross-sectional study in Ghana

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Abstract

Background Hypertension and diabetes remain the primary cause of non-communicable disease (NCD) related morbidity and mortality globally. Rural–urban transitions in developing countries might aggravate the risk factors and prevalence of these conditions. The study aims to determine prevalence, demographic, anthropometric, and diet-related predisposing factors for hypertension and diabetes among urban and rural dwellers and assess participants' self-awareness of their hypertension and diabetes status.

Methods This cross-sectional survey involved 850 adult males and females age ≥ 18 years residing in urban and rural areas in the Hohoe Municipality of Ghana, randomly sampled using probability proportional to size. Data included demographic, anthropometric, physiologic (blood pressure, fasting blood glucose), and dietary information. Nutrient quantities were analysed using the Research to Improve Infant Nutrition and Growth (RIING) Nutrient Database Software. All other data was analysed in SPSS (v25). Risk factors for hypertension were estimated through ordinal logistic regression and the odds ratio (OR) with the corresponding 95% confidence level (CI) documented.

Results More females participated than males (58.4% vs 41.6%), similarly rural compared to urban inhabitants (53.5% vs 47.5%, $p = 0.002$) with a mean age of 47.3 ± 16.1 years. Females generally had higher adiposity, rural dwellers had higher BMI, whereas urban dwellers had higher waist and hip circumferences. Overall, 4.4% and 18.5% were diabetics and prediabetics,, while 20.4% and 12.1% were overweight and obese respectively. Of the 36.8% hypertensives, only 18.2% were aware of their status, with significant male (40.3%) female (59.7%), and urban (43.5%) rural (56.6%) differences. Males had higher intakes of energy and nutrients of public health importance to hypertension, similar as rural inhabitants except for cholesterol. Advancing age (95% CI: 0.02.03–0.05), being male (OR: 1.56 95% CI:0.12–0.81), and increased BMI (95% CI: 0.01–0.11) were independently associated with hypertension.

Conclusions One third of the population were hypertensives but were unaware. Findings challenge the assumption of lower predisposition among rural inhabitants as we observe lifestyle habits consistent with increasing urbanisation. Efforts to mitigate rising NCD trend requires intensified community-based screening, awareness creation, and lifestyle interventions to improve diet, physical activity, and health seeking.

Keyword Elevated blood pressure · Elevated blood glucose · Non-communicable diseases · Adiposity · Body mass index · Urbanization · Undiagnosed

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Background

Globally, nutrition-related non-communicable diseases (NCDs) including cardiovascular diseases, hypertension, and diabetes mellitus (DM) are the primary cause of morbidity and mortality [1]. According to the World Health Organization (WHO), NCDs are responsible for 71% (41 million) of the 57 million deaths globally and 85% of NCD deaths are reported in low- and middle-income countries

(LMIC) [2]. Self-reported high blood pressure has increased from 594 million (in 1975) to 1.3 billion (in 2015) with the increase mostly in LMIC (2). Hypertension is a risk factor for many NCDs worldwide, with the highest prevalence of 27% reported in African [2]. In sub-Saharan Africa, 19.4 million adults aged 20–79 years had diabetes in 2019 with 6.8% of all-cause mortality attributed to diabetes [3].

NCDs are estimated to account for 43% of all deaths [4] with hypertension and diabetes ranked seventh and ninth respectively among the ten most common causes of mortality in Ghana, in 2016 [5]. The current situation of hypertension in many LMIC is a burden on resource limited health care and is already higher than in high-income countries [6]. In Ghana, a systematic review reported an increase in hypertension prevalence from 19 to 48% from 1970 to 2007 [7]. Diabetes in Ghana represents 2% of all deaths and prevalence is around 4.8% but is predicted to rise [8]. Meanwhile, related risk factors of overweight and obesity are at 30.8% and 10.9% respectively [9], albeit the absence of a national survey data assessing blood glucose levels.

Worldwide, demographic, socio-economic, dietary, lifestyle, and behavioural factors are associated risk factors for hypertension, and this is similar for Africa [10]. NCDs have increased notably from the growth in urbanisation in many LMICs [11]. Some differences have been observed between urban and rural areas in Ghana in relation to prevalence and occurrence of risk factors, in that urban populations have a higher prevalence and risk factors for hypertension. [12–15]. Despite this, there is limited data on the prevalence and risk factors in rural areas as these areas are given less research attention [12, 14]. For instance, in urban Accra in Ghana, reported prevalence of hypertension was 28.3%, and most alarmingly, 92.6% of participants were not aware of their condition. Of those that were aware, only 3.9% of participants accessed treatment [13].

Urbanisation is considered a determinant of health and one of the key drivers of NCDs, especially in LMICs [16], although industrialisation varies from country to country and differences between urban and rural regions of the same geographical area are evident [17]. Whilst this has been demonstrated in previous research in many areas of Ghana where economic shifts have resulted in increasing urbanisation, the impact of urbanisation in transitional areas of the country is rarely reported. This applies to largely rural areas now undergoing development and urbanisation as a consequence of economic development. Ghana is experiencing growth in its cities and districts due to urbanisation and these areas are being redefined as peri-urban and urban areas. Furthermore, occupation and gender roles of women particularly in rural areas is often different from urban areas where many women find employment outside the home and area of residence.

Determining the prevalence and risk factors of hypertension in peri-urban and rural areas is important to guide public health policy. Furthermore, assessing the awareness is critical not only to inform health promotion activities but also to prevent development of related NCDs such as diabetes [18]. We aimed to undertake a cross-sectional survey in a rural and peri-urban setting in Ghana. We assessed prevalence and associated risk factors for hypertension and diabetes. We also compared the rates among males and females in rural and developing peri-urban sub-districts of the Hohoe municipality in Ghana and included an additional focus on diabetes to assess the current situation.

Methods

Study design and location

The cross-sectional survey was conducted in the Hohoe Municipality, with data collection completed in 2018. The Hohoe municipality is one of the 17 administrative districts in the newly re-demarcated Volta region, one of 16 regions in Ghana. Hohoe municipality, the second largest municipality in the region, is located in the north-eastern end of the region, about 78 and 218 km (km) from Ho, the Volta regional capital, and Accra, the national capital respectively. The municipality shares its boundaries with the Republic of Togo to the East, Jasikan District to the North, Kpando District to the West, and Afadjato South District to the South. It covers an area of 1403 km^2 consisting of 174 communities with a population of 188,963 comprising 52.1% females and 47.9% males [19]. The municipality is youthful (35.9% of the population are under age 15 years) and also largely urban (52.6%) (19).

Study population

Inclusion criteria: Free-living adult males and self-reporting non-pregnant females age 18 years and above were recruited from urban and rural areas of the Hohoe municipality ($n = 850$). Exclusion criteria: Males and females under 18 and not residing in the Hohoe municipality were excluded from the study.

Study communities were selected by random sampling using probability proportional to size. This method was carried out by creating a cumulative list of communities with the respective populations in the six sub-districts of the Hohoe municipality (Hohoe, Gbi rural, Alavanyo, Agumatsa, Likpe, Akpafu/Santrokofi) (Table 1) after which a systematic sample was drawn from a random start. Based on the WHO's Expanded Programme on Immunization (EPI) sampling method, 30 clusters representing 30 communities were chosen and the total municipality population of 195,856 inhabitants divided by the 30 clusters to obtain the sampling interval [20]. This generated a sample size of

Table 1 Distribution of participants by sub-districts and geographical location

Sub-district	Classification of geographical location	*n*	%
Hohoe	Urban	405	47.6
Gbi-rural	Rural	52	6.1
Alavanyo	Rural	36	4.2
Akpafu/Sanko	Rural	77	9.1
Agumatsa	Rural	39	4.6
Likpe	Rural	241	28.4
Total		850	100

n participants

850 participants. Thereafter, proportional allocation was employed to derive a representative sample size from each community identified and bias was eliminated.

Data collection tools and procedures

A pre-piloted structured quantitative questionnaire with mainly closed questions was used to collect the data. Information elicited included demographic, anthropometric, and physiologic measurements. Dietary data was collected using a multiple-pass 24-h recall method and common household measures used as visual tools to assist in quantifying the portion sizes. Participants were asked to provide a list of all foods, drinks, beverages, and snacks eaten the day prior to the survey from when they awake in the morning to when they go to sleep. Data was collected by trained health professionals pursuing a top-up Bachelor degree in Public Health Nutrition at the School of Public Health, University of Health and Allied Sciences, Hohoe Ghana (F. Z., F. A., and B. E.). Data was obtained through face-to-face interview using the questionnaire and measurements tools. Data collected on a daily basis was checked by members of the research team to check for missing data and address this (O.F.K, D.D, and B.E). Data was inputted into the databases by two assistants and checked by other members of the reseach team.

Anthropometric measurements

Weight, height, waist, and hip measurements were recorded according to the Centre for Disease Control standardised anthropometric [21] protocols by trained researchers with participants wearing lightweight clothing without shoes. All measurements were taken in triplicate, and the two nearest measurements recorded to achieve consistency of data collected. Height was measured with a SECA stadiometer (SECA 875) to the nearest 0.1 cm. Weight was measured with a SECA digital scale (SECA 217) to the nearest 0.1 kg. Waist and hip circumference were measured using a non-extensible measuring tape to the nearest 0.1 cm. Waist circumference was measured an inch above the upper hip bone with the tape measure drawn around the waist parallel to the floor. The hip was identified at the widest part around the buttocks.

Physiological measurements

Resting upper arm arterial blood pressure (BP) was measured using the Omron digital sphygmomanometer recorded in mmHg. Repeated measurements were taken in triplicates at 5-min intervals, and the average of the two nearest measurements was recorded. Fasting blood glucose level was measured from a capillary thumb prick using the OneTouch digital glucometer and was recorded in mmol/L. Only subjects who were fasting at the point of data collection (before 9 am) had their fasting blood glucose levels measured.

Data handling and statistical analysis

Dietary information was analysed using the Research to Improve Infant Nutrition and Growth (RIING) Project Nutrient Database Software developed by the Department of Nutrition and Food Science, University of Ghana. The focus was on energy and nutrients of public health importance to hypertension. These included protein, carbohydrate, total fat, cholesterol, magnesium, potassium, sodium, and fibre. Nutrient values were automatically generated onto an Excel sheet and checked by a second researcher. Out-of-range values were flagged and cross-checked to identify possible coding errors (O.F.K). The Excel output was exported into Statistics Package for Social Sciences (SPSS, 24.0 IBM, USA) for analysis. Energy and nutrient values were compared with the Public Health England dietary reference values [22]. Under or over-reporting of dietary intakes were calculated as the ratio of energy intake (EI) to Basal Metabolic Rate (BMR) [23]. The EI to BMR ratio was calculated for each individual, and the cut off values used to identify under-reporters (< 1.14–1.34), normal reporters (1.35–2.39), and over-reporters (≥ 2.4).

Waist-to-hip ratio (WHR) was calculated by dividing waist circumference (WC) by hip circumference (HC). Cut-offs for obesity defined by WHR and WC was > 0.8 and > 88 cm respectively as recommended by the WHO [24]. Body mass index (BMI) was calculated based on WHO [25] criteria as weight in kilogram divided by height in meters squared, and the corresponding BMI were defined as < 18.5 kg/m^2 underweight, 18.5–24.9 kg/m^2 normal weight, 25.0–29.9 kg/m^2 overweight, and > 30 kg/m^2 obese.

Hypertension was defined as a systolic BP of at least 140 mmHg and a diastolic BP of at least 90 mmHg according to National Institute for Health and Care Excellence

(NICE) criteria [26]. Also, BP < 130/85 mmHg was considered as normal and 130 to 139/85 to 89 mmHg as high normal (pre-hypertension).

Fasting blood glucose less than 5.6 mmol/L was considered normal, 5.6 to 6.9 mmol/L was considered pre-diabetic (impaired fasting glucose), and 7 mmol/L or higher was defined as diabetes according to the WHO criteria [27].

Data analysis focused on the relationship between hypertension and diabetes status of individuals and their anthropometric measurements, dietary intakes, and their awareness thereof. All statistical analyses were performed using the Statistics Package for Social Sciences (SPSS IBM version 25). Kolmogorov–Smirnov test of normality was used to test the distribution of variables. Comparisons between groups were made using one-way analysis of variance (ANOVA), and Kruskal–Wallis test was used to determine whether the data was normally distributed. Post hoc Bonferonni correction and Dunn's test were used for ANOVA. Differences in nutrient intakes were examined with Mann–Whitney *U* test. Categorical data were examined using chi-square test and reported as frequencies and percentages. Continuous data were presented as means with the corresponding standard deviation (SD). The relationship between hypertension, diabetes, and its risk factors was examined through ordinal logistic regression by computing the unadjusted odds ratio at 95% confidence level (CI). Differences $p < 0.05$.were considered significant.

Results

Demography of participants

Demographic characteristics of study participants are presented in Tables 1 and 2. Overall, 41.6% were males and 58.4% were females ($p = 0.002$); 47.5% resided in urban areas and 53.5% in

Table 2 Demographic status of participants according to gender and place of residence

Variables	All *n* (%)	Male *n* (%)	Female *n* (%)	Urban *n* (%)	Rural *n* (%)
Gender					
Male	354 (41.6)			168(47.5)	186(52.5)
Female	496 (58.4)			237(47.8)	259(52.2)
Age groups					
< 20	12 (1.4)	8 (2.3)	4 (0.8)	8 (2.0)	4 (0.9)
20–29	129 (15.2)	70 (19.8)	59 (11.9)	86 (21.2)	43 (9.7)
30–39	148 (17.4)	66 (18.6)	82 (16.5)	91 (22.5)	57 (12.8)
40–49	162 (19.1)	68 (19.2)	94 (19.0)	76 (18.8)	86 (19.3)
50–59	184 (21.6)	58 (16.4)	126 (25.4)	75 (18.5)	109 (24.5)
60–69	130 (15.3)	42 (11.9)	88 (17.7)	39 (9.6)	91 (20.4)
70–79	68 (8.0)	35 (9.9)	33 (6.7)	24 (5.9)	44 (9.9)
80–89	17 (2.0)	7 (2.0)	10 (2.0)	6 (1.5)	11 (2.5)
Occupation					
Trading	208 (24.5)	23(6.5)	185(37.3)	133(32.8)	75(16.9)
Farming	262(30.8)	113(31.9)	149(30.0)	37(9.1)	225(50.6)
Artisan	146(17.2)	92(26.0)	54(10.9)	95(23.5)	51(11.5)
Formal job	81(9.5)	48(13.6)	33(6.7)	55(13.6)	26(5.8)
Schooling	38(4.5)	27(7.6)	11(2.2)	26(6.4)	12(2.7)
Retired	30(3.5)	21(5.9)	9(1.8)	11(2.7)	19(4.3)
Unemployed	61(7.2)	15(4.2)	46(9.3)	30(7.4)	31(7.0)
Others*	24(2.8)	15(4.2)	9(1.8)	18(4.4)	6(1.3)
Education					
No education	78(9.2)	14(4.0)	64(12.9)	47(11.6)	31(7.0)
Primary school	117(13.8)	25(7.1)	92(18.5)	56(13.8)	61(13.7)
Junior high school	397(46.7)	149(42.1)	248(50.0)	175(43.2)	222(49.9)
Senior high school	149(17.5)	91(25.7)	58(11.7)	63(15.6)	86(19.3)
Tertiary	109(12.8)	75(21.2)	34(6.9)	64(15.8)	45(10.1)
Sub-district					
Urban	405(47.5)	168(47.5)	237(47.8)		
Rural	445(53.5)	186(52.5)	259(52.2)		
Total	850	354	496	405	445

*Not included in any other group such as watchman rural areas. Mean age of participants was 47.3 ± 16.1 years. In the rural and urban areas, the primary occupations were farming and trading respectively. In terms of educational level, the highest level of completed education among the majority was junior high school. Table 3 represents the demographic analysis of participants categorised according to gender and place of residence.

Anthropometric indicators

Females had a higher BMI than males ($p < 0.001$) with a mean BMI of 26.1 ± 5.6 kg/m^2 compared to 22.5 ± 3.6 kg/m^2 for their male counterparts. Rural inhabitants had higher BMI than urban inhabitants ($p < 0.05$). Also, females had higher waist and hip circumferences than males ($p < 0.001$).

Dietary intakes and lifestyle habits

Dietary intakes are presented in Table 3. The mean energy intake was 2032.41 ± 863.81 kcal for males and 1802.43 ± 770.40 kcal for females. Mean protein intake for males and females was 98.66 ± 74.21 and 96.94 ± 70.95 g,

Table 3 Anthropometry and dietary intakes according to gender and place of residence

Variables	Mean (SD)			*p*-value	Mean (SD)		*p*-value
	All	Male ($n = 354$)	Female ($n = 496$)		Urban ($n = 405$)	Rural ($n = 445$)	
Age (years)*	47.3 (16.1)	45.4 (17.2)	48.6 (15.2)	0.002	43.2 (16.0)	51.0 (15.4)	< 0.001
Body mass index (kg/m^2)*	24.6 (5.2)	22.5 (3.6)	26.1 (5.6)	< 0.001	22.5 (5.5)	23.8 (4.8)	< 0.001
Waist circumference (cm)*	83.2 (14.8)	79.8 (10.4)	85.6 (14.1)	< 0.001	84.9 (12.6)	81.6 (13.2)	< 0.001
Hip circumference (cm)*	96.5 (12.3)	91.9 (8.04)	99.8 (13.63)	< 0.001	98.9 (11.3)	94.4 (12.8)	< 0.001
Waist hip ratio*	0.86 (0.08)	0.86 (0.08)	0.86 (0.08)	0.113	0.86 (0.08)	0.86 (0.08)	0.083
Fasting glucose (mmol/L)*	5.35 (1.41)	5.42 (1.46)	5.29 (1.37)	0.200	5.46 (1.57)	5.23 (1.20)	0.158
Diabetes$^\chi$ (*n* %)	61 (9.2)	27 (9.6)	34 (8.8)	0.464	46 (10.1)	15 (7.2)	0.173
Diastolic BP (mmHg)*	82.35 (14.2)	81.7 (14.3)	82.8 (15.2)	0.188	81.99 (15.0)	82.68 (14.7)	0.510
Systolic BP (mmHg)*	132.2 (23.9)	132.6 (22.6)	131.7 (24.9)	0.598	130.0 (22.9)	134.0 (24.8)	0.054
Energy (kcal)	1898.21 (818.02)	2032.41 (863.81)	1802.43 (770.40)	< 0.001	1707.86 (706.79)	2071.45 (872.85)	< 0.001
Protein (g)	97.66 (72.29)	98.66 (74.21)	96.94 (70.95)	0.732	72.90 (49.35)	120.18 (81.91)	< 0.001
Carbohydrate (g)	248.17 (118.42)	275.85 (126.58)	228.42 (108.10)	< 0.001	240.59 (114.27)	255.07 (121.79)	0.117
Total fat (g)	52.93 (34.54)	56.06 (36.57)	50.70 (32.88)	0.028	49.87 (31.63)	55.72 (36.81)	0.037
Cholesterol (mg)	32.83 (84.26)	37.51 (88.9)	29.49 (80.70)	0.178	41.48 (89.46)	24.96 (78.5)	< 0.001
Fibre (g)	18.37 (12.74)	21.2 (14.27)	16.33 (11.10)	< 0.001	18.09 (12.90)	18.61 (12.60)	0.381
Magnesium(mg)	58.35 (68.35)	66.03 (74.92)	54.58 (62.89)	0.016	66.03 (74.92)	54.58 (62.89)	< 0.001
Potassium (mg)	375.36 (464.4)	450.10 (564.74)	322.02 (368.36)	< 0.001	450.10 (564.74)	322.02 (368.36)	< 0.001
Sodium (mg)	498.29 (1493.26)	604.01 (1992.56)	422.84 (989.66)	0.081	604.01 (1992.56)	422.84 (989.66)	< 0.001
Smoking$^\chi$ (Yes) (n %)	49 (5.8)	46 (13)	3 (0.6)	$\chi^2 = 58.36$, $p < 0.001$	13 (3.2)	36 (8.1)	$\chi^2 = 9.295$, $p = 0.002$
Alcohol consumption$^\chi$ (Yes) (*n* %)	354 (41.6)	207 (58.5)	147 (29.6)	$\chi^2 = 70.68$, $p < 0.001$	130 (32.1)	224 (50.3)	$\chi^2 = 29.02$, $p = 0.001$
Physical activity$^\chi$ (Yes) (*n* %)	631 (74.2)	297 (83.9)	334 (67.3)	$\chi^2 = 30.80$, $p < 0.001$	268 (66.2)	363 (81.6)	$\chi^2 = 26.291$, $p < 0.001$

Values with mean and standard deviations were continuous, and number and percentage were categorical. Fasting glucose and diabetes were measured for $n = 665$ participants who were still in a fasting state at the time of data collection

BP blood pressure

*Mann–Whitney *U* test reporting the mean

$^\chi$Chi-square test reporting the proportions respectively. Mean carbohydrate intake was 275.85 ± 126.58 and 228.42 ± 108.10 g for males and females respectively. Public Health England recommends protein intakes of 55.5 g/day for males and 45.0 g/day for females, and carbohydrate intakes of at least 333 g/day and 267 g/day for males and females respectively [22]. Our findings show higher protein and lower carbohydrate intake than the recommendations in both males and females. Energy, carbohydrate, total fat, fibre, magnesium, and potassium intakes of males were significantly higher than females. Regarding the accuracy of reporting dietary intakes, 43.5% were under-reporters, 44% reported as actually consumed, and 12.3% were over-reporters. There was no statistical difference between gender, BMI, and WC classifications among under- or over-reporters of dietary intake (data not shown).

When we compared urban and rural dwellers, we identified higher intakes of energy, protein, and total fat among rural dwellers. Mean energy intake was 1707.86 ± 706.79 kcals, and 2071.45 ± 872.85 kcals, for urban and rural dwellers, respectively. In rural areas, mean protein intake was higher (120.18 ± 81.91 g) compared to urban areas (72.90 ± 49.35 g). The significant differences in protein intake might be due to rural communities having access to more nutritious foods of much higher dietary quality probably because they are more inclined to work in animal rearing. However, the consumption of plant-based protein is common in rural areas. In urban areas, mean cholesterol intake was 41.48 ± 89.46 g, while in rural areas, it was lower (24.96 ± 78.5 g). Although unsubstantiated, a plausible reason for the high cholesterol levels of urban inhabitants might be due to the availability of cooked and processed foods high in saturated fatty foods. Furthermore, urban inhabitants had higher intakes of magnesium, potassium, and sodium compared to rural inhabitants ($p < 0.05$). On a weekly basis, 5.8% of participants smoked cigarettes and 41.6% drank alcohol (obtained as a yes or no binary question). In relation to frequency of physical activity, there was a significant difference based on gender; males were more physically active than females ($p < 0.001$), and the physical activity took the form of walking.

Physiologic parameters

Overall, 665 eligible participants had their FBG measured (the rest had already taken breakfast). Mean FBG was 5.35 ± 1.41 mmol/L with no significant relationship between males and females nor urban and rural dwellers. Mean BP was 133/82 mmHg (SD 22.6/14.3) for males and 132/83 mmHg (SD 24.9/15.2) for females. Diastolic BP was slightly higher in females (82.8 ± 15.2 mmHg) than males (81.7 ± 14.3 mmHg) ($p = 0.188$). Mean systolic BP was 132.1 ± 23.9 mmHg in all participants with no statistical difference between males and females. Figure 1 presents participants' educational status and geographical location categorised according to BP values.

Mean diastolic and systolic BP was higher among participants who had only primary or no formal education and also among rural inhabitants compared to urban participants. Systolic BP was significantly higher among rural inhabitants. This finding suggests a relationship with isolated systolic hypertension (ISH). ISH is defined as systolic BP (SBP) ≥ 140 mmHg and diastolic BP (DBP) < 90 mmHg [28]. ISH is the most common type of hypertension and is associated with older age [28]. We noticed a higher mean age in the rural sub-districts (Table 2), yet participants were largely younger than 65 years. Thus, we find this elevated SBP at an earlier age profile among rural communities. Exploring the possible relationships between urban and rural areas as well as both DBP and SBP, we observed a significant relationship between SBP and rural residency ($p < 0.005$).

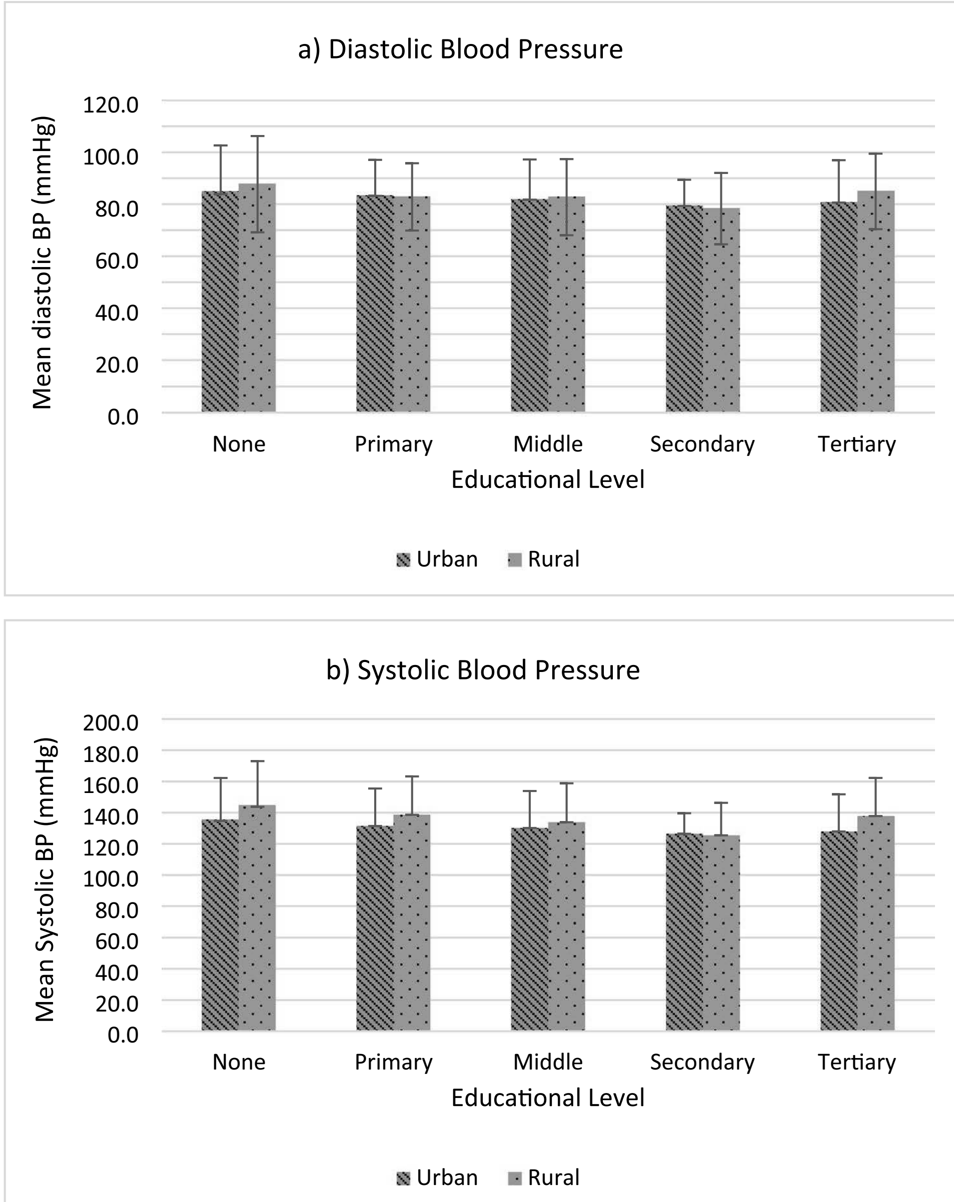
Table 4 presents blood pressure levels according to fasting blood glucose and anthropometric status. Overall, 36.8% had hypertension of which 40.3% were males and 59.7% females. Furthermore, 43.5% of urban dwellers and 56.6% of rural dwellers had hypertension. Fasting blood glucose levels of the hypertensive participants were the highest when compared with those with high-normal and normal measurements ($p < 0.05$). Hypertensive participants had higher BMI than non-hypertensives ($p < 0.001$) with a mean BMI of 25.32 ± 5.78 kg/m^2. According to BMI groups, a significant proportion of the hypertensives were overweight (24.7%) and obese (19.6%) (totalling 44.3%) in comparison to the normal group (totalling 32.5%). Hypertensive participants had the highest WC and WHR than the other participants ($p < 0.001$).

Risk factors for hypertension and diabetes

Age, BMI, gender, and educated to SHS/VocTech between education categories were found significant covariates for hypertension (significance level 95%) (Table 5). Aging (95% CI, 0.0251–0.0464; $p < 0.001$) increases the risk for hypertension. Being male is also a risk factor (OR, 1.586, 95% CI, 0.1174–0.8083; $p = 0.0086$) as is an increase in BMI (95% CI, 0.0120–0.1065; $p = 0.014$). Men were about 1.59 times more likely to have high blood pressure than women. SHS/Voc/Tech education level was at lower risk of having high blood pressure than those in the "none" education level. Those who had no education were 2.03 times more likely to have high blood pressure than those SHS/Voc/Tech education level. However, neither energy, dietary magnesium, fat, fibre, calcium, and sodium intakes were significantly associated with hypertension.

Gender is the only risk factor with high blood glucose level at significance level 90% for this population

Fig. 1 Mean diastolic and systolic blood pressure values classified according to educational level and place of residence



group (Table 6). Men are at a higher risk of having high fasting glucose than women. Men are about 1.45 times more likely to have high fasting glucose than women (OR, 1.4457, 90% CI, – 0.0450–0.7822; $p > 0.05$). Dietary factors were not associated with diabetes in our study group.

Self-awareness of hypertension and diabetes status

In this study, 36.8% of participants were hypertensive (Table 4), but when asked whether they were diagnosed in a healthcare facility, only 49.5% of those we detected to be hypertensive (from our measurements) were aware of being hypertensive (data not shown). As a consequence, the unaware participants were not under any treatment. Furthermore, 10% of participants had concomitant hypertension and diabetes, but only 29.0% were diagnosed in a healthcare facility.

Figure 2a presents diagnosis by a health professional vis-à-vis the actual measures of hypertension according to gender and place of residence. In total, 173 participants were aware of being hypertensive as diagnosed by a health professional (45 males and 128 females). However, from our assessment, 126 males and 187 females were hypertensive, and an additional 64 males and 86 females had high-normal hypertension without knowing. Meanwhile, 24 participants (5 males and 19 females) reported being hypertensive but were instead found to have high-normal hypertension. This may reflect a positive impact of their

Table 4 Hypertension status of participants classified according to demographic, glycaemic, and anthropometric status

Variables	Normal** ($n=387$)	High-normal** ($n=150$)	Hypertension** ($n=313$)	p-value
All$^{\chi}$ (%)	45.5	17.7	36.8	$\chi^2=0.398$, $p>0.05$
Male (%)	42.4	42.7	40.3	
Female (%)	57.6	57.3	59.7	
Urban (%)	49.9	50.7	43.5	$\chi^2=3.525$, $p=0.172$
Rural (%)	50.1	49.3	56.5	
Fasting blood level* (mean ± SD)	5.17 ± 1.19	5.47 ± 1.39	5.51 ± 1.62	0.011
Diabetes (%)***	4.4	8.5	10	$\chi^2=10.015$, $p<0.05$
IFG (%)***	18.5	20.3	23.3	
Normal (%)***	77.2	71.2	66.7	
BMI* (mean ± SD)	23.82 ± 4.85	25.05 ± 4.51	25.32 ± 5.78	< 0.001
Underweight (%)	11.4	3.3	6.7	$\chi^2=20.633$, $p<0.05$
Normal (%)	56.1	52.7	49.0	
Overweight (%)	20.4	28.0	24.7	
Obese (%)	12.1	16.0	19.6	
WC* (mean ± SD)	80.67 ± 11.33	83.81 ± 12.30	86.02 ± 14.00	< 0.001
WHR* (mean ± SD)	0.85 ± 0.80	0.86 ± 0.67	0.88 ± 0.86	< 0.001

IFG impaired fasting glucose, *BMI* body mass index, *WC* waist circumference, *WHR* waist-to-hip ratio

*ANOVA

$^{\chi}$Chi-square

**Normal: blood pressure < 130/85 mmHg; high-normal (pre-hypertension): 130 to 139/85 to 89 mmHg; and hypertension: ≥ 140 mmHg [25]

***Normal: fasting blood glucose < 5.6 mmol/L; impaired fasting glucose (pre-diabetic): 5.6–6.9 mmol/L; and diabetes: ≥ 7 mmol/L [26]

medication in controlling their BP, thus reducing it to high-normal levels (pre-hypertensive) (Fig. 2b).

Exploring awareness on diabetes, Fig. 3a presents diagnosis of diabetes by a health professional and the actual measures of diabetes according to gender and place of residence. Twelve participants (six males and six females) reported having been diagnosed as diabeteic by a health professional. However, from our results, 27 males and 34 females were diagnosed with diabetes, while another 48 participants (24 males and 24 females) had impaired fasting blood glucose (IFG). Furthermore, five participants (two males and three females) reported having diabetes but were found to have IFG. This might be due to a positive treatment outcome (Fig. 3b).

Table 7 presents an analysis of questions on knowledge of NCDs and their management. Participants were asked if they could identify one cause and one action to manage and reduce HT and DM. Regarding knowledge on hypertension, there was a significant relationship identified between correct responses and place of residence. However, there is no significant relationship between gender and correct responses for hypertension. According to our results, more females were able to state correctly one action to reduce and manage hypertension ($p<0.005$). For similar questions on DM, more females were able to mention one action to prevent and manage diabetes compared to males ($p<0.05$) and rural dwellers were able to state this compared to urban dwellers ($p<0.05$).

Discussion

This study aimed to assess the prevalence of hypertension and diabetes in the context of wider risk factors for NCDs among adult males and females residing in urban and rural areas in Ghana. The findings have good internal validity and also external validity and are therefore generalisable. The hypothesis is that the prevalence of these risk factors and associated diseases are higher than expected for areas which are considerably less urbanised. Increasing age, being male, and having a BMI in the overweight and obese category were associated with being hypertensive.

Other Ghanaian studies have reported advancing age and overweight/obesity as risk factors for increasing BP and thus HT [14, 15]. In urban Accra and a peri-urban area, males were found to have an increased risk for HT. Likewise we found that being male presents a higher risk [15, 29]. We found in our study the only risk factor for diabetes was being male. There was no association between dietary intake (such as energy, fat, micronutrients, etc.)

Table 5 Ordinal logistic regression showing the risk factors for high blood pressure

High blood pressure								
		β	Std. error	p	95% confidence interval		*Odds ratio*
					Lower bound	Upper bound	
	Age (years)	0.0358	0.0054	< 0.001	0.0251	0.0464	-
	Waist circumference (cm)	0.0144	0.0091	0.1144	−0.0035	0.0323	-
	BMI (kg/m2)	0.0592	0.0241	0.0140	0.0120	0.1065	-
	Energy	0.0001	0.0006	0.8336	−0.0011	0.0014	-
	Carbohydrate	0.0009	0.0027	0.7320	−0.0043	0.0062	-
	Fat	−0.0025	0.0058	0.6596	−0.0138	0.0087	-
	Fiber	−0.0083	0.0072	0.2497	−0.0224	0.0058	-
	Sodium	4.16×10^{-6}	0.0001	0.9388	−0.0001	0.0001	-
	Potasium	0.0001	0.0002	0.6021	−0.0004	0.0006	-
	Magnesium	−0.0014	0.0016	0.3885	−0.0046	0.0018	-
	Calcium	-9.11×10^{-6}	0.0001	0.9515	−0.0003	0.0003	-
Gender	Male/female	0.4629	0.1763	0.0086	0.1174	0.8083	1.5886
	Urban/Rural	0.0644	0.1566	0.6808	−0.2426	0.3714	1.0666
Education level	Primary	−0.1292	0.2913	0.6573	−0.7002	0.4417	0.8788
	JHS	−0.3944	0.2659	0.1380	−0.9155	0.1267	0.6741
	SHS/Voc/Tech	−0.7093	0.2913	0.0149	−1.2802	-0.1384	0.4920
	Middle School	−0.3483	0.2745	0.2044	−0.8863	0.1896	0.7059
	Tertiary	−0.5241	0.3570	0.1420	−1.2238	0.1755	0.5921
	Others	2.1502	1.1655	0.0650	−0.1340	4.4345	8.5866
Occupation	Trading	0.6627	0.4245	0.1185	−0.1693	1.4947	1.9401
	Farming	0.5574	0.4233	0.1879	−0.2722	1.3869	1.7460
	Artisan	0.4444	0.4230	0.2935	−0.3847	1.2735	1.5596
	Formal job	0.6348	0.4801	0.1861	−0.3063	1.5758	1.8866
	Schooling	0.8081	0.5202	0.1203	−0.2114	1.8275	2.2435
	Retired	1.0511	0.5878	0.0738	−0.1010	2.2031	2.8607
	Unemployed	0.7824	0.4779	0.1016	−0.1542	1.7190	2.1867
	Alcohol	0.2038	0.1462	0.1633	−0.0827	0.4904	1.2261
	Smoking	−0.1695	0.3011	0.5735	−0.7597	0.4207	0.8441
Physical Activity	Never/none	−0.2669	0.2543	0.2939	−0.7653	0.2315	0.7657
	Once a while	−0.0433	0.2502	0.8627	−0.5336	0.4471	0.9577
	Quite often	−0.2839	0.3142	0.3662	−0.8997	0.3319	0.7529
	Very often-regularly	−0.1185	0.2436	0.6267	−0.5960	0.3590	0.8883

Goodness-of-fit test of overall model (likelihood ratio): chi-square = 154.878, df = 32, p-value = 0.000, pseudo R-square = 0.167. Test of parallel lines (likelihood ratio): chi-square = 44.572, df = 32, p-value = 0.069. Rural, gender: female, education level: none educated, occupation: others, alcohol usage: no, smoking: no, physical activity: daily exercising were used as reference category

and hypertension and diabetes. There are other factors known to be related to NCDs which we analysed for our study participants; however, none of these were risk factors for the participants.

We visited participants in their homes early morning when household members of working age (males and younger females) might already have left for work. In rural settings, this assumption corroborates the observation that men usually leave for the farm much earlier than females and allow the females to follow much later as they were responsible for preparing the children for school and also preparing food to take along to the farm. This could, therefore, be a plausible reason why more females were recruited compared to males.

We also found urban–rural differences. Our mean diastolic (82.35 ± 14.82 mmHg) and systolic BP (132.12 ± 23.9 mmHg) were similar as reported by Obirikorang et al. (80.0 vs 133 mmHg) [12]. They also found that among urban dwellers, diastolic BP was significantly higher and they were more likely to have cardiometabolic risk factors such as higher BMI and WC [12]. We found a significant relationship between the systolic

Table 6 Ordinal logistic regression showing risk factors for high fasting glucose

High fasting glucose							
		β	S.E	*p*	95% confidence interval		Odds ratio
					Lower bound	Upper bound	
	Age	0.0102	0.0064	0.1106	−0.0023	0.0227	-
	Waist circumference	0.0183	0.0113	0.1068	−0.0039	0.0405	-
	BMI	0.0097	0.0286	0.7350	−0.0464	0.0657	-
	Energy	0.0005	0.0007	0.5044	−0.0009	0.0018	-
	Carbohydrate	−0.0019	0.0029	0.5115	−0.0075	0.0037	-
	Fat	−0.0014	0.0062	0.8241	−0.0136	0.0108	-
	Fiber	0.0090	0.0083	0.2745	−0.0072	0.0253	-
	Sodium	−0.0001	0.0001	0.4410	−0.0002	0.0001	-
	Magnesium	−0.0025	0.0017	0.1447	−0.0058	0.0009	-
	Calcium	−0.0002	0.0002	0.1405	−0.0006	0.0001	-
Gender	Male/Female	0.3686	0.2110	0.0807	−0.0450	0.7822	1.4457
	Urban/Rural	0.2459	0.1945	0.2062	−0.1354	0.6272	1.2788
Education level	Primary	0.1964	0.3236	0.5438	−0.4377	0.8306	1.2171
	JHS	−0.1676	0.3106	0.5894	−0.7764	0.4412	0.8457
	SHS/Voc/Tech	−0.2417	0.3345	0.4700	−0.8973	0.4139	0.7853
	Middle school	−0.1098	0.3074	0.7208	−0.7123	0.4926	0.8960
	Tertiary	−0.3081	0.3927	0.4327	−1.0778	0.4616	0.7348
	Other	1.0834	0.6690	0.1054	−0.2278	2.3945	2.9546
Occupation	Trading	0.2953	0.5850	0.6136	−0.8512	1.4418	1.3436
	Farming	−0.1244	0.5905	0.8331	−1.2818	1.0330	0.8830
	Artisan	0.4008	0.5781	0.4881	−0.7322	1.5338	1.4930
	Formal	0.4069	0.6250	0.5150	−0.8180	1.6319	1.5022
	Schooling	−0.2104	0.7434	0.7771	−1.6674	1.2465	0.8103
	Retired	0.8520	0.6779	0.2088	−0.4767	2.1807	2.3443
	Unemployed	0.2053	0.6334	0.7459	−1.0362	1.4468	1.2279
	Alcohol	0.1682	0.1669	0.3134	−0.1588	0.4953	1.1832
	Smoking	−0.0943	0.3429	0.7833	−0.7664	0.5778	0.9100
Physical activity	Never/none	−0.1386	0.2917	0.6347	−0.7104	0.4332	0.8706
	Once a while	−0.0022	0.2796	0.9938	−0.5501	0.5457	0.9978
	Quite often	−0.3059	0.3706	0.4091	−1.0323	0.4205	0.7365
	Very often-regularly	−0.2603	0.2878	0.3658	−0.8245	0.3038	0.7708

Goodness-of-fit test of overall model (likelihood ratio): chi-square = 59.830, df = 31, *p*-value = 0.001, pseudo R-square = 0.086. Test of parallel lines (likelihood ratio): chi-square = 11.658, df = 31, *p*-value = 0.999. Rural, gender: female, education level: none, occupation: others, alcohol usage: no, smoking: no, physical activity: daily exercising were used as reference category

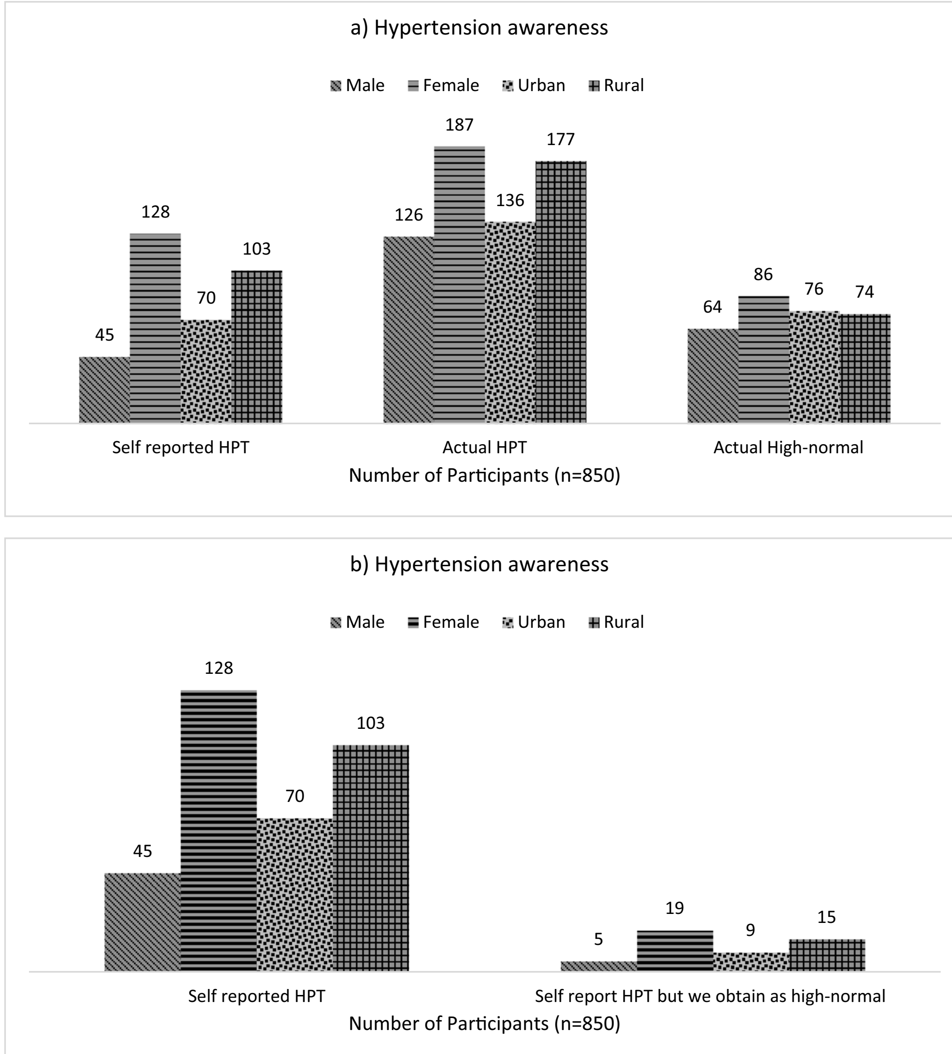
S.E. standard error, *CI* confidence interval for EXP(B)

BP of rural inhabitants. Meanwhile, research on cardiovascular risk factors in relation to rural–urban transition shows a significantly higher prevalence of hypertension among urban inhabitants [11].

In our findings, BMI was higher in rural areas, yet like other studies on obesity and cardiometabolic risk factors, WC and WHR were higher in urban areas [12]. Compared to lateral obesity (where the fat is distributed around the body), central obesity imposes a higher risk for cardiometabolic diseases and could be a reflection of unhealthy dietary habits and sedentary lifestyle in urban areas.

Overweight and obesity are risk factors for NCDs, including hypertension, diabetes, and cardiovascular diseases [12]. Increasing BMI is a known risk factor for higher BP, thereby predisposing overweight and obese individuals to hypertension compared to normal-weight individuals [30]. We observed a significant relationship between higher BMI and the category of hypertension, but this was not surprising as similar results have been reported [14, 15, 29, 31]. While we observed a 1.7-fold likelihood of developing high BP with increasing BMI, 2.6-fold (95% CI = 2.3–2.9) increased likelihood for hypertension has been reported among overweight

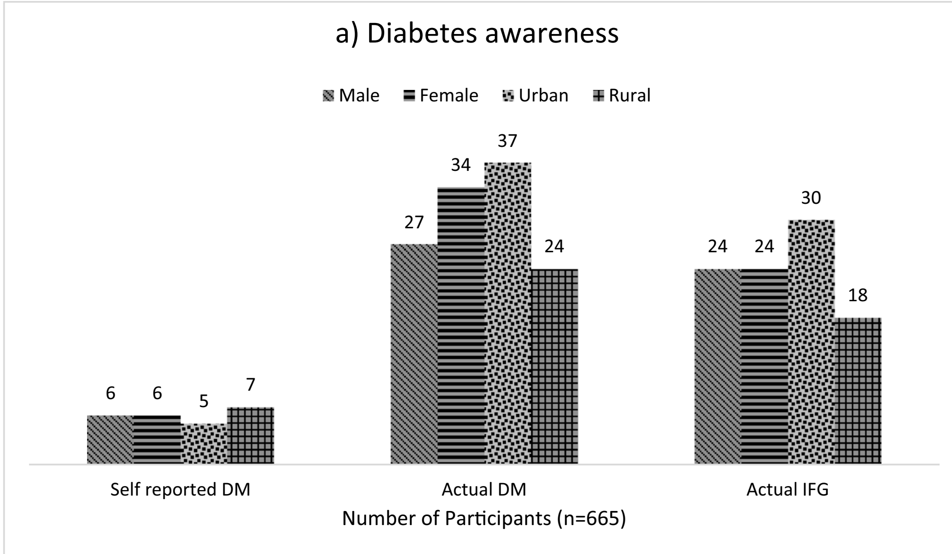
Fig. 2 Distribution of self-awareness on hypertension status classified by gender and place of residence



and obese persons [32]. Furthermore, a significant relationship was observed between WC and hypertension; a finding confirmed by Jayawardana et al. [31].

Research shows a 35% prevalence of hypertension in Ghana [33], which is similar to our findings of 36.8%. However, our results support a direct relationship between increasing age and hypertension despite the majority of our sample being below 65 years of age. Other studies in Ghana have similarly reported aging as a risk factor for hypertension with ages 22–59 [34], 18–45 [15], and ≥ 40 years [35] being the most associated with hypertension [31]. Hypertension leads to changes in the vasculature which includes endothelial dysfunction, vessel walls thickening, reduced flexibility, and arterial stiffening as a consequence of aging [36] thereby affecting the development and progression of micro and macro complications of diabetes unless interventions are instituted [37]. Concomitant hypertension and diabetes increase the risk of metabolic syndrome [37]. Like our findings, a recent study in Ghana found a positive association between fasting blood glucose and BP in urban areas but with only diastolic BP in rural areas [12]. Elsewhere in Ghana, the prevalence of hypertension was 32.4%, but only 46.2% of the hypertensive individuals were aware of their status [33].

Few studies have reported on the combined awareness of hypertension and diabetic status in African communities [35, 38]. In our study, 10.0%, of hypertensives had concurrent diabetes, whereas 20.3% of hypertensives were pre-diabetics. We noticed large numbers of participants being unaware of either their hypertension or diabetic status, which could increase the incidence of stroke [39]. This finding indicates a public health problem which needs to be addressed through enhanced health screening in communities. In relation to awareness, more females correctly identified factors which trigger hypertension as well as their management. Despite this, females were more hypertensive. This could be linked to their availability and willingness to participate in research, complemented by their positive health-seeking behavior. We



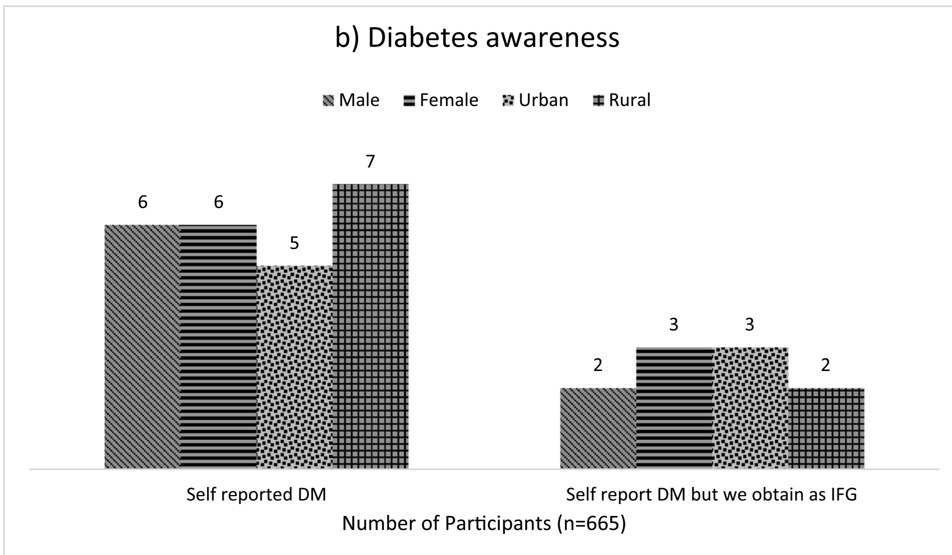


Fig. 3 Distribution of awareness on diabetes status by gender and place of residence

Table 7 Knowledge of participants on the causes, prevention and management of hypertension and diabetes

Questions	Correct respond	Male *n* (%)	Female *n* (%)	*p*-value$^{\chi}$	Urban *n* (%)	Rural *n* (%)	*p*-value$^{\chi}$
Able to identify at least one cause of HT correctly	Y	200 (56.5)	312 (62.9)	0.060	226 (55.8)	286 (64.3)	0.012
	N	154 (43.5)	184 (37.1)		179 (44.2)	159 (35.7)	
Able to state at least one action to prevent/manage HT	Y	160 (45.2)	273 (55.0)	0.005	193 (47.7)	240 (53.9)	0.067
	N	194 (54.8)	223 (45.0)		212 (52.3)	205 (46.1)	
Able to identify at least one cause of DM correctly	Y	196 (55.4)	252 (50.8)	0.189	210 (51.9)	238 (53.5)	0.634
	N	158 (44.6)	244 (49.2)		195 (48.1)	207 (46.5)	
Able to state at least one action to prevent/manage DM	Y	154 (43.5)	179 (36.1)	0.025	143 (35.3)	190 (42.7)	0.023
	N	200 (56.5)	317 (63.9)		262 (64.7)	255 (57.3)	
Total		354 (100.0)	496 (100.0)		445 (100.0)	405 (100.0)	

$^{\chi}$Chi-square test, *HT* hypertension, *DM* diabetes mellitus, *Y* yes, *N* no identified more hypertension among rural inhabitants and a significant relationship with their knowledge. Similarly, there was a significant relationship between urban dwelling and knowledge on the management of diabetes. However, we identified less awareness of diabetes in urban areas.

Excessive intake of dietary salt is related with increased risk of hypertension [40]. The Dietary Approach to Stop Hypertension (DASH) study shows that a reduction in sodium intake decreases BP [34]. In line with this, we expected a significant association between consumption of dietary sodium and hypertension, but that was not observed. Williams et al. reported a significant association between salt and alcohol consumption and diastolic BP, especially in males [14], similar as reported by Mohammed et al. [15]. We, however, did not obtain any association between alcohol consumption and BP.

Magnesium also regulates BP [41], with an inverse relationship between dietary magnesium intake and hypertension risk. In a recent systematic review, 100 mg/day increase in dietary magnesium intake decreased hypertension risk by 5% [42]. Public Health England ‘s recommendations for magnesium intake for males and females are 300 mg/day and 270 mg/day, respectively [22]. We noticed low consumption of magnesium (males:66.03 ± 74.92 vs females:54.58 ± 62.89 mg/day). Increasing dietary intakes of magnesium is essential for health and also to reduce hypertension in this community as intakes are below the reference nutrient intake. Contrary to expectations, no significant association was observed between dietary magnesium intake and hypertension. Establishing optimal intakes of magnesium for this population is worthy of further research. Moreover, this is an observational study. To observe an effect, an analytical design is required. Effect of dietary fibre on decreasing BP has been reported [43], but we did not find any significant difference between participants’ consumption of dietary fibre and hypertension.

Hypertension is a major risk factor contributing to increased morbidity and mortality, particular for NCDs. Hypertension and its related co-morbidities impact on health systems in many sub-Saharan African countries [44]. Currently, 70% of individuals with diagnosed hypertension are not accessing treatment, while only 13% have controlled BP. In terms of diabetes, the reported prevalence is 9% [5]. Nonetheless, as our study shows, this may be an underestimation especially as accessibility and affordability of health service for diabetes detection, management, and control are limited, especially in the rural areas [45].

Limitations

Despite the generalisability of the study findings, some limitations are worth noting. Being a cross-sectional study, we are limited in assessing causation and studying prevalence and incidence over time. Low levels of physical activity, including its under- and over-reporting, may influence the findings. Also, data on the intensity of physical activity was not collected. Dietary data is self-reported, which is often subject to reporting and memory biases. Using a 1-day diet recall method rather than a 3-day diet diary may have resulted in the lack of association between dietary factors and HT and diabetes. Use of digital dietary methodologies may be a useful future approach. The questions used for alcohol consumption, smoking, and physical activity were crude measures of exposure, thereby lacking internal validity to reflect real exposures. To provide information on the nature and extent, more valid measures would have been appropriate. Our methodology may also have affected the prevalence of diabetes because not all participants were eligible for BP testing. Furthermore, type 1 and type 2 diabetes could not be differentiated despite the varying prevalence and risk factors among older adults. Cholesterol levels were not measured due to financial constraints. It would have enhanced the findings in relation to cardio-metabolic risk. Lastly, we did not investigate some of the known risk factors of diabetes, such as genetic predisposition. Despite these limitations, based on published data, the RIING software is a validated dietary database for Ghanaian foods and has enhanced the value of the dietary data. With a powerful sample size of 850 participants, our findings provide valuable data for health policymakers to initiate public health interventions.

Conclusions

Our prevalence study, the first of its nature in Hohoe, Ghana, showed males, older persons, and those who are overweight/obese have greater odds/risk for hypertension consistent with other literature. Pre-diabetes and pre-hypertension, in addition to undiagnosed diabetes and hypertension, were common with high proportions of these individuals unaware of their health status. Poor diet underpins the rates. Although participants asserted undertaking physical activity, the nature and extent are unknown.

There was an apparent shift in the health status of the rural inhabitants, particularly women, who were less active, thus predisposing them to greater risk for NCDs. The assumption that there is lower prevalence of these risk factors in rural areas is now challenged, as we observed an epidemiological shift consistent with increasing urbanisation. However, we found no evidence of nutrition transition affecting the diets of rural inhabitants. Rural-to-urban transitions are often associated with marked changes in behavior and lifestyle, such as diminished physical activity. However, our data suggests a level of inactivity already exists [11].

In Ghana, rising levels of NCDs are mainly attributed to inadequate health care and interventions [46]. However, the rapid changes, particularly in rural areas, are changing the landscape and exacerbating the NCD problem [47] [48]. Our findings support the need for community-based screening using inexpensive rapid test kits and educational interventions in rural areas (using a variety of media and social media) to address risk factors for hypertension and diabetes in populations which are clearly predisposed but unaware of their risk status. Improvements in physical activity and dietary intakes that provide key micronutrients are necessary [49]. Health professionals working in these areas need to be mindful of health literacy and ensure that behavior change communication takes cognisance of the low education of rural communities [50]. We conclude that efforts to mitigate the rising levels of hypertension and diabetes require concerted action, intensified testing, awareness creation on NCDS, lifestyle interventions to improve dietary intakes, physical activity, and health-seeking behaviors that involve rural inhabitants as well.

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Author contribution BE, FA, and FBZ conceived the study, drafted the protocol, and designed the instruments for data collection. BE acquired funding. FA, FZ, and BE trained, collected, and supervised the data collection process. OFK cleaned and managed the data obtained, and DD undertook the analysis supervised by BE. BE, DD, and BS wrote the first draft of the manuscript. All authors critically reviewed the manuscript and also interpreted the findings for intellectual soundness.

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Data availability The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval This research was conducted in accordance with the Declaration of Helsinki. The study was approved by the University of Chester's Faculty of Health and Social Care Ethics Sub-Committee (RESC0514-518) and the Ghana Health Service Ethical Review Committee (GHS-ERC: 06/07/14).

Inforrmed concent Individual written informed consent was obtained from all participants.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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