Predictive Factors Associated With Hypertension Alone, Diabetes Alone And The Coexistence Of Both Among Adults In Ghana.

Ekpereka S. Nawfal, Christine Unson, Chinyere Okeke, Evi Abada

ABSTRACT: The purpose of this study was to examine the predictive factors associated with hypertension alone, diabetes alone and the coexistence of both among adults in Ghana. Hypertension and diabetes are known silent killers. Cardiovascular disease is one of the ten leading causes of death worldwide, and it is noted that hypertension and diabetes are major risk factors for cardiovascular disease. This was a cross-sectional study design using self-reported secondary data from World Health Organization (WHO) Study on Global AGEing and adult health (SAGE), Ghana – 2007/8, wave 1 and the data was analyzed using SPSS version 23 with statistical significant level at p=0.05. A total number of 5573 samples were analyzed for the study. The participants were aged 18years and above with an average age of 60.19 years (*SD* = 14.06). Hypertension and diabetes variables were documented for 5089 (91.3%) and 5090 (91.3%) respondents respectively. Out of the number of documented respondents, 12.1% had hypertension, 3.5% had diabetes, while 1.5% had coexistence of hypertension and diabetes. Bivariate analyses result showed that gender, age, BMI, waist circumference and physical activity were independently significantly associated with hypertension alone, diabetes alone and the coexistence of both. Multivariate analyses revealed that age has the greatest impact on the three dependent variables.

Keywords: Coexistence of hypertension and diabetes, diabetes, hypertension, obesity, physical inactivity, waist circumference, BMI.

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1 INTRODUCTION

Non-communicable diseases such as heart disease, cancer, diabetes, hypertension and chronic lung diseases are rapidly increasing worldwide. They have gradually overtaken infectious disease as the leading cause of mortality in Africa [1]. Globally, hypertension and diabetes are among the commonest non-communicable diseases and the major risk factors for cardiovascular disease, which is the second leading cause of death in Africa especially among adult above thirty years [2, 3]. Annually, cardiovascular disease account for about 17 million deaths worldwide (about one third of total global death), and 9.4 million of these deaths occur from complications of hypertension [11]. The dramatic rise of cardiovascular disease (CVD) in sub-Sahara Africa poses a new public health challenge in the region because the burden imposed by hypertension and diabetes on the national health care system globally are enormous, especially in already resource-constraint countries Diabetes mellitus, simply known as diabetes, is a chronic metabolic disease that is characterized by elevated blood sugar (hyperglycemia) of 126 mg/dl or higher, resulting from multiple etiology that may lead to long-term damage, dysfunctional and failure of various organs in the body [4,5]. There are two major types of diabetes – type 1 and type 2 diabetes.

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Type 1 diabetes (juvenile-onset diabetes or insulin dependent diabetes mellitus) usually develops in children and adolescents but can occur in any age and it represents 10% of all diabetes cases, whereas type 2 diabetes (adult-onset diabetes or non-insulin dependent diabetes mellitus) develops in adulthood and it is the most common type of diabetes because it accounts for at least 90% of diabetic cases worldwide [4, 6]. The etiology of type 1, in most cases, is idiopathic but has been attributable to disruption in one's own immune system resulting in self-destruction of the pancreatic islet beta–cell that is responsible for producing insulin, whereas type 2 diabetes mainly occurs as a result of the body cells resistant to the action of insulin [5]. Diabetes is increasingly becoming common in sub-Sahara Africa. For instance, in urban Cameroon, Nigeria and Tanzania, apparently, diabetes is no longer rare as previously thought [7]. In 2013, the prevalence of diabetes was 382 million and it is expected that the number will increase to 592 million by 2035 or one in 10 adults, with about 90% increase in Africa [8]. Eighty per cent of diabetes cases are recorded in low and middle income countries but surprisingly, in Africa, majority of people with diabetes (78%) are undiagnosed and unaware that they are diabetic [9]. Approximately 60% to 80% of diabetic cases in Cameroon, Ghana and Tanzania are undetected [10]. Diabetes – especially when not detected early and not adequately treated – silently evolves into more complications such as renal failure, retinopathies and gangrenous foot (diabetic foot) resulting in amputation [10]. It accounts for approximately 5.1 million deaths among people between the ages of 20-79 years, 8.4% global all-cause mortality within the age group in 2013 [8]. Also, diabetes causes a rising global economic burden, as the global health care expenditure attributed to diabetes in 2013 was at least USD 548 billion (10.8% of total health expenditure worldwide) and it is postulated to exceed USD 627 billion in 2035 [8]. Kirigia (2008) showed that the calculated total economic attributable loss to diabetes in African region was approximately USD 41.76 billion [16]. Hypertension, also called high blood pressure, on the other hand is a chronic disease characterized by an increase in the pressure (tension) of the blood against the wall of the arteries, that is, the force exerted within the arteries that help in circulation of blood from the heart to various parts of the body, with the systolic blood pressure of $\geq$ 140 mm Hg and diastolic blood pressure of $\geq$ 90 mm Hg [11].

Table 1 in appendix A

Generally, the cause of hypertension is unknown but the several risk factors associated with hypertension and diabetes are mostly attributed to behavioral risk factors which include: physical inactivity, unhealthy diet, alcohol abuse and obesity [11]. Hypertension rarely causes symptoms at the early stage because, most often, it remains undiagnosed until relatively late in its course leading to variety of other life-threatening conditions [11, 17] that result in tremendous medical and economic burden. It was revealed that the direct healthcare cost traceable to high blood pressure in sub-Saharan Africa was approximately 2 billion US dollars in 2001 [18]. "Recent global data on burden of hypertension showed that nearly 1 billion of the world's adult population had hypertension in 2000 and it was projected that this number will increase by about 60% (1.56 billion) by 2025; and this population burden is more in developing countries" [19]. The coexistence of hypertension and diabetes in the same individual markedly increases the risk of all target organs damages and premature death [2]. The prevalence of microvascular (for example retinopathy) and macrovascular (such as stroke and myocardial infarction) complications are significantly more in diabetic patient with coincidental hypertension than in those without hypertension [13]. Studies have shown that both conditions are commonly associated, and the overlapping of hypertension in individual with diabetes enhances the increased risk of coronary heart disease and renal disease already associated with diabetes when left untreated [14]. Hypertension is noted to be twice more common in individual with diabetes (especially in people with type 2 diabetes) than in non-diabetes [13]. It is reported that approximately 70%, over two-thirds, of individual with diabetes have hypertension [2, 15]. Ghana is one of the countries in sub-Sahara Africa region and the only country in the region where the WHO SAGE was conducted, with a total population of 27,672,800 and life expectancy at birth for women/men stated as 63/60 years [20]. Ischemic heart disease is among the top 5 causes of death in Ghana [20]. Interesting, Ghana is faced with the challenges of cardiovascular diseases (CVD), like other sub-Saharan countries, as indicated by CDC. William (2010) revealed that the number of new cases of hypertension recorded in outpatient public health facilities in Ghana increased from 49,087 in 1988 to 505,180 in 2007 [18].

1.1 Predictive factors

Anthropometric indicators. Obesity has been particularly recognized as a powerful independent risk factor for type 2 diabetes and hypertension [13]. A theoretical analysis of the hemodynamics of obesity showed that obesity is associated with an increase in blood volume and a decrease in peripheral vascular resistance resulting in disproportional increase in cardiac output and heart rate that lead to a rise in blood pressure [24, 25]. More so, obesity has the individual potential to engender insulin resistance, and insulin resistance is a fundamental etiology of type 2 diabetes which is also linked to hypertension [26]. Meanwhile, those who are not obese using the traditional weight criteria but have these chronic illnesses may have increased central adiposity [5]. Several researchers have shown significant association between the different anthropometric indicators - body mass index (BMI), waist circumference and waist-height ratio, that are used as proxy for total fat and abdominal fat to assess risk of diseases - with hypertension and diabetes [17, 27, 28]. A cross-sectional study conducted to investigate the indices of obesity most associated with high blood pressure among 316 elderly people > 60 years that reside in the northeastern Brazil revealed that the body mass index (BMI) and body adiposity index indicators are more closely associated with hypertension in both genders [29]. Moreover, these indicators can also predict these diseases even in non-obese adults as shown in the study carried out by Sharaye et al. (2013) among 174 non-obese adult in Zaria, Nigeria [17]. They found an association between BMI, waist circumference, waist-height ratio, waist-hip ratio and hypertension risk. However, the study postulated that waist-height ratio showed stronger statistically significant correlation than the other anthropometric indices in predicting hypertension among non-obese adults of both gender, followed by waist circumference [17]. Similarly, systematic review of both prospective and cross sectional datasets showed that waist circumference (WC), waist-height ratio (WHtR) and BMI are significant predictors of diabetes and cardiovascular diseases (CVD), but waist circumference and waist-height ratio had stronger predictive power than BMI [27]. Even when BMI was adjusted for, WC and WHtR still predict diabetes and CVD independent of BMI [27]. Stewart et al. (2010) found that an increased BMI was associated with higher prevalence of hypertension in both rural and urban Africa [30]. Consistent with this study, Danquah et al. (2012) found that type 2 diabetes and hypertensive patients had higher BMI, waist-hip ratio, and percentage body fat in comparison with the control in their study that was conducted with patients in Ghana [28].

Age. Globally, various studies done have shown that age drastically influences the rising prevalence of hypertension and diabetes with the elderly mostly at risk [31]. In 2002, the estimated prevalence rate of hypertension among adults between the ages of 40-55 years was about 35% and 40% in those above 50 years, compared to approximately 6% in those below 40 years in Ghana, and hypertension was found to be more common among females than males in the middle-aged and elderly [32]. Similarly, approximately 70% of adults > 50 years in Dakar, Senegal, were believed to suffer from hypertension [31]. According to Gambert & Pinkstaff (2006) approximately 20 million people in the United States are diagnosed with diabetes, and half of those currently affected are within > 60 years and above, most prevalent in those > 80 year old, and the number is expected to reach 40 million by 2050 [33].

Gender. A study showed glaring gender disparity, with the prevalence of non-communicable diseases generally higher in females than in males as the risk factors were more evident in females [34]. Most of the women were overweight or obese, physically inactive, reside in the urban areas and are in the lower socioeconomic class (depicted by their lower annual income, lower educational achievement and higher unemployment rate) which is linked to decreased health awareness and practices [34]. On the contrary, there were increased prevalence of hypertension in male than in females in a study done in Malawi [35]. The study showed that the males had higher frequency of tobacco smoking and alcohol drinking than females, while raised cholesterol, overweight, physical inactivity were more common among the women than men and there was no significant gender difference in the prevalence of diabetes. Similarly, Katte et al., (2014) found that men were more likely to take excessive alcohol consumption, smoke tobacco, engage more in physical activity and has raised blood pressure than women [2].

Tobacco smoking and alcohol consumption. Tobacco smoking, excessive alcohol consumption, physical inactivity and poor dietary intake have shown shared risk factors in major non-communicable diseases such as cancer, diabetes, and hypertension [35]. From the study in Malawi, the researchers were able to prove that excessive alcohol consumption, tobacco smoking, overweight, obesity and physical inactivity were associated with hypertension and diabetes, and it is gender related [35]. A 5-year prospective study, with a 70% success rate, of African volunteers (aged > 30years) from randomly selected household in North West Province, South Africa, revealed that participants who became hypertensive had smoked more (68.2%) and had more alcohol intake than the normotensive individuals [36].

Physical inactivity. Studies have shown that physical activity have been decreasing in sub-Saharan Africa due to increasing urbanization and sedentary lifestyles, with public transport replacing the traditional long distance walking and white collar jobs that have less physical labor than in rural employment or rural daily activities like chopping of woods and farming [37]. More so, the high level of crimes and increased frequency of watching of television in urban setting contributes to physical inactivity [37]. Studies conducted in sub-Sahara Africa showed the impact of physical inactivity on other cardiovascular diseases risk factors, and revealed that physical inactivity was independently associated with increased prevalence of metabolic syndrome (hypertension, diabetes and obesity), and more common in the urban than rural population [35, 38, 39].

Nutrition. In Africa, there have been large nutritional transition from the traditional diet – which comprised mainly of low fat, high in unrefined carbohydrate, and high fruit and vegetable consumption - to westernized unhealthy diet as a result of the rapid urbanization, decreased agricultural practices and increase in importation of canned food, inorganic products as well as increasing aggressive food companies marketing in the continent [37]. A meta-analysis of 13 prospective independent cohort studies demonstrated that increased consumption of fruit and vegetable to sufficient amount per day is related to a 17% reduction in coronary heart disease risk such as hypertension, supporting the protective effect fruit and vegetable [40].

Comorbidity of Diabetes Mellitus and Hypertension. Aknes et el. (2008) conducted an active-controlled randomized VALUE trial study of new onset diabetes in hypertensive patients on antihypertensive drugs, using 9995 non-diabetic hypertensive patients at baseline [41]. The study showed that 1298 patients developed diabetes mellitus during the average follow-up of 4.2 years, and some of the significant predictors of diabetes identified in the study were increased BMI, age, non-Caucasian race, and baseline glucose [41]. Similarly, study of multimorbidity of chronic diseases among adults patients (> 18 years) in an urban clinic in Ghana found that the most common combination of chronic diseases was hypertension and diabetes (36.6%) compared to hypertension and musculoskeletal diseases (19.9%), and hypertension with other cardiovascular diseases (11.4%) [42]. Furthermore, the above study identified age, family history of any chronic condition (genetic factor) and female gender as the significant risk factors associated with the occurrence of multimorbidity, with age being the most significant independent risk factor as older patient are increasingly at higher risk of multimorbidity. Supporting aforementioned study, was the study conducted in semi-urban Cameroon which found that increasing age, adiposity predictors (such as waist circumference) and females are the most important risk factors for co-occurrence of hypertension and diabetes, while alcohol consumption has no significant overall effect on hypertension alone, diabetes alone or coexistence of both [2]. However, the participants for both studies were self-selected affecting the ability to generalize their findings to other population. With the rapidly increasing prevalence of these diseases and their comorbidity in sub-Sahara Africa, it is hopeful that this study will add to the wealth of knowledge of the predictive factors related to hypertension, diabetes and the coexistence of both diseases among adults in Ghana.

1.2 Research Hypotheses

H1: BMI, waist circumference, age, gender, tobacco smoking, alcohol consumption, physical inactivity and nutrition will be associated with hypertension among adults in Ghana.

H2: BMI, waist circumference, age, gender, tobacco smoking, alcohol consumption physical inactivity and nutrition will be associated with diabetes among adults in Ghana.

H3: There will be an association between the study predictors and the coexistence of hypertension and diabetes among adults in Ghana.

2 MATERIALS AND METHODS

2.1 Sampling

This study used secondary data from World Health Organization (WHO) Study on Global AGEing and adult health (SAGE), Ghana – 2007/8, wave 1. The Ghana SAGE sample comprised of 5,265 individual respondents aged 18 years and older. Respondents were selected using a stratified, multistage, random cluster sampling design. The primary sampling units (PSU) were stratified by region and location (urban/rural) using the Census Enumerated Area (CEA) as the sampling frame. Within each stratum, enumeration areas were selected independently with probability proportional to size of the region; the measure of size being the number of individuals aged 18 years or more in the enumerated areas. All respondents aged 18 years and older within the WHS/SAGE Wave 0 and follow-up households with one or more members $\geq$ 18 years were eligible for the face-to-face interview, with additional respondents from the new household with members aged 18years, which were randomly selected using systematic sampling.

2.2 Instrumentation

The questionnaire used for the study was based on the WHO Model Questionnaire with some modification and many few additions. The individual questionnaire was administered to eligible respondents and a proxy questionnaire was administered to individual respondents who had cognitive limitations [43].

Dependent variables. The dependent variables are hypertension, diabetes and hypertension/diabetes and these variables are categorical. For hypertension, respondents were asked: "Have you ever been diagnosed with high blood pressure (hypertension)?" Responses were documented as 1-Yes or 0 - No. Also, for diabetes**,** respondents were asked: "Have you ever been diagnosed with diabetes (high blood sugar)?" This did not include diabetes associated to pregnancy. Responses were documented as 1 – Yes or 0 – No. For, the coexistence of both variable, hypertension and diabetes variables were merged into the hypertension/diabetes category labelled as "hypertensiondiabetes". Respondents who have both hypertension and diabetes were documented as "1 – Yes" and ".0 – No" for those who do not have both diseases.

Independent variables. The following predictors are the independent variables:

Body mass index (BMI). BMI was computed, using SPSS version 23, from the measured weight in kilograms divided by the height in meters squared (after converting the measured height from centimeters to meters). Height was measured in centimeters after the respondents were asked to take off their shoes, put their feet and heels close together, stand straight, and look straight ahead with their back, head, and heels touching the wall. The body weight was measured in kilograms after the respondents took off their shoes. It is categorized by WHO as; underweight < 18.5, normal weight 18.5–24.9, overweight 25 to 29.9, and obese $\geq$30 [44].

Waist circumference. The waist circumference was measured in centimeters using tape measure placed at the top of the hip bone and making sure the tape measure is parallel to the floor all the way around the body. This is used to measure central obesity. Men with waist measurements $\geq$ 102 cm and women with $\geq$ 88 cm were considered to have central obesity [44].

Age. The respondents' ages were stratified into 3 categories: young adults (18 – 49years), middle-aged adults (50 – 69 years) and older adults (70 years and older).

Gender. Gender, which was also a categorical variable, was documented as 1 – Male or 2 – Female.

Physical inactivity. It was a self-reported question and respondents were asked: "How much time do you usually spend sitting or reclining on a typical day?" Responses were documented in hours/day and the question was labeled in the data as "leisure hours/day".

Tobacco smoking. Respondents were asked - "Have you ever smoked tobacco or used smokeless tobacco?" The responses were categorized into: 1- Yes and 2 – No.

Alcohol consumption. Alcohol consumption was quantified in terms of alcohol content. Participants responded to the question: "Have you ever consumed a drink that contains alcohol (such as beer, wine, spirits, etc.)?" The responses were documented as: 1- Yes and 2 – No, never.

Nutrition. The SAGE diet question was about the quantity of fruit and vegetable consumed daily. The question asked was: "How many servings of fruit/vegetables do you eat on a typical day (country-specific)?" According to WHO recommendation, "insufficient intake of fruit/vegetables is defined as less than 5 servings (80g per serving) on a typical day".[43] The quantity of fruit and vegetable consumed daily was divided into 2 categories: 1 = 0 – 4 (insufficient intake) and 2 = $\geq$ 5 (sufficient intake). The question was labelled as "fruitcat." and "vegcat."

2.3 Data Analysis

All analysis was carried out using SPSS version 23. Results of the descriptive analysis were summarized as count and proportions (percentages) for qualitative variables, then mean and standard deviation (*SD*) for quantitative variables. For the bivariate analysis, comparison of the each of the group variables – gender, age, BMI, alcohol, tobacco smoking, fruit and vegetable intake- with hypertension, diabetes and coexistence of both was done using Pearson chi square tests, while the independent student t-test was conducted to test the association between the quantitative variables – waist circumference and physical inactivity - with hypertension, diabetes and coexistence of both. Binary logistic regression model was used to investigate the potential determinant from the set of independent variables of hypertension, diabetes and coexistence of both. The variables were entered into the logistic regression model using a stepwise procedure with alpha criteria set at .05. The *F*-statistic was computed to test the overall significance of the final model. The results was accepted to be statistically significant based on the alpha criteria set.

3 RESULTS

3.1 Characteristics of Study Participants

Table 2 shows a summary of the sample characteristics. The total number of respondents (N) surveyed was 5573. The participants were aged 18years and above with a mean age of 60.19 years (SD = 14.06). The proportion of male to female was almost equal, with slightly more males (51.2%) than females, and majority of the respondents (59.1%)

reside in the rural areas. Approximately, 60% of the participants were currently married and exactly half (50%) of the respondents had no formal education. Hypertension and diabetes variables were documented for 5089 (91.3%) and 5090 (91.3%) respondents respectively. Out of the number of documented respondents, 12.1% had hypertension, while 3.5% had diabetes and 1.5% had coexistence of hypertension and diabetes. The body mass index (BMI) of majority of the participants (57.4%) were within the normal range (18.5 – 24.9), while the mean waist circumference of the respondents was 84.16 cm (SD = 12.64) and the mean leisure hours/day was 3.17 (SD = 2.48). High proportion (75.6%) of the respondents have never used tobacco and the proportion of respondents who responded "yes" to ever taken alcohol was 58.7%. Only 9.1% of 5032 respondents and 1.3% of 4946 respondents take sufficient quantity of fruit and vegetable respectively.

Table 2 in appendix A

3.2 Bivariate Analysis

The lifestyle predictors (alcohol consumption and fruit/vegetable intake) were not significant in the initial bivariate analyses conducted. Hence, they were not presented in the final bivariate analysis and also were not included in the multivariate analysis.

Association between hypertension and the predictive factors. The Pearson Chi square results indicate that there are significant difference between hypertension and gender X^2 (1, *N* = 5089) = 64.50, $p < .001$, hypertension and age X^2 (2, *N* = 5087) = 63.96, $p < .001$, hypertension and BMI X^2 (3, *N* = 4960) = 212.64, $p < .001$ as well as hypertension and tobacco smoking X^2 (1, *N* = 5087) = 24.52, $p < .001$. Females (16.1%) were significantly more likely than male (8.7%) to have hypertension. The statistically significant difference in the probability of having hypertension increases with age and BMI categories. AgeCat.3 ($\geq$70 years) were 15.3% more likely than AgeCat.2 (50 – 69 years) 12.8% and AgeCat.3 (18 – 49 years) 4.0% to have hypertension, while respondents who are obese (27.4%) were more likely than those who are overweight (18.5%), normal weight (8.3%) and underweight (5.8%) to have hypertension. Respondents who have never used tobacco (13.4%) were significantly more likely to have hypertension compared to those who have used tobacco (8.1%). An independent sample t -test was conducted to determine if the mean waist circumference and leisure hours/day of the hypertensive respondents were significantly different from the mean of non-hypertensive respondents. The variables waist circumference and leisure hours/day were normally distributed given same skewness score of 0.78. Test for homogeneity of variances for waist circumference and leisure hour/day were significant (*F* = 49.71, $p < .001$ *and F* = 8.72*, p* = .003 respectively) which indicate that the variance of the two categories of hypertension were not equal. There was statistically significant difference between the average waist circumference of hypertensive and non-hypertensive respondents *t* (696.85) = 13.89, $p < .001$, *95%* CI (7.62, 10.13), and the average leisure hours/day of hypertensive and non-hypertensive respondents in the sample *t* (694.75) = 6.98, $p < .001$, *95%* CI (0.61, 1.09). The average waist circumference of hypertensive respondents was higher (*M* = 91.99, *SD* = 14.92) than the average of non-hypertensive (*M* = 83.11, *SD* = 11.91), and the average leisure hours/day of hypertensive respondents was higher (*M* = 3.92, *SD* = 2.78) than the average of non-hypertensive (*M* = 3.07, *SD* = 2.42).

Association between diabetes and the predictive factors. The Pearson Chi square results showed that there are significant difference between diabetes and gender X^2 (1, *N* = 5090) = 4.91, $p < .05$, diabetes and age X^2 (2, *N* = 5088) = 14.02, *p* = .001, and diabetes and BMI X^2 (3, *N* = 4961) = 38.59, $p < .001$. Females (4.1%) were significantly more likely than male (2.9%) to have diabetes. AgeCat.3 (3.8%) and AgeCat.2 (3.9%) have almost exact more likelihood than AgeCat.1 (1.3%) to have diabetes, while for the BMI variable, respondents who are obese (6.6%) were significantly more likely than those who are overweight (5.4%), normal weight (2.6%) and underweight (1.6%) to have diabetes. While for the independent t-test conducted, homogeneity of variances for waist circumference and leisure hour/day were not significant indicating that the variance of the two categories of diabetes were equal (*F* = 2.56, *p* = .110 *and F* = .170*, p* = .681 respectively). There were statistically significant difference between the mean waist circumference of diabetic and non-diabetic respondents *t* (4958) = 7.49, $p < .001$, *95%* CI (5.43, 9.28), and the mean leisure hours/day of diabetic and non-diabetic respondents in the sample *t* (4799) = 3.23, *p* = .001, *95%* CI (0.25, 1.03). The mean waist circumference of diabetic respondents was higher (*M* = 91.23, *SD* = 13.81) than the mean of non-diabetic (*M* = 83.91, *SD* = 12.53), and the mean leisure hours/day of diabetic respondents was higher (*M* = 3.79, *SD* = 2.38) than the average of non-diabetic (*M* = 3.15, *SD* = 2.48).

Association between coexistence of hypertension/diabetes and the predictive factor. Pearson Chi square results indicate that there are significant difference between hypertension/diabetes and gender X^2 (1, *N* = 5090) = 5.46, $p < .05$, hypertension/diabetes and age X^2 (2, *N* = 5088) = 12.91, *p* = .002, and hypertension/diabetes and BMI X^2 (3, *N* = 4961) = 29.48, $p < .001$. Females (1.9%) were significantly more likely than male (1.1%) to have hypertension/diabetes. AgeCat.3 (2.0%) were more likely than AgeCat.2 (1.6%) and AgeCat.1 (0.1%) to have hypertension/diabetes, while the respondents who are obese (3.6%) were significantly more likely than those who are overweight (2.1%), normal weight (1.1%) and underweight (0.3%) to have hypertension/diabetes. To test for the relationship between coexistence of both diseases with waist circumference, and leisure hours per day, an independent sample t-test was conducted. Test for homogeneity of variances for waist circumference and leisure hours/day were not significant which also indicate that the variance of the two categories of coexistent hypertension/diabetes were equal (*F* = 2.15, *p* = .142 *and F* = 1.58*, p* = .209 respectively). There were statistically significant difference between the mean waist circumference of hypertension/diabetic and non-hypertension/diabetic respondents *t* (4958) = 6.83, $p < .001$, *95%* CI (7.38, 13.32), and the mean leisure hours per day of hypertension/diabetic and non-hypertension/diabetic respondents in the sample *t* (4799) = 3.42, *p* = .001, *95%* CI

(0.44, 1.63). The mean waist circumference of hypertension/diabetic respondents was higher (*M* = 94.37, *SD* = 14.26) than the mean of non-hypertension/diabetic (*M* = 84.02, *SD* = 12.56), and the mean leisure hours per day of hypertension/diabetic respondents was higher (*M* = 4.19, *SD* = 2.64) than the average of non-hypertension/diabetic (*M* = 3.16, *SD* = 2.48).

3.3 Multivariate Analysis

To assess how well hypertension, diabetes and the coexistence of both can be explained by the five predictive variables - gender, age, BMI, waist circumference, and leisure hours per day - a binary logistic regression was conducted. Tobacco smoking analysis was not included as initial analysis was statically insignificant.

Hypertension. The model is significant, Cox & Snell R and Nagelkerke R square predict 8 to 15.3 percent of the variance. The five predictive variables, when considered together significantly predict hypertension, X^2 = 381.96, *df* = 8, *N* = 4664, *p* < .001. Table 3 presents the odd ratios, which suggest that: i) with each year increase in age, the odds of getting hypertension increases by 362% if the respondent is in AgeCat.3 (≥ 70 years) and by 212% if the respondent is in AgeCat.2 (50 – 69 years) compared to if the respondent is in AgeCat.1 (18 – 49 years); ii) the odds of getting hypertension increases by 50% if the respondent is female compared to male. iii) for each unit increase in waist circumference, the odds of getting hypertension increase by 3%; iv) with each hour increase in the leisure hours/day (physical inactivity), the odds of getting hypertension increase by 10%; v) for each unit increase in BMI, the odds of getting hypertension increases by 151% if respondent is overweight (BMICat.3) and by 209% if respondent is obese (BMICat.4) compares to if respondent is underweight (BMICat.1), while there is no statistically significant difference (*p* = .072) if respondent is normal weight (BMICat.2). Age and BMI have the greatest impact on hypertension.

Table 3 in appendix A

Diabetes. The model is significant, Cox & Snell R and Nagelkerke R square predict 2 to 6 percent of the variance. The five predictive variables, when considered together, significantly predict diabetes, X^2 = 71.89, *df* = 8, *N* = 4665, *p* < .001. Table 4 presents the odd ratios, which suggest that: i) with each year increase in age, the odds of getting diabetes increases by 228% for AgeCat.3 (≥ 70 years) and by 198% for AgeCat.2 (50 – 69 years) compared to respondent in AgeCat.1 (18 – 49 years); ii) for each unit increase in waist circumference, the odds of getting diabetes increase by 3%; iv) with each hour increase in the leisure hours/day (physical inactivity), the odds of getting diabetes increase by 7%. There are no statistically significant difference between gender with diabetes (*p* = .624), and BMICAT with diabetes (*p* = .224). Age has the greatest impact on diabetes.

Table 4 in appendix A

Coexistence of hypertension and diabetes. The model is significant, Cox & Snell R and Nagelkerke R square, predict 1 to 10.4 percent of the variance. The five predictive variables, when considered together, significantly predict diabetes, X^2 = 65.84, *df* = 8, *N* = 4665, *p* < .001. Table 5 presents the odd ratios, which suggest that: i) with each year increase in age, the odds of getting the coexistence of both increases by 45% for AgeCat.3 (≥ 70 years) and by 5% for AgeCat.2 (50 – 69 years) compared to respondent in AgeCat.1 (18 – 49 years); ii) for each unit increase in waist circumference, the odds of getting the coexistence of both increase by 4%; iv) with each hour increase in the leisure hours/day (physical inactivity), the odds of getting the coexistence of both increase by 12%. There are no statistically significant difference between gender with the coexistence of both (*p* = .633), and BMICAT with coexistence of both (*p* = .325). Also, age has the greatest impact on the coexistence of both chronic diseases.

Table 5 in appendix A

4 DISCUSSION

This study examines the association between the predictors – age, gender, BMI, waist circumference, tobacco smoking, alcohol consumption, nutrition and physical inactivity - with hypertension alone, diabetes alone and the coexistent of both focusing on adults in Ghana, and it established that there are significant associations between most of the predictive factors and the chronic diseases. Convincing findings from the result showed that these three outcomes (hypertension alone, diabetes alone and the coexistent of both) are linked to increasing age in this population with an increased risk among participants in the upper age stratum (≥ 70 years), and the age variable significantly had more effect on the risk of hypertension alone. This finding collaborates with the result from the study conducted in semi-urban Cameroon which associated increasing age, with an apparent multiplicative effect of age, to the steadily increased risk of hypertension alone, diabetes alone and the combination of both using multinomial logistic regression [2]. Congruently, Nimako et al. (2013), using a logistic regression, found that patients aged 40 years and above were progressively more likely to present with multimorbidity compared to those aged 18 – 39 years, of which the commonest combination of diseases were hypertension and diabetes [42]. Therefore, it is not surprising that this study found that age has the greatest impact on the outcomes because various studies have always shown advancing age as an inevitable cause of hypertension, especially in industrialized areas, and it is mostly associated with degenerative structural changes that occur in the arteries as one ages causing arterial stiffness [45]. Also, another study found that the systolic blood pressure (SBP) increased by 2.6 mmHg (1.86mmHg males; 3.6 mmHg females) and diastolic blood pressure (DBP) increased by 2.2 mmHg (1.6 mmHg males; 3.0mmHg females) per decade increase in age [46]. More so, the chances of being diagnosed with diabetes increases with age as aging is associated disturbance in carbohydrate metabolism resulting from a rise in insulin resistance, about 50% reduction in insulin sensitivity, and impaired insulin secretion from the beta cells of the pancreas [33]. Concerning the anthropometric predictors, such as body mass index (BMI) and waist circumference, the bivariate analysis result showed that BMI and waist circumference were independently associated with the risk of hypertension alone, diabetes alone and coexistence of both. Supporting the concept of these indices of obesity as predictors of the chronic diseases are various studies that found an association with these anthropometric indicators used to assess the risk of the diseases in their different studies [17, 27, 28]. Of note was that the percentage of likelihood of having the diseases increases with the BMI categories as those who are obese are most likely to have hypertension, diabetes or both, which explain further that obesity has an influence on diabetes and hypertension risk. This correlates with the linear regression result from a study done in a poor urban slum community in Kenya, which revealed that for every unit increase in BMI, the SBP in both gender increased by 0.2 mmHg, and DBP increased by 0.12 mmHg in males and 0.06 mmHg in females, while every five centimeter increase in waist circumference showed an increased SBP by 0.50 mmHg (0.78 mm Hg males & 0.35 mmHg females) and DBP increased by 0.40 mmHg (0.56 mmHg male; 0.32 mmHg females) [46]. However, interesting findings from this study multivariate analysis revealed that while the odd risk of getting diabetes or the coexistence of hypertension and diabetes significantly increases with waist circumference, there were no significant effects of the BMI categories on diabetes or the coexistence of both, even though BMI had a great impact on the risk of hypertension. A possible explanation could be that the effect of obesity on type 2 diabetes is not only determined by the degree of obesity but also the area of the body where the fat accumulates as accumulation of upper body fat, seen as increased waist circumference and waist-to-hip ratio, is associated with diabetes and cardiovascular disease [47]. Furthermore, a systemic review conducted by Browning et al. (2010) showed that waist circumference and waist-to-hip ratio have stronger predictive power on diabetes and cardiovascular disease than BMI, which may also explain the insignificant impact seen between BMI categories on diabetes and the coexistence of hypertension and diabetes in this study result [27]. Previous studies have shown that there is gender disparity in the risk of chronic diseases. This study established, from the bivariate analysis, that females are more likely than males to have hypertension, diabetes and both. Similarly, Ekpenyong et al. (2012) found that the prevalence of these diseases were higher in females than males, relating their finding to the fact that most females were overweight or obese, physically inactive, live in urban area and of the lower socioeconomic class [34]. Although, results from this study multivariate analysis showed that there was no significant gender disparity in the risk of diabetes as well as the coexistence of hypertension and diabetes in this population but it showed that females had 50% higher risk of hypertension than males. Furthermore, gender disparity with the risk of having hypertension varies in adult life, as the prevalence of untreated hypertension in non-diabetic people is less in females than in males until in older age (55 – 64years) when the prevalence in females begin to increase in a rapid rate and exceed that of men [13]. Whereas, the prevalence of untreated hypertension in diabetic female reaches that of diabetic male in approximately one decade earlier (about 45 – 54 years) [13]. The study finding was linked to the fact that menopause, family history of hypertension, smoking as well as the predictors analyzed in this study are all independently associated with an increase in blood pressure [13]. This can be inferred to the findings of this present study which showed higher risk of hypertension among female because more than half of the respondents (3188) are within 50 – 69 years and about half of the respondents used in the study are females. However, the studies conducted by Msyamboza et al. (2011) showed that there was no significant gender difference in the prevalence of diabetes but found that males have higher prevalence of hypertension than females, while Katte et al. (2014) found that the prevalence of hypertension, compared to diabetes or coexistence of both, was higher in males than females [2,35]. Both studies linked their findings to the higher frequency of tobacco smoking and excess alcohol consumption in males compared to females, as moderate alcohol consumption was associated with reduced odd of diabetes and hypertension [2]. Though, another study found that men are less likely to have comorbidity, however, the data for that study was collected from a single urban secondary care clinic using a convenient sampling of all patients seen in the clinic within a period of time [42]. This may have resulted in oversampling of same gender and complicated cases or frequent attendees as indicated in their study limitation. For this study, a chi square statistics was conducted to test the relationship between gender disparity with tobacco smoking and alcohol consumption just for comparison. Similar to the findings of Msyamboza et al. (2011) and Katte et al. (2014), the result was statistically significant and it showed that men (39.2%) were more smokers compared to women (7.5%) and men (68.3%) consume more alcohol than women (47.7%) [2, 35]. But in contrast to their studies, this study as stated earlier, found that females have higher risk of having hypertension compared to males and this may be as a result of other confounders (menopause, increased BMI, increased waist circumference etc.) that may be present in the female respondents. Although tobacco smoking was significantly associated with only hypertension from this study, surprisingly the result showed that participants who have never used tobacco (13.4%) were significantly more likely to have hypertension compared to those who have used tobacco (8.1%) contradicting most previous studies that stated otherwise. Probably, the fact that majority of the respondents (75.6%) selected for the study have never used tobacco and 92.5% out of the non-smoker respondents are females, may have affected the finding as result showed that females are more likely to have hypertension. The hours/day an individual is being physically inactive (leisure hours/day), when analyzed independently and also with other variables, was found to be statistically significantly associated with hypertension, diabetes and the coexistence of both. Collaborating with the finding from a study done in Cameroun (West African) which showed that physical inactivity was independently associated with increased metabolic syndrome such as hypertension and diabetes [38]. This infers that physical activity have an important protective effect in reducing the risk of these diseases. The effect of physical inactivity as a potential modifiable risk factor for hypertension was first demonstrated in the earliest study published in 1968 and 1970 by Paffenbarger et. al and Boyer & Kasch respectively [48, 49, 50]. The former demonstrated decreased incidence of hypertension two to three decades later in life among men who exercise more than 5 hours/week, while the latter showed a decrease in blood pressure in both hypertensive and normotensive male who trained in aerobic interval program 2 days/week [48, 49, 50]. Afterwards, several studies provided consistent findings suggesting an association between physical inactivity and the incident of hypertension, and strongly supported the effect of physical activity in the prevention of cardiovascular diseases [50]. Additionally, there are numerous indisputable evidences of the effective impact of regular physical activity in the primary and secondary prevention of chronic diseases such as hypertension, diabetes and obesity. In the insightful evaluation of literatures on the role of physical inactivity in the development of chronic diseases, various prospective studies have shown that there were associated 6% decrease in the incidence of type 2 diabetes with each increase of 500 kcal (2100 kJ) in energy expenditure per week, especially in high-risk individuals (those with high body mass index) [51]. To further explain this significant association of physical inactivity as a predictor of hypertension, diabetes and the coincidental of both, it is established that exercise and other physical activities reduces the risk of these chronic diseases through different biological mechanism to improve the body composition [51]. Most importantly, routine physical activity increases the body energy expenditure above resting levels to maintain glucose homeostasis and improve insulin sensitivity, and also improve blood circulation, augment heart function and decrease blood pressure [51]. Therefore, it is seen that when an individual is physically active it improves the weight control leading to reduced waist circumference and obesity, which invariably decreases the risk of hypertension, diabetes and coexistence of both.

5 LIMITATIONS OF THE STUDY

One of the limitations of this study was the study design. A cross sectional study design was used, thus causality of association between the predicative factors analyzed in this study and the dependents variables (hypertension, diabetes and the coexistence of both) cannot be inferred. Furthermore, most of the information in the study data were self-reported, and this is limited by the fact that the information provided by the participants were assumed to be accurate and the assumption can rarely be independently verified. This predisposed the study to recall bias. Also, the use of face-to-face interview format in data collection may have also altered the accuracy of information obtained as respondents may have overstated or understated their responses.

6 RECOMMENDATION

The surge in hypertension and diabetes in sub-Saharan Africa is largely explained by these risk factors. Most of the predictive factors, as identified from the literatures reviewed and this study, are modifiable behavioral risk factors, indicating that behavior has a pivotal role in health. In the prevention and management of hypertension, diabetes and other diseases such as chronic obstructive diseases, HIV/AIDS, etc., it is postulated that behavioral change interventions can effectively prevent diseases by targeting their risk factors, improve the management of existing disease, increase quality of life, and reduce healthcare cost [52]. The strong association between these risk factors and the diseases have provided more insight for effective health education programs that will help create awareness about the complications of these chronic diseases as well as their preventive measures. Several theoretical framework focused at solving health problems from the behavioral perspective have informed the design and implementation of prevention strategies. Therefore, the need for integrating the multifaceted and interactive concepts of the socio-ecological model, that focuses not solely on intrapersonal level, for the behavioral change, developing culturally appropriate and sensitive intervention strategies [53]. Response to the health burden of CVD in this region is hindered by the poverty and shortage of health-care workers [54]. Thus, cost-effective comprehensive prevention strategies seeking to reduce the reversible risk factors identified in this study and targeting the high risk population or existing cases, adapting to the needs and resources of the countries, are useful approaches to prevent and control chronic diseases [22]. The strategies should aim at reducing these attributable behavioral risk factors at early adulthood, lowering the risk of hypertension, diabetes and their complications later in life that transcend to improving the quality of life.

7 CONCLUSION

Many developing countries in the African region are faced with challenges of limited resources and double burden of infectious and chronic diseases. From this study, we were able to establish some of the risk factors that are associated with the increase prevalence of hypertension, diabetes or the coexistence of both in an individual. This study will be relevant to public health because it will provide additional knowledge in the monitoring of the health status of this population. Also, the strong knowledge on the predictive factors provide evidence-based information needed for advocacy for public health policy as well as planning of prevention and control measures of chronic illnesses .

8 ACKNOWLEDGEMENT

A profound gratitude to World Health Organization (WHO) for providing the secondary data used in conducting the study.

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APPENDIX A

Table 1: *Classification of Blood Pressure. Reprinted from the Facts about High Blood Pressure, American Heart Association (AHA), 2014 [12].*

Blood Pressure Category	Systolic mm Hg (Upper Number)		Diastolic mm Hg (Lower Number)
Normal	less than 120	and	less than 80
Prehypertension	120 – 139	or	80 – 89
High Blood Pressure (Hypertension) Stage 1	140 – 159	or	90 – 99
High Blood Pressure (Hypertension) Stage 2	160 or higher	or	100 or higher
Hypertensive Crisis (Emergency care needed)	Higher than 180	or	Higher than 110

Table 2: *Sample characteristics*

Sample Characteristics	*n*	Proportions (%)	Mean	*SD*
Demographic				
Age (≥ 18 years):	5563		60.19	14.06
AgeCat.1 (18 – 49 years)	839	15.1		
AgeCat.2 (50 – 69 years)	3188	57.3		
AgeCat.3 (≥70 years)	1536	27.6		
Gender:	5565	100		
Male	2851	51.2		
Female	2714	48.8		
Location	5571	100		
Rural	3290	59.1		
Urban	2281	40.9		
Marital status	5530	100		
Never married	160	2.9		
Currently married	3308	59.8		
Cohabitating	65	1.2		
Separated/divorced	688	12.4		
Widowed	1309	23.7		
Socio-economic				
Highest education level	5534	100		
No formal education	2767	50.0		
Less than primary school	635	11.5		
Primary school completed	656	11.8		
Secondary school completed	337	6.1		
High school (or equivalent) completed	950	17.2		
College/university completed	177	3.2		
Post-graduate degree completed	12	0.2		
Biological				
Had hypertension	617	12.1		
No hypertension	4472	87.9		
Had diabetes	177	3.5		
No diabetes	4913	96.5		
Had hypertension and diabetes	75	1.5		
Body Mass Index (BMI, kg/m^2):	4967		23.36	5.83
BMICat.1 (< 18.5, Underweight)	675	13.6		
BMICat.2 (18.5 – 24.9, Normal)	2849	57.4		
BMICat.3 (25 – 29.9, Overweight)	946	19.0		

BMICat.4 (≥ 30, Obese)	497	10.0		
Waist Circumference (cm)	4966		84.16	12.64
Health related behavior				
Physical inactivity:				
Leisure hours/day	4803		3.17	2.48
Ever used tobacco?	5090	100		
Yes	1241	24.4		
No	3849	75.6		
Ever used alcohol?	5091	100		
Yes	2988	58.7		
No, never	2103	41.3		
Nutrition				
Fruit intake:	5032	100		
FruitCat. 1(insufficient)	4575	90.9		
FriutCat. 2(sufficient)	457	9.1		
Vegetable intake:	4946	100		
VegCat.1(insufficient)	4882	98.7		
VegCat.2(sufficient)	64	1.3		

Note: *n* = number of respondents, *SD* = Standard Deviation, Cat. = Category

Table 3: *Variables in the Equation*

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	AgeCAT			55.671	2	.000	
	AgeCAT(1)	1.137	.198	33.113	1	.000	3.116
	AgeCAT(2)	1.530	.208	54.282	1	.000	4.618
	Gender(1)	.405	.099	16.878	1	.000	1.499
	Waist circumference	.032	.005	46.902	1	.000	1.033
	Leisure hr/day	.094	.019	25.515	1	.000	1.099
	BMICAT			33.070	3	.000	
	BMICAT(1)	.349	.194	3.241	1	.072	1.417
	BMICAT(2)	.919	.217	18.010	1	.000	2.507
	BMICAT(3)	1.127	.249	20.464	1	.000	3.087
	Constant	-7.054	.443	253.019	1	.000	.001

a. Variable(s) entered on step 1: AgeCAT, gender, waist circumference, leisure hr/day, BMICAT. Note: Categorical variables coding; AgeCAT (AgeCAT.1 = 0, AgeCAT.2 = 1, AgeCAT.3 = 2), Sex (Male = 0, Female = 1), BMICAT (BMICAT.1 = 0, BMICAT.2 = 1, BMICAT.3 = 2, BMICAT.4 = 3). Dependent variable encoding; Hypertension (No = 0, Yes = 1), Diabetes (No = 0, Yes = 1), Hypertensiondiabetes (No = 0, Yes = 1).

Table 4: *Variables in the Equation*

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	AgeCAT			10.624	2	.005	
	AgeCAT(1)	1.091	.352	9.609	1	.002	2.976
	AgeCAT(2)	1.186	.372	10.188	1	.001	3.275
	Gender(1)	.082	.168	.241	1	.624	1.086
	Waist circumference	.031	.008	17.304	1	.000	1.032
	Leisure hr/day	.070	.031	4.978	1	.026	1.072
	BMICAT			4.368	3	.224	
	BMICAT(1)	.388	.346	1.255	1	.263	1.474
	BMICAT(2)	.727	.382	3.616	1	.057	2.068
	BMICAT(3)	.561	.442	1.605	1	.205	1.752
	Constant	-7.831	.743	111.175	1	.000	.000

a. Variable(s) entered on step 1: AgeCAT, gender, waist circumference, leisure hr/day, BMICAT. Note: Categorical variables coding; AgeCAT (AgeCAT.1 = 0, AgeCAT.2 = 1, AgeCAT.3 = 2), Sex (Male = 0, Female = 1), BMICAT (BMICAT.1 = 0, BMICAT.2 = 1, BMICAT.3 = 2, BMICAT.4 = 3). Dependent variable encoding; Hypertension (No = 0, Yes = 1), Diabetes (No = 0, Yes = 1), Hypertensiondiabetes (No = 0, Yes = 1).

Table 5: *Variables in the Equation*

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	AgeCAT			7.349	2	.025	
	AgeCAT(1)	2.349	1.015	5.358	1	.021	10.477
	AgeCAT(2)	2.676	1.027	6.793	1	.009	14.530
	Gender(1)	.125	.262	.228	1	.633	1.133
	Waist circumference	.042	.011	14.086	1	.000	1.042
	Leisure hr/day	.114	.045	6.470	1	.011	1.120
	BMICAT			3.471	3	.325	
	BMICAT(1)	1.779	1.023	3.024	1	.082	5.927
	BMICAT(2)	1.938	1.055	3.378	1	.066	6.946
	BMICAT(3)	2.006	1.098	3.339	1	.068	7.436
	Constant	-12.505	1.671	55.994	1	.000	.000

a. Variable(s) entered on step 1: AgeCAT, gender, waist circumference, leisure hr/day, BMICAT. Note: Categorical variables coding; AgeCAT (AgeCAT.1 = 0, AgeCAT.2 = 1, AgeCAT.3 = 2), Sex (Male = 0, Female = 1), BMICAT (BMICAT.1 = 0, BMICAT.2 = 1, BMICAT.3 = 2, BMICAT.4 = 3). Dependent variable encoding; Hypertension (No = 0, Yes = 1), Diabetes (No = 0, Yes = 1), Hypertensiondiabetes (No = 0, Yes = 1).