Konlan et al. BMC Cardiovascular Disorders (2025) 25:164
https://doi.org/10.1186/s12872-025-04594-y

BMC Cardiovascular Disorders

RESEARCH Open Access

Risk factors of CVDs among residents of resource-limited rural settings. Preliminary findings based on a cross-sectional study, Ghana

Kennedy Diema Konlan[1], Agani Afaya[2], Judith A. Anaman-Torgbor[1*], David Adedia[3], Mathias Todzro-Agudze[4], Abigail Cobba Biney[5], Anthony Kuug[2], Hadiru Mumuni[2], Frank Baiden[6], Sea HyoJung[7,8] and Soyoon Kim[8]

Abstract

Backgrounds Cardiovascular disease (CVD) risk factors lead to morbidity and mortality among adults globally. In Ghana, there is a lack of coordinated efforts at all levels of healthcare service to prevent risk factors of cardiovascular disease (CVD). This study assessed cardiovascular disease risk factors among residents of resource-limited rural settings.

Methods This descriptive cross-sectional design is the first phase of a two-year community-level study aimed at implementing an intervention to reduce CVD risk in a rural community in Ghana. The study population included 379 people living in the Avenui community. We conducted a nurse-led door-to-door visit, screened for CVD risk, provided health education, and collected data using an adapted questionnaire. The data were analyzed using SPSS. Categorical data were expressed as frequencies and proportions, and the Chi-Square test of associations. A multivariable logistic regression analysis with a backward elimination method was used to examine the association of the risk factors with the risk of developing CVD.

Results The CVD risk among participants was categorized as 'very high' (35.4%), high (55.4%), and low or moderate (9.2%). There was a positive correlation between lifestyle ($r=0.126$, $p\text{-value}<0.05$), stress ($r=0.114$, $p\text{-value}<0.05$), blood sugar level ($r=0.102$, $p\text{-value}<0.05$) inflammation and pain ($r=0.109$, $p\text{-value}<0.05$), and high blood pressure ($r=0.268$, $p\text{-value}<0.01$) with history of CVD. CVD high risk was significantly associated with marital status ($p\text{-value}=0.001$), employment status ($p\text{-value}=0.001$), perception of personal health ($p\text{-value}=0.045$), lifestyle ($p\text{-value}=0.034$), knowledge of peripheral arterial disease ($p\text{-value}=0.018$), and knowledge on deep vein thrombosis and pulmonary embolism ($p\text{-value}=0.002$). The backward multiple logistic regression model was significant (78.912, p-value < 0.001) with a non-significant Hosmer and Lemeshow Test (2.145, p-value = 0.976) and a Cox & Snell R Square and Nagelkerke R Square of 0.393 and 0.619, respectively. The significant predictors of a 'very high' CVD risk include marital status being single ($p\text{-value}=0.001$), those that exercise only two (2) times a week ($p\text{-value}=0.001$) employment status being part-time worker ($p\text{-value}=0.015$), poor perception of overall personal health ($p\text{-value}<0.001$), and those listening to the radio ($p\text{-value}=0.024$).

*Correspondence:
Judith A. Anaman-Torgbor
janaman@uhas.edu.gh
Full list of author information is available at the end of the article

Conclusion The risk factors associated with CVD were identified to be multiple and interacted variable among rural community dwellers. These factors included marital status, exercise, employment, perception of health, and listening to the radio. We recommend implementing primary prevention strategies that involve adopting a comprehensive assessment and management of the risk factors of CVD in Ghana.

Keywords Cardiovascular disease, Risk factors, Rural settings Ghana, Sub-Saharan Africa

Background

Cardiovascular disease (CVD) risk factors lead to morbidity and mortality among adults globally. The global burden of CVD is expected to rise due to the increasing ageing population, rising incidence of risk factors, increasing health disparity and relatively low health awareness [1–3]. The World Health Organisation (WHO) indicated that CVDs are a group of disorders of the heart and blood vessels [1] and account for about 34.0% of all global deaths [2, 3]. Also, coronary heart disease and stroke are the common cause of the worldwide burden of disease, making the WHO concerned about this trend [4]. Consequently, in 2017 the burden of deaths associated with CVD was estimated at 17.8 million people, representing about 330 million years of life lost, with over 35.6 million living with disability in Iran [5]. Individuals who develop heart attacks and strokes yearly have one or more CVD risk factors, including hypertension, diabetes mellitus, high blood lipids, obesity, smoking, and physical inactivity [3, 6, 7]. There is evidence that CVDs are becoming an epidemic in low resource-limited settings, including sub-Saharan Africa [8]. When interventions are implemented appropriately, the impact of CVD can drastically be mitigated. Yet, there is limited evidence of feasible, cost-effective, scalable, and comprehensive primary prevention programs to reduce the CVD risk in resource-limited, poor economic settings.

The high impact of CVD in Ghana may be a result of poor healthcare infrastructure, limited lay consciousness and knowledge (health literacy), weak healthcare systems (including biomedical, local/traditional, and complementary), and the lack of non-communicable disease policies [6]. There is generally a lack of coordinated efforts at all healthcare service delivery levels by stakeholders to concentrate efforts on preventing CVD and mitigating specific risk factors [6]. These CVD risks were identified to include gender (male), family history of hypertension, kidney diseases [9], high body mass index (BMI) (obesity), alcohol use, tobacco use, and the use of other drugs [10], including the influence of pesticides and weedicides that are mostly used in crop cultivation [9]. It was reported that rural and peri-urban residents are at increased CVD risk compared to urban dwellers [6, 10]. The prevalence of major chronic non-communicable disease and their risk factors has increased over time, contributing significantly to Ghana's disease burden and aggravated by poverty [11]. This high economic burden associated with chronic non-communicable disease further deepens the poverty gap and increases the health disparity among rural and urban residents [10–12].

The presence of modifiable risk factors within local communities emphasizes the need for public health interventions to prevent the incidence of CVD [13, 14]. However, interventions that aim to identify these risk factors and institute measures to mitigate them are usually challenged by dispersed settlements, cultural variations, diversity in socioeconomic, and demographic characteristics, anthropological interpretations (usually regarding diet, mitigation of stress, traditional medical practices, etc.), difficulty in sampling, and limited resources [7, 13, 15, 16]. In rural Ghana, due to the challenges (already mentioned above) and other nonmodifiable factors (like sex, age, and ethnicity), the prevalence of CVD risk factors is increasing. Therefore, there is an increased need for researchers to delve into this terrain to identify specific risk factors associated with CVD. It is appropriate to utilize resources judiciously by targeting specific multi-faceted rural communities with clearly defined circumscribed geographical boundaries to identify scalable, cost-effective interventions to reduce the CVD risk. This is because CVDs and associated risk conditions are remarkably neglected in Ghana's public health policy agenda, with more attention given to infectious diseases [10]. This study describes the CVD risk factors among residents of a rural community (Avenui community) in the Ho-West district. It is expected that the findings will help to develop lifestyle modification interventions targeting risk factors of CVDs, including tobacco and alcohol use, unhealthy diet, and inadequate physical activity.

Materials and methods

Design

This cross-sectional study is the first part of a pre-test post-test quasi-experimental study in a rural community in Ghana that assessed the influence of a community-based nurse-led one-on-one health education intervention program on CVD. The intervention involves multiple levels of implementation with two times annual data collection points and a one-on-one health education aimed at reducing risk factors associated with CVD.

The protocol

This paper is the first phase of a two-year community-level educational intervention program aimed at eventually reducing CVD risk in rural communities in Ghana. The study was structured to span two years, with two times yearly data collection and monthly monitoring of those with a higher CVD risk. As part of the protocol currently being implemented, there will be four cross-sectional surveys within the duration of 2 years commencing from July 2022 to August 2024. The intervention entailed a door-to-door visit by a trained community health nurse, who administered the study questionnaire and provided a structured health education intervention. The preliminary data collection allowed the researchers to categorize the participants into 'very high', high and moderate or low-risk groups. Those with low risk continued to receive monthly education, while participants with high and 'very high' risk received monthly education with continuous monitoring at the community health facility.

Study setting

The study setting was the Avenui community of the Ho West district of the Volta region of Ghana; in 2012 (January), following a legislative instrument (LI), the Ho West district was demarcated out of the Ho Municipality and inaugurated in June 2013. The district has boundaries, to the Adaklu district in the southern section, and the northern segment borders the Afadjato south district. The Ho municipality and Ghana Togo border constitute the eastern part, and the south Dayi district is to the west. The district has a total land area of 1,002.79 km^2 and a population density of 94.3% based on 94,600, with males constituting 48%. There are about 20 healthcare facilities in the Ho West district (health centres, maternity homes, clinics, and community-based health planning and services (CHPS) compounds). The Avenui community is in the western part of the district, and it is made up of five sub-communities, namely, Avenui, Camp, Bame, Quarters, and Nkwanta. It shares the district's physical features, has well-defined geographical boundaries, and is culturally multi-faceted. The people of Avenui are mostly farmers. There is one CHPS compound in Avenui and two chemical shops. The CHPS compound is managed by a midwife and supported by six (6) staff comprising one (1) Midwife, four (4) Community Health Nurses, one (1) enrolled nurse, community volunteers (2), and the Community Health Management Committee (CHMC). The Avenui community has a community structure led by a chief and his elders with local government officials (assembly members and unit committees). The average number of houses within the five communities is over 700, containing over 1800 households.

Study population and sample

The study population included those living in the Ho West district (Avenui community). This category of respondents was targeted because CVD is more common among residents in rural areas, mostly in poor socio-economic settings [17–19]. It is estimated that the average number of people within the community above the age of 35 years is 900 adults. The selected participants were adults who lived in the Avenui community for up to two years before the commencement of this study. Also, people diagnosed with hypertension, borderline hypertension, or currently on antihypertensive therapy were enrolled in the study. Pregnant women or adults who were mentally incapable (suffering from a mental illness, mental retardation, momentarily drunk, etc.), could not provide informed consent or had not planned to stay in the community throughout the study were excluded (July 2022 to August 2024). This study adopted the whole population sampling method, where all participants who met the inclusion criteria and consented were enrolled [20]. The population sampling method is touted as valuable for implementing behavioural intervention research [20].

Data collections and management

Five registered community health nurses were trained as research assistants for the data collection. The research assistants were trained in research ethics, questionnaire administration, community services, screening for CVD risk factors, and conducting home visits. Data were collected on demographic characteristics, and socio-economic and behavioural risk factors including alcohol use, physical activity, anthropometric measures, and blood pressure. The socio-demographic and risk-taking behaviour data were collected using a self-developed questionnaire. The assessment included age, socio-economic status, marital status, educational level, lifestyle, occupation, alcohol use, diet, and physical exercise. The WHO CVD-risk package and the protocol for screening for CVD risk were adopted for the screening. This tool comprised eight items used to screen for CVD risk.

The CVD risk levels were determined using scores of participants' cardiovascular history, lifestyle, stress levels, sleep, bowel toxicity, blood sugar, inflammation and pain, diet, and blood pressure. Blood pressure was categorized into low, normal, and high. If the overall total scores of the above measures were added and scored including those of lipids, thyroid function, and weight management, the risk classifications were computed as low risk: −88 – 100, moderate risk: 101 – 220, high risk: 221 – 350 and 'very high' risk: 351 and above. However, in this study, scores for lipids, thyroid function, and weight management were not added because they were not measured due to logistical and resource constraints. As a result, the total scores of lipids, thyroid function, and weight management (200), were deducted from all intervals, which resulted in intervals of low risk: −288 – −100, moderate risk: −99 –20, high risk: 21 – 150 and 'very high' risk: 151 and above. To classify someone as low risk, moderate risk, high risk or/ and 'very high' risk, the person's score needs to fall within a certain range, which we refer to as the interval.

The anthropometric measurements included participants' weight, height, and hip circumference. Participants' weight was measured using a digital weight scale to the nearest 0.1 kg using a calibrated digital weighing machine (Beurer 700, Germany). The hip circumference was measured using a tape measure and approximated to the nearest decimal place in centimetres and at the largest area of the buttocks. The participants' heights were measured using tape measures, starting from the feet to the highest body point (head) in an upright anatomical position. The blood pressure levels were also measured with a calibrated mercury sphygmomanometer according to protocols recommended by the guidelines for hypertension management [21]. The participants took a mandatory 10-min rest before their blood pressure levels were measured by the trained research assistants using the standardized calibrated blood pressure apparatus. Three systolic and diastolic blood pressure measurements were done. The first reading was discarded, while the average of the two subsequent readings (the second and third), was spaced by 15-min average time intervals used. BMI was computed by dividing the body weight in Kilograms by a squared value of height in meters (kg/m2) and categorized into obese (≥ 30 kg/m2), overweight (25.0–29.9 kg/m2), average/normal weight (18.5–24.9 kg/m2) and underweight (18.5 kg/m2) according to WHO criteria [22].

Data analysis

The data were checked for completeness and appropriateness of responses, and entered in an Excel for cleaning, then subsequently transferred into SPSS version 25. The Shapiro-Wilks test was used to verify the normality of each quantitative data. To compare the mean ages of participants for the three levels of CVD risk, the Shapiro-Wilks test was used to assess if the ages were normal for the three groups. Kruskal–Wallis test with Dunn's post-hoc test was used to compare means ages since the data were non-normal. The results were reported in a box plot. Also, categorical data were expressed as frequencies and proportions in tables and a bar chart, and the Chi-Square test was used to determine associations between the variables. Spearman correlation analysis was used to determine correlations and strengths of association between the measures of CVD risk. A multivariable logistic regression analysis with a backward elimination method was used to model and determine the CVD risk factors. The backward elimination stepwise regression was used to remove redundant independent variables, and multicollinearity and prevent overfitting. The test was defined as significant if a two-sided p-value is less or equal to a level of significance of 0.05.

Ethical considerations

The study adhered to the principles enshrined in the Helsinki Declaration for the conduct of human subject research. Ethical approval was obtained from the Institute of Health Research Ethics Committee of the University of Health and Allied Sciences (UHAS-REC A7 (1) 2 l-22). Administrative approvals for the study were also obtained from the district and regional health directorates. Written consent was obtained from each participant before their enrolment. Study participants were designated specific study codes (telephone numbers), and all related documentation was referenced to these codes such that the confidentiality and privacy of study subjects were protected.

Results

Socio-demographic characteristics

Out of 379 participants, about 70% were females, 31% were married, 29% were single, and 39.6% were widowed/cohabiting/separated/divorced. Some of the respondents had a minimum primary level of education (60.9%). The mean age of the participants was 48.67 ± 19.21 years, with the age range of (21, to 104 years). The majority of the participants were Christians (97.1%), employed (55.2%), and had health insurance (87.8%). Among those who had health insurance, 85.7% were active. It was shown that the majority had an income less than GH₵ 500 per month, while only 8% had greater than GH₵ 1000. The socio-demographic characteristics of the respondents are shown in Table 1.

Proportion and correlates of CVD Risk

The minimum CVD risk score was −88 and the maximum is around 1051. In this study, the participants had a 'very high' (35.4%), high (55.4%), and low or moderate risk (9.2%) of CVD. Participants with a 'very high' risk are significantly older than those with a high risk (*p-value* < 0.001) and moderate or low risk (*p-value* = 0.011). The CVD risk distribution by age is shown in Fig. 1. The items used to determine CVD risk include CVD history, lifestyle, stress, sleep, bowel toxicity, blood sugar, inflammation and pain, diet, blood pressure, and waist measurement. CVD history was weakly positively correlated to lifestyle ($r = 0.126$, *p-value* < 0.05),

Table 1 Distribution of socio-demographic characteristics

Characteristics	Frequency	Percentage
Age (years) 48.67 ± 19.21		
Sex		
Male	114	30.1
Female	265	69.9
Marital status		
Widowed/cohabiting/separation/divorced	150	39.6
Single	111	29.3
Married	118	31.1
Education		
No formal education	19	5
Primary	231	60.9
Secondary	81	21.4
Higher	48	12.7
Religion		
Christian	368	97.1
Non-Christian	11	2.9
Employment		
Unemployed	121	32.1
Retired	20	5.3
Others	28	7.4
Employed	208	55.2
Have Health Insurance		
Yes	331	87.8
No	46	12.2
Validity of Health Insurance		
Yes	281	85.7
No	47	14.3
Earnings per month		
Less than GH₵ 500	251	74
GH₵ 500–1000	61	18
Greater than GH₵ 1000	27	8

stress ($r=0.114$, *p-value* < 0.05), blood sugar level ($r=0.102$, p-value < 0.05), having inflammation and pain ($r=0.109$, p-value < 0.05), and high blood pressure ($r=0.268$, *p-value* < 0.01). Lifestyle was weakly positively correlated with sleep ($r=0.233$, *p-value* < 0.01) and blood pressure ($r=0.124$, *p-value* < 0.05) but negatively weakly correlated with stress ($r=-0.147$, *p-value* < 0.01). Sleep also had a weak positive correlation with diet ($r=0.127$, *p-value* < 0.05) and blood pressure ($r=0.117$, *p-value* < 0.05). Blood sugar had weak positive correlations with waist measurement ($r=0.143$, *p-value* < 0.01), and inflammation and pain ($r=0.155$, *p-value* < 0.01). In contrast, blood pressure had weak positive correlations with diet ($r=0.149$, *p-value* < 0.01) and waist measurement ($r=0.127$, *p-value* < 0.05) (Table 2).

Factors associated with High Risk for CVDs

Table 3 shows the bivariate analyses of the association between high CVD risk and factors. High CVD risk was associated with marital status (*p-value* = 0.001), employment status (*p-value* = 0.001), perception of overall personal health (*p-value* = 0.045), lifestyle (*p-value* = 0.034), knowledge of peripheral arterial disease (*p-value* = 0.018), knowledge of deep vein thrombosis and pulmonary embolism (*p-value* = 0.002). Widowed, cohabiting, separated, or divorced were more likely to have a high CVD risk than those married. Also, participants who rated their health as good and above are less likely to have a high CVD risk than those who rated their health below good. Participants who did not know that peripheral arterial disease is a type of CVD were more likely to have a higher CVD risk than those who had knowledge. Finally, those with knowledge of deep vein thrombosis and pulmonary embolism as a type of CVD are less likely to have a higher CVD risk than those who have no knowledge. The correlates for high risk for CVD are shown in Table 3.

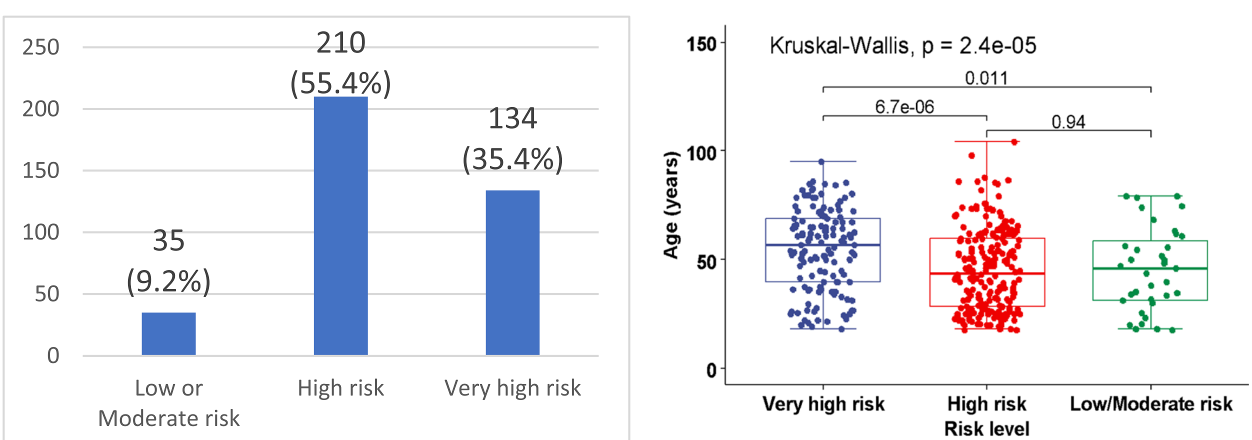

Fig. 1 CVD risk proportion and distribution by age

Table 2 The correlation analysis of CVD Risk Measures

CVD history		1	2	3	4	5	6	7	8
Lifestyle	**.126***								
Stress	.114*	-.147**							
Sleep	0.028	.233**	0.068						
Bowel toxicity	0.090	0.054	0.027	0.056					
Blood sugar	.102*	−0.008	.139**	0.024	0.014				
Inflammation and Pain	.109*	0.057	.118*	0.087	0.028	.155**			
Diet	0.00	−0.012	−0.02	.127*	−0.038	−0.05	0.065		
Blood pressure	.268**	.124*	0.06	.117*	−0.019	0.055	0.032	.149**	
Waist Measurement	0.062	−0.09	0.099	-.018	−0.009	.143**	0.042	−0.018	.127*

* *p*-value < 0.05, ***p*-value < 0.01

Lifestyle (1), Stress (2), Sleep (3), Bowel toxicity (4), Blood sugar (5), Inflammation and Pain (6), Diet (7), Blood pressure (8), and Waist Measurement (9)

Also, the backward multiple logistic regression model was significant (29.82, *p-value* < 0.001), with a non-significant Hosmer and Lemeshow test (4.412, *p-value* = 0.818) as well as Cox & Snell R Square and Nagelkerke R Square values of 0.139 and 0.247, respectively. These results imply a good model fit.

The predictors of high CVD risk include participants' knowledge of deep vein thrombosis and pulmonary embolism as a type of CVD, knowledge of severe headache with no known cause as a stroke symptom, and marital status. Participants with knowledge of deep vein thrombosis and pulmonary embolism as a type of CVD are less likely to have a high CVD risk, whilst those without the knowledge of severe headaches with no known cause as a symptom of stroke were less likely to develop a high CVD risk. However, widowed, cohabiting, separated, or divorced participants were more likely to develop a high CVD risk than those who were married. The predictors of high risk for CVD are shown in Table 3.

Factors Associated with 'Very High' CVD Risk

Bivariate analysis showed a 'very high' CVD risk was associated with sex, marital status, employment, belonging to a social group, perception of personal health, watching television, drinking alcohol, exercise, physical lifestyle, psychological lifestyle, knowledge of the peripheral arterial disease, congenital heart disease, deep vein thrombosis, and pulmonary embolism, and severe headache with no known cause as a symptom of stroke (Table 4).

In assessing the factors associated with CVD 'very high' risk, the backward multiple logistic regression model was significant (78.912, *p-value* < 0.001). The Hosmer and Lemeshow Test was non-significant (2.145, *p-value* = 0.976), implying the adequacy of the fitted model. The model also reported Cox & Snell R Square and Nagelkerke R Square of 0.393 and 0.619, respectively. The significant predictors of a 'very high' CVD risk include marital status, employment, personal health, listening to the radio, drinking alcohol, and exercise. Participants who were Single (*p-value* = 0.001), and those who were widowed, cohabiting, separated, or divorced (*p-value* < 0.001) were more likely to develop a 'very high' CVD risk as compared to participants who were married. Similarly, participants who do not exercise at least two (2) times (*p-value* = 0.001) a week are more likely to develop CVD because they had a 'very high' risk than those who exercise 3 to 5 times a week. Employment statuses, such as unemployment (*p-value* = 0.044), retirement (*p-value* = 0.047), and other forms of employment like part-time work (*p-value* = 0.015) were less likely to lead individuals to CVD 'very high' risk compared to those employed. Compared with the below-good perception of personal health, the perception of good (*p-value* < 0.001) and above-good health (*p-value* < 0.001) are less likely to lead participants to have a 'very high' CVD risk. Correspondingly, not listening to the radio (*p-value* = 0.024) and drinking alcohol reduced the chances of participants developing a 'very high' CVD risk (Table 4).

Discussion

This study investigated CVD risk factors among residents of resource-limited rural settings. This preliminary data identified the CVD risk in this rural community where healthcare access is generally poor with poorly developed healthcare and community-level infrastructure. The CVD risk factors clustering among rural community adults is 'very high', raising concerns that CVD incidence will rise steeply shortly if multifaceted intervention approaches are not implemented to tackle these CVD risks. This is further aggravated by the paucity of healthcare systems that address preventive and curative

Table 3 Bivariate analysis and multiple logistic regression modelling of factors of High CVD Risk

	High risk	Low/Moderate risk	COR(95% C.I), p-value	AOR(95% C.I), p-value
Sex				
Male	65(80.2)	16(19.8)	0.53(0.26,1.10), 0.086	
Female	145(88.4)	19(11.6)	(ref)	
Marital status				
Widowed/cohabiting/separation/ divorced	82(95.3)	4(4.7)	6.51(2.12,20.00), < 0.001	13.71(2.86,65.69), 0.001
Single	65(85.5)	11(14.5)	1.88(0.83,4.23), 0.126	2.4(0.9,6.42), 0.081
Married	63(75.9)	20(24.1)	(ref)	(ref)
Employment				
Unemployed	63(86.3)	10(13.7)	0.72(0.3,1.71), 0.45	
Retired	10(90.9)	1(9.1)	1.14(0.14,9.57), 1	
Others	12(54.5)	10(45.5)	0.14(0.05,0.37), < 0.001	
Employed	123(89.8)	14(10.2)	(ref)	
Belong to Social Group				
Yes	44(80)	11(20)	0.58(0.26,1.29), 0.177	
No	158(87.3)	23(12.7)	(ref)	
Personal Health				
Below good	74(93.7)	5(6.3)	(ref)	
Good	74(81.3)	17(18.7)	0.29(0.1,0.84), 0.017	
Above good	55(82.1)	12(17.9)	0.31(0.1,0.93), 0.03	
Weekly Exercise				
0–2 times	111(90.2)	12(9.8)	2.10 (.99,4.46), 0.051	
3–5 times	97(81.5)	22(18.5)	(ref)	
Perception Lifestyle (Physical)				
Free from stress	72(87.8)	10(12.2)	(ref)	
Stressful	91(89.2)	11(10.8)	1.15(.46,2.86), 0.765	
Relatively Stressful	25(71.4)	10(28.6)	0.35(0.13,0.93), 0.031	
Very stressful	21(87.5)	3(12.5)	0.97(0.25,3.86), 1	
Perception of Lifestyle (Emotional)				
Free from stress	92(88.5)	12(11.5)	(ref)	
Stressful	87(87.9)	12(12.1)	0.95(0.40,2.22), 1	
Relatively Stressful	19(70.4)	8(29.6)	0.31(0.11,.086), 0.033	
Very stressful	10(90.9)	1(9.1)	1.30(.15,11.11), 1	
Perception of Lifestyle (Psychological)				
Free from stress	94(89.5)	11(10.5)	(ref)	
Stressful	81(88)	11(12)	0.86(0.36,2.09), 0.742	
Relatively Stressful	20(69)	9(31)	0.26(0.1,0.71), 0.01	
Very stressful	14(82.4)	3(17.6)	0.55(0.14,2.2), 0.412	
Peripheral Arterial Disease- Type of CVD				
Yes	76(78.4)	21(21.6)	(ref)	
No	13(92.9)	1(7.1)	3.59(0.44,29.06), 0.295	
Do not know	120(90.9)	12(9.1)	2.76(1.29,5.94), 0.007	
Congenital Heart Disease—Type of CVD				
Yes	89(83.2)	18(16.8)	(ref)	
No	7(70)	3(30)	0.47(0.11,2.00), 0.383	
I do not know	111(89.5)	13(10.5)	1.73(0.80,3.72), 0.179	
Deep Vein Thrombosis and Pulmonary Embolism—Type of CVD				
Yes	51(75)	17(25)	0.33(0.16,0.69), 0.002	0.31(0.13,0.76), 0.011
No	155(90.1)	17(9.9)	(ref)	(ref)
Severe Headache a Symptom of Stroke				
Yes	115(89.8)	13(10.2)	(ref)	(ref)
No	32(78.0)	9(22.0)	0.40(0.16,1.03), 0.051	0.2(0.06,0.62), 0.006
Do not know	62(84.9)	11(15.1)	0.64(0.27,1.51), 0.302	0.55(0.19,1.59), 0.27

COR Crude Odds Ratio, *AOR* Adjusted Odds ratio issues related to CVD in rural communities. Ghana's primary health care system, usually implemented through the community health planning and services system does not allow for staff at those levels to provide curative services including CVD care [23]. The finding of this study emphasized that assessing the CVD risk in poor rural communities is critical in identifying and implementing interventions to promote health and reduce the general risk of vulnerable populations [23, 24]. This study is part of a two-year longitudinal study that assesses and implements an educational intervention for reducing CVD in the Avenui community of the Volta region. Educational interventions are critical cost-effective primary interventions for the control of CVDs [23–25]. As a result, implementing an educational intervention by identifying and preventing the CVD risk factors was a primary step toward prevention and control [7, 23–25]. We used the CVD risk assessment tool to ascertain the CVD risk among community members. We found that 35.4% of participants had a 'very high' CVD risk, 55.4% had a high CVD risk, and 9.2% had a low or moderate CVD risk. The high proportion of risk to CVD warrants that immediate steps have to be instituted to promote the adoption of health behaviour in a feasible, cost-effective, and acceptable manner. Participants with a 'very high' risk were significantly older than those with a high risk and moderate or low risk. Our finding is higher than previous estimates that showed that in Iran, 10.39% [5] had CVD risk, and 4.5% in Bangladesh [26]. Our study confirms previous evidence that high CVD risk levels are common in economically developing countries [27]. The discrepancy between our findings and the previous studies might be due to the complex interaction of various environmental, social, economic, and genetic factors. Healthcare authorities in Ghana must begin to consider the possibility of integrating CVDs and other chronic disease care into the robust primary healthcare systems that have shown tremendous improvement in maternal and child health indices. This can be achieved through testing and implementing interventions, especially in rural and peri-urban settings to unearth the cultural factors influencing program adoption and acceptance.

The tool used to assess the CVD risk in this current study is comprehensive and involves the clustering of several variables to provide the estimated prevalence. The adopted tool used for this study is the one used by the WHO for assessing CVD risk because it is robust, systematic and comprehensive and hence provides a more reliable estimate. Therefore, the results presented indicate that the current estimates are not an exaggeration but a reflection of the growing prevalence of CVDs as well as the associated risk among rural residents. This probably may also be associated with the low prevalence of CVD risk factors that were reported in previous studies [5, 26, 27] That notwithstanding, a systematic review among six sub-Saharan African countries, including Ghana, revealed an increased risk of developing CVD among adults [28] due to the rise in economic development /urbanization presenting a new burden on an already weak health system. The findings of the present study showed that the rising prevalence is not only an issue in high-income countries but also an increasing health problem in SSA as well as Ghana [4, 10, 28] which soon may constitute a heavy social and economic burden. The increasing access to oil and fat-related diets, late eating habits, increased alcohol intake, modern methods of smoking (including the use of "*shisha*"), weakening family and social support systems, improved economies leading to increasing sedentary lifestyle, and increasing stressors (both from work and personal development) may be associated with this 'high risk' of CVD. Therefore, addressing these modifiable risk factors must be imperative especially as there is a risk of CVD epidemic [13, 14].

In this study, we found that several and multiple socio-demographic characteristics of the participants were associated with higher CVD risk. The factors that are shown to be significantly associated with high risk for CVD in the logistics regression model were marital status, level of physical activity, employment, perception of overall health, and listening to radio. The role of traditional and social media in disseminating health-related information in resource-constrained settings is imperative. Health service providers can leverage the role of media in the dissemination of health-related information as most rural folks are likely to adopt a behaviour said over the media. It was shown that single and those who were widowed, cohabiting, separated, divorced, or never married were more likely to develop high and 'very high' CVD risk. This may be explained by the higher stress associated with such a state as well as the society's higher demand for all adults to be married. Consistent with a systematic review and meta-analysis showed that being unmarried was associated with increased CVD [29]. A review of evidence described improved health status and reduced CVD risk with married status [30]. Various mechanisms have been suggested to account for the protective effect of marital status on CVD risk. For example, evidence indicates that staying together with another person allows for early detection and response to warning symptoms [31, 32] of CVDs, such as myocardial infarction if it becomes instantly disabling [32]. Also, married people have a likelihood to be less stressed as a result of the support and companionship they gain from their spouses including financial support. Some studies have also indicated that the unmarried had long delays in

Table 4 Bivariate analysis and multiple logistic regression modelling of factors of 'Very High' CVD Risk

Variables	Very high risk	Low/Moderate risk	COR (95% CI), p-value	AOR (95% CI), p-value
Sex				
Male	33(67.3)	16(32.7)	0.39(0.18,0.84), 0.014	
Female	101(84.2)	19(15.8)	(ref)	
Marital status				
Widowed/cohabiting/separation/divorced	64(94.1)	4(5.9)	9.14(2.9,28.87), < 0.001	62.68(8.72,450.27), < 0.001
Single	35(76.1)	11(23.9)	1.82(0.76,4.35), 0.177	15.28(3.22,72.58), 0.001
Married	35(63.6)	20(36.4)	(ref)	(ref)
Employment				
Unemployed	48(82.8)	10(17.2)	0.95(0.39,2.31), 0.904	0.23(0.06,0.96), 0.044
Retired	9(90)	1(10)	1.78(0.21,15.14), 0.699	0.05(0,0.96), 0.047
Others	6(37.5)	10(62.5)	0.12(0.04,0.38), < 0.001	0.1(0.02,0.65), 0.015
Employed	71(83.5)	14(16.5)	(ref)	(ref)
Belong to any social group				
Yes	23(67.6)	11(32.4)	0.43(0.19,1.01), 0.049	
No	111(82.8)	23(17.2)	(ref)	
Perception of Personal health				
Below good	84(94.4)	5(5.6)	(ref)	(ref)
Good	38(69.1)	17(30.9)	0.13(0.05,0.39), < 0.001	0.02(0,0.12), < 0.001
Above good	11(47.8)	12(52.2)	0.06(0.02,0.18), < 0.001	0.02(0,0.16), < 0.001
Read a newspaper or a magazine				
Not at all	111(81.6)	25(18.4)	3.81(1.18,12.31), 0.029	
Less than once a week	7(53.8)	6(46.2)	(ref)	
At least once a week	13(81.3)	3(18.8)	3.71(.70,19.59), 0.226	
Listen to radio				
Not at all	29(87.9)	4(12.1)	1.79(.57,5.61), 0.311	0.11(0.02,0.74), 0.024
Less than once a week	11(61.1)	7(38.9)	.39(.14,1.11), 0.071	0.48(0.07,3.24), 0.451
At least once a week	93(80.2)	23(19.8)	(ref)	(ref)
Watch Television				
Not at all	52(88.1)	7(11.9)	5.57(1.49,20.86), 0.014	
Less than once a week	8(57.1)	6(42.9)	(ref)	
At least once a week	73(77.7)	21(22.3)	2.61(0.81,8.35), 0.182	
Alcohol use				
Yes	32(68.1)	15(31.9)	0.4(0.18,0.87), 0.019	0.27(0.08,0.93), 0.038
No	102(84.3)	19(15.7)	(ref)	(ref)
Weekly exercise				
0–2 times	91(88.3)	12(11.7)	3.97(1.8,8.78), < 0.001	11.75(2.72,50.66), 0.001
3–5 times	42(65.6)	22(34.4)	(ref)	(ref)
Perception of lifestyle (Physical)				
Free from stress	44(81.5)	10(18.5)	(ref)	
Stressful	66(85.7)	11(14.3)	1.36(0.53,3.48), 0.516	
Relatively Stressful	11(52.4)	10(47.6)	0.25(0.08,0.75), 0.011	
Very stressful	13(81.3)	3(18.8)	0.99(0.24,4.12), 1	
Perception of lifestyle(Emotional)				
Free from stress	52(0.813)	12(0.188)	(ref)	
Stressful	65(84.4)	12(15.6)	1.25(.52, 3.01), 0.619	
Relatively Stressful	12(60)	8(40)	.35(.12, 1.03), 0.051	
Very stressful	5(83.3)	1(16.7)	1.15(.12,10.81), 1	

Table 4 (continued)

Variables	Very high risk	Low/Moderate risk	COR (95% CI), p-value	AOR (95% CI), p-value
Perception of lifestyle(Psychological)				
Free from stress	51(82.3)	11(17.7)	(ref)	
Stressful	66(85.7)	11(14.3)	1.29(0.52,3.22), 0.579	
Relatively Stressful	8(47.1)	9(52.9)	0.19(0.06,0.61), 0.006	
Very stressful	9(75)	3(25)	0.65(0.15,2.79), 0.687	
Coronary heart disease a type of CVD				
Yes	72(79.1)	19(20.9)	(ref)	
No	4(57.1)	3(42.9)	.35(.072,1.71), 0.344	
I do not know	55(84.6)	10(15.4)	1.45(.63,3.37), 0.412	
Peripheral arterial disease a type of CVD				
Yes	45(68.2)	21(31.8)	(ref)	
No	6(85.7)	1(14.3)	2.8(0.32,24.76), 0.431	
I do not know	82(87.2)	12(12.8)	3.19(1.44,7.08), 0.003	
Congenital heart disease a type of CVD				
Yes	51(73.9)	18(26.1)	(ref)	
No	3(50)	3(50)	0.35(0.07,1.91), 0.34	
I do not know	79(85.9)	13(14.1)	2.15(0.97,4.75), 0.057	
Deep vein thrombosis and pulmonary embolism a type of CVD				
Yes	35(67.3)	17(32.7)	0.36(0.17,0.78), 0.008	
No	98(85.2)	17(14.8)	(ref)	
Feeling weak, light-headed, or fainting are symptoms of a heart attack				
Yes	61(85.9)	10(14.1)	(ref)	
No	10(62.5)	6(37.5)	.27(.08, 0.92), 0.04	
I do not know	62(78.5)	17(21.5)	0.60(.25,1.41), 0.237	
Chest pain or discomfort a symptom of a heart attack				
Yes	70(76.9)	21(23.1)	(ref)	
No	11(68.8)	5(31.3)	.66(.21, 2.11), 0.531	
I do not know	48(87.3)	7(12.7)	2.06(.81,5.22), 0.124	
Sudden confusion or trouble speaking or understanding others are symptoms of a stroke				
Yes	89(82.4)	19(17.6)	(ref)	
No	8(57.1)	6(42.9)	.29(.09, .92), 0.039	
I do not know	37(82.2)	8(17.8)	.99(.40,2.46), 1	
Severe headache a symptom of stroke				
Yes	85(86.7)	13(13.3)	(ref)	
No	10(52.6)	9(47.4)	0.17(0.06,0.5), 0.002	
I do not know	39(78)	11(22)	0.54(0.22,1.32), 0.173	

COR Crude Odds Ratio, *AOR* Adjusted Odds ratio

seeking medical care and longer duration when having ischemic heart disease [31, 33, 34]. Evidence also showed that spouses encourage concordant health behaviour (healthy lifestyle) and treatment adherence that promotes cardiovascular health [31, 35–38]. In contrast, marital dissolution negatively affects the health behaviour mentioned above [39]. This might have accounted for the high risk among those separated, widowed, and divorced compared to those married. We found that participants who do not exercise or do so at most twice per week were more likely to develop a 'very high' CVD risk than those who exercised 3 to 5 times a week. Our finding is consistent with previous studies that found that physical activity reduced the CVD risk [5, 40]. Prior studies have demonstrated the beneficial effects of physical activity on traditional risk factors [41–43]. Physical exercise when done properly can promote cardiac health, increase blood circulation, promote vascular health, and improve total cardiovascular functioning. However, some individuals may experience large changes in risk levels following physical exercise, while most individuals experience modest short-term changes [42, 44]. We may attribute our findings to prior evidence which indicates that regular exercise training improves the CVD risk profile by reducing triglycerides and increasing high-density lipoprotein cholesterol [45], reducing BP [46], increasing glucose metabolism and insulin sensitivity [47], body weight reduction, and reducing inflammatory markers [48]. These enumerated CVD risk combined improves 59% of the reduction in CVD [42], while the remaining 41% may also result from enhanced vagal tone producing lower heart, vascular remodelling, improved endothelial function, and an enhanced nitric oxide bioavailability [49–51].

This study found that unemployed participants were less likely to develop a 'very high' CVD risk. The finding is counterintuitive to several previous pieces of evidence that showed that unemployed participants were associated with an increased CVD risk [14, 26, 52–54]. A plausible explanation for our finding could be that our study focuses on a sample of older adults (the mean age of the participants was 48.67 ± 19.21 years). Although unemployment is associated with poorer health [14, 15, 55], the effects of unemployment, and the potentially ameliorating impact of unemployment benefits, may be weaker in retired or mature workers who have already established careers and accumulated financial resources [56–58]. In the Ghanaian rural setting, people who are not employed are not exposed to unhealthy eating lifestyles [14, 59] due to the general financial constraints imposed by their employment status. Also, our results showed that having a higher knowledge of the CVD risk factors protected rural residents. This emphasizes the need to increase public knowledge of CVD disease and related risk factors. Participants who knew deep vein thrombosis and pulmonary embolism as a type of CVD and knowledge of severe headaches with no known cause as a stroke symptom were less likely to be at high CVD risk. This is because people with knowledge about CVD might be cautious by avoiding unhealthy behaviour that predisposes them to the disease. Participants who were believed to have good health were also less likely to have CVD risk. People with a good perception of their health might be aware of unhealthy lifestyles that could predispose them to disease. Therefore, they might be involved in activities and lifestyles that will help them maintain healthy lifestyles, thereby reducing the CVD risk. It is therefore imperative that healthcare interventions for the control of CVD risk among rural residents focus on increasing knowledge and improving positive general perception of health.

Strengths and limitations

This study highlighted the CVD risk in a resource-limited rural setting and used the robust, comprehensive, systematic and multifaceted WHO tool. One limitation of this study is that it was a single-centre study in rural settings, limiting comparability to other settings. Therefore, it may be an exaggeration to directly translate these findings to urban settings where increasing urbanization may result in higher prevalence. However, this will be overcome in future publications from this project as it will provide an opportunity to compare the progress attained over time in reducing the CVD risk. Also, the questionnaire involved a self-report as behaviour desirability bias could influence the responses of participants. However, this was overcome as research assistants involved in data collection were rigorously trained on data collection methods, the study tools, and research ethics before the study. Also, researchers were trained nurses with at least a bachelor's degree and fair knowledge in conducting these studies. Regardless of these limitations that are stated above, the findings provide a one-time understanding of the CVD risk among rural residents. This preliminary data also serves as a basis for future comparison of study findings following a comprehensive CVD risk education to be implemented in the study settings.

Conclusion

The significant predictors of a 'very high' CVD risk include marital status being single, those who exercise only two (2) times a week, employment being part-time workers, poor perception of overall personal health, and those listening to the radio. We recommend implementing primary prevention education strategies that involve adopting a comprehensive assessment and management of the risk factors of CVD among community-dwelling rural folks. These educational interventions must incorporate local cultural perspectives that focus on dieting, social relationships, and the creation of health awareness through improved behaviour modifications. These will involve incorporating multiple strategies/ interventions in rural communities must be adopted to reduce the CVD risk. It was also shown that increasing knowledge of CVD risk factors and having a positive perception of overall health were protective of CVD risk. Consequently, it is important that tailored health education is given to rural residents on CVD risk and the means to prevent the same.

Acknowledgements

We are most grateful to the UHAS-Yonsei collaboration project for securing funding for this project. The UHAS – Yonsei collaboration project was funded through the National Research Foundation (NRF) of Korea through the Public Health Education Capacity Development of the University of Health & Allied Sciences' project. We also appreciate the contribution of all the research assistants, community leaders and people of the Avenui community.

Authors' contributions

The authors confirm contribution to the paper as follows: study conception and design: KDK, AA, JAA, SK; data collection: KDK, AA, JAA, DA, MT, TA, ACB, AK, HM, FB, HJ, SK; analysis and interpretation of results: KDK, AA, JAA, DA; draft manuscript preparation: KDK, AA, JAA, DA. All authors reviewed the results and approved the final version of the manuscript.

Funding
This study was funded by the National Research Foundation (NRF) of Korea through the Public Health Education Capacity Development of the University of Health & Allied Sciences project. The funding institution only provided funding and did not influence the content of this study.

Data availability
All data on which the conclusion of this paper is based is included in this file, and no data is deposited in any data repositories.

Declarations

Ethics approval and consent to participate
The study adhered to the principles enshrined in the Helsinki Declaration for the conduct of human subject research. Ethical approval was obtained from the Institute of Health Research Ethics Committee of the University of Health and Allied Sciences (UHAS-REC A7 (1) 2 l-22). Administrative approvals for the study were also obtained from the district and regional health directorates. Written consent was obtained from each participant before their enrolment. Study participants were designated specific study codes (telephone numbers), and all related documentation was an inference to these codes such that the confidentiality and privacy of study subjects were protected. Written informed consent was obtained from each participant.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Public Health Nursing, School of Nursing and Midwifery, University of Health and Allied Sciences, Ho, Ghana. [2]Department of Nursing, School of Nursing and Midwifery, University of Health and Allied Sciences, Ho, Ghana. [3]Department of Basic Sciences, School of Basic and Biomedical Sciences, University of Health and Allied Sciences, Ho, Ghana. [4]Department of Midwifery, School of Nursing and Midwifery, University of Health and Allied Sciences, Ho, Ghana. [5]Finance Directorate, University of Health and Allied Sciences, Ho, Ghana. [6]Department of Epidemiology and Biostatistics, Fred Newton Binka School of Public Health, University of Health and Allied Sciences, Hohoe, Ghana. [7]Department of Medical Law and Ethics, Graduate School, College of Medicine, Yonsei University, Seoul 03722, Korea. [8]Asian Institute for Bioethics and Health Law (WHO Collaborating Centre for Health Law & Bioethics Researcher), Yonsei University Health Systems, 50-1 Yonsei-Ro, Seodaemungu-Gu, Seoul, Korea.

Received: 5 February 2024 Accepted: 19 February 2025
Published online: 07 March 2025

References

1. Pagidipati NJ, Gaziano TA. Estimating deaths from cardiovascular disease: a review of global methodologies of mortality measurement. Circulation. 2013;127(6):749–56.
2. Al-Makki A, DiPette D, Whelton PK, Hassan Murad M, Mustafa RA, Acharya S, Beheiry HM, et al. Hypertension pharmacological treatment in adults: a World Health Organization guideline executive summary. Hypertension. 2022;79(1):293–301.
3. Davies M, Hollman A. The World Health Organisation. Heart. 1997;78(6):529.
4. Mensah GA, Sampson UK, Roth GA, Forouzanfar MH, Naghavi M, Murray CJ, et al. Mortality from cardiovascular diseases in sub-Saharan Africa, 1990–2013: a systematic analysis of data from the Global Burden of Disease Study 2013. Cardiovascular journal of Africa. 2015;26(2 H3Africa Suppl):S6.
5. Baeradeh N, Ghoddusi Johari M, Moftakhar L, Rezaeianzadeh R, Hosseini SV, Rezaianzadeh A. The prevalence and predictors of cardiovascular diseases in Kherameh cohort study: a population-based study on 10,663 people in southern Iran. BMC Cardiovasc Disord. 2022;22(1):1–12.
6. Konlan KD, Lee H, Lee M, Kim Y, Lee H, Asibi Abdulai J. Risk factors associated with the incidence and prevalence of hypertension in Ghana: an integrated review (2016-2021). Int J Environ Health Res. 2023;33(11):1132–47.
7. Shin J, Konlan KD, Mensah E. Health promotion interventions for the control of hypertension in Africa, a systematic scoping review from 2011 to 2021. PLoS ONE. 2021;16(11):e0260411.
8. World Health Organisation. Global action plan on physical activity 2018–2030: more active people for a healthier world. Geneva: World Health Organisation; 2019.
9. Gyamfi D, Obirikorang C, Acheampong E, Danquah KO, Asamoah EA, Liman FZ, Batu EN. Prevalence of pre-hypertension and hypertension and its related risk factors among undergraduate students in a Tertiary institution. Ghana Alexandria Journal of Medicine. 2018;54(4):475–80.
10. Ofori-Asenso R, Agyeman AA, Laar A, Boateng D. Overweight and obesity epidemic in Ghana—a systematic review and meta-analysis. BMC Public Health. 2016;16(1):1–18.
11. van de Vijver S, Oti S, Addo J, de Graft-Aikins A, Agyemang C. Review of community-based interventions for prevention of cardiovascular diseases in low-and middle-income countries. Ethn Health. 2012;17(6):651–76.
12. Tenkorang EY, Kuuire VZ. Noncommunicable diseases in Ghana: Does the theory of social gradient in health hold? Health Education & Behavior. 2016;43(1_suppl):25S-36S.
13. Reiner RC, Wiens KE, Deshpande A, Baumann MM, Lindstedt PA, Blacker BF, et al. Mapping geographical inequalities in childhood diarrhoeal morbidity and mortality in low-income and middle-income countries, 2000–17: analysis for the Global Burden of Disease Study 2017. The Lancet. 2020;395(10239):1779–801.
14. Konlan KD, Aku Baku E, Japiong M, Dodam Konlan K, Razak Doat A, Nawunimali Suuk A, Mensima Amoah R. Practices of adults in a periurban community of the Ho municipality on prevention of hypertension. Int J Hypertens. 2020;(1):2136213.
15. Konlan KD, Afam-Adjei CJ, Afam-Adjei C, Oware J, Akua Appiah T, Diema Konlan K, Bella-Fiamawle J. Practice and Sociodemographic Factors Influencing Self-Monitoring of Blood Pressure in Ghanaians with Hypertension. Int J Chronic Dis. 2020;(1):6016581.
16. Adler AJ, Laar A, Prieto-Merino D, Der RM, Mangortey D, Dirks R, et al. Can a nurse-led community-based model of hypertension care improve hypertension control in Ghana? Results from the ComHIP cohort study. BMJ Open. 2019;9(4): e026799.
17. de Miguel-Yanes JM, Méndez-Bailón M, Jiménez-García R, López-de-Andrés A. Comment on Burrows et al. Declining rates of hospitalization for selected cardiovascular disease conditions among adults aged≥ 35 years with diagnosed diabetes, US, 1998–2014. Diabetes Care 2018; 41: 293–302. Diabetes Care. 2018;41(4):e58-e.
18. Nangia R, Singh H, Kaur K. Prevalence of cardiovascular disease (CVD) risk factors. medical journal armed forces india. 2016;72(4):315–9.
19. Owiredu E-W, Dontoh E, Essuman SES, Bazanfara BB. Demographic and lifestyle predictors of prehypertension: A cross-sectional study among apparently healthy adults in Kumasi, Ghana. Biomed Res Int. 2019;(1):1764079.
20. Gitlin LN, Czaja SJ. Behavioral intervention research: Designing, evaluating, and implementing. Springer publishing company; 2015.
21. Williams B, Mancia G, Spiering W, Rosei EA, Azizi M, Burnier M, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. Kardiologia Polska (Polish Heart Journal). 2019;77(2):71–159.
22. Moyer VA, Force* UPST. Screening for and management of obesity in adults: US Preventive Services Task Force recommendation statement. Annals of internal medicine. 2012;157(5):373–8.
23. Pitts SBJ, Vu MB, Garcia BA, McGuirt JT, Braxton D, Hengel CE, et al. A community assessment to inform a multi-level intervention to reduce CVD risk and risk disparities in a rural community. Fam Community Health. 2013;36(2):135.
24. Schwalm J-D, McCready T, Lopez-Jaramillo P, Yusoff K, Attaran A, Lamelas P, et al. A community-based comprehensive intervention to reduce cardiovascular risk in hypertension (HOPE 4): a cluster-randomised controlled trial. The Lancet. 2019;394(10205):1231–42.

25. Richards SH, Anderson L, Jenkinson CE, Whalley B, Rees K, Davies P, et al. Psychological interventions for coronary heart disease: Cochrane systematic review and meta-analysis. Eur J Prev Cardiol. 2018;25(3):247–59.
26. Khanam F, Hossain MB, Mistry SK, Afsana K, Rahman M. Prevalence and risk factors of cardiovascular diseases among Bangladeshi adults: findings from a cross-sectional study. Journal of epidemiology and global health. 2019;9(3):176.
27. Gu D, Gupta A, Muntner P, Hu S, Duan X, Chen J, et al. Prevalence of cardiovascular disease risk factor clustering among the adult population of China: results from the International Collaborative Study of Cardiovascular Disease in Asia (InterAsia). Circulation. 2005;112(5):658–65.
28. Ab Hamid MR, Yusof NDBM, Buhari SS, Malek KA, Noor HM. Development and validation of educational video content, endorsing dietary adjustments among patients diagnosed with hypertension. Int J Health Promot Educ. 2024;62(4):197–208.
29. Wong CW, Kwok CS, Narain A, Gulati M, Mihalidou AS, Wu P, et al. Marital status and risk of cardiovascular diseases: a systematic review and meta-analysis. Heart. 2018;104(23):1937–48.
30. Manfredini R, De Giorgi A, Tiseo R, Boari B, Cappadona R, Salmi R, et al. Marital status, cardiovascular diseases, and cardiovascular risk factors: a review of the evidence. J Womens Health. 2017;26(6):624–32.
31. Kilpi F, Konttinen H, Silventoinen K, Martikainen P. Living arrangements as determinants of myocardial infarction incidence and survival: a prospective register study of over 300,000 Finnish men and women. Soc Sci Med. 2015;133:93–100.
32. Sorlie PD, Coady S, Lin C, Arias E. Factors associated with out-of-hospital coronary heart disease death: the national longitudinal mortality study. Ann Epidemiol. 2004;14(7):447–52.
33. Muntner P, Anderson A, Charleston J, Chen Z, Ford V, Makos G, et al. Hypertension awareness, treatment, and control in adults with CKD: results from the Chronic Renal Insufficiency Cohort (CRIC) Study. Am J Kidney Dis. 2010;55(3):441–51.
34. Hadi Khafaji HA, Al Habib K, Asaad N, Singh R, Hersi A, Falaeh HA, et al. Marital status and outcome of patients presenting with acute coronary syndrome: an observational report. Clin Cardiol. 2012;35(12):741–8.
35. Dupre ME, George LK, Liu G, Peterson ED. Association between divorce and risks for acute myocardial infarction. Circulation: Cardiovascular Quality and Outcomes. 2015;8(3):244–51.
36. Floud S, Balkwill A, Canoy D, Wright FL, Reeves GK, Green J, et al. Marital status and ischemic heart disease incidence and mortality in women: a large prospective study. BMC Med. 2014;12(1):1–9.
37. Wu J-R, Lennie TA, Chung ML, Frazier SK, Dekker RL, Biddle MJ, Moser DK. Medication adherence mediates the relationship between marital status and cardiac event-free survival in patients with heart failure. Heart Lung. 2012;41(2):107–14.
38. Konlan KD, Shin J. Determinants of self-care and home-based management of hypertension: an integrative review. Glob Heart. 2023;18(1):16.
39. Matthews KA, Gump BB. Chronic work stress and marital dissolution increase risk of posttrial mortality in men from the Multiple Risk Factor Intervention Trial. Arch Intern Med. 2002;162(3):309–15.
40. Saki N, Karandish M, Cheraghian B, Heybar H, Hashemi SJ, Azhdari M. Prevalence of cardiovascular diseases and associated factors among adults from southwest Iran: Baseline data from Hoveyzeh Cohort Study. BMC Cardiovasc Disord. 2022;22(1):1–10.
41. Celis-Morales CA, Lyall DM, Welsh P, Anderson J, Steell L, Guo Y, et al. Association between active commuting and incident cardiovascular disease, cancer, and mortality: prospective cohort study. bmj. 2017;357:j1456.
42. Mora S, Cook N, Buring JE, Ridker PM, Lee I-M. Physical activity and reduced risk of cardiovascular events: potential mediating mechanisms. Circulation. 2007;116(19):2110–8.
43. Murtagh EM, Nichols L, Mohammed MA, Holder R, Nevill AM, Murphy MH. The effect of walking on risk factors for cardiovascular disease: an updated systematic review and meta-analysis of randomised control trials. Prev Med. 2015;72:34–43.
44. Green DJ, O'Driscoll G, Joyner MJ, Cable NT. Exercise and cardiovascular risk reduction: time to update the rationale for exercise?. J Appl Physiol. 2008;105(2):766–8.
45. Mann S, Beedie C, Jimenez A. Differential effects of aerobic exercise, resistance training and combined exercise modalities on cholesterol and the lipid profile: review, synthesis and recommendations. Sports Med. 2014;44:211–21.
46. Whelton SP, Chin A, Xin X, He J. Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. Ann Intern Med. 2002;136(7):493–503.
47. Kirwan JP, Sacks J, Nieuwoudt S. The essential role of exercise in the management of type 2 diabetes. Clevel Clin J Med. 2017;84(7 Suppl 1):S15.
48. Szostak J, Laurant P. The forgotten face of regular physical exercise: a 'natural'anti-atherogenic activity. Clin Sci. 2011;121(3):91–106.
49. Beere PA, Glagov S, Zarins CK. Experimental atherosclerosis at the carotid bifurcation of the cynomolgus monkey. Localization, compensatory enlargement, and the sparing effect of lowered heart rate. Arteriosclerosis and Thrombosis: A Journal of Vascular Biology. 1992;12(11):1245–53.
50. Eijsvogels TM, Molossi S, Lee D-c, Emery MS, Thompson PD. Exercise at the extremes: the amount of exercise to reduce cardiovascular events. Journal of the American College of Cardiology. 2016;67(3):316–29.
51. Joyner MJ, Green DJ. Exercise protects the cardiovascular system: effects beyond traditional risk factors. J Physiol. 2009;587(23):5551–8.
52. Meneton P, Kesse-Guyot E, Méjean C, Fezeu L, Galan P, Hercberg S, Ménard J. Unemployment is associated with high cardiovascular event rate and increased all-cause mortality in middle-aged socially privileged individuals. Int Arch Occup Environ Health. 2015;88:707–16.
53. Mosquera PA, San Sebastian M, Waenerlund A-K, Ivarsson A, Weinehall L, Gustafsson PE. Income-related inequalities in cardiovascular disease from mid-life to old age in a Northern Swedish cohort: A decomposition analysis. Soc Sci Med. 2016;149:135–44.
54. Zagożdżon P, Parszuto J, Wrotkowska M, Dydjow-Bendek D. Effect of unemployment on cardiovascular risk factors and mental health. Occup Med. 2014;64(6):436–41.
55. Gallo WT, Teng H-M, Falba TA, Kasl SV, Krumholz HM, Bradley EH. The impact of late career job loss on myocardial infarction and stroke: a 10 year follow up using the health and retirement survey. Occup Environ Med. 2006;63(10):683–7.
56. Lundin A, Lundberg I, Hallsten L, Ottosson J, Hemmingsson T. Unemployment and mortality—a longitudinal prospective study on selection and causation in 49321 Swedish middle-aged men. J Epidemiol Community Health. 2010;64(01):22–8.
57. Stuckler D, Basu S, Suhrcke M, Coutts A, McKee M. The public health effect of economic crises and alternative policy responses in Europe: an empirical analysis. The Lancet. 2009;374(9686):315–23.
58. Walter S, Glymour M, Avendano M. The health effects of US unemployment insurance policy: does income from unemployment benefits prevent cardiovascular disease? PLoS ONE. 2014;9(7): e101193.
59. Osei E, Amu H, Appiah-Kubi P, Konlan KD, Mumuni H, Orish VN, Saa-Eru Maalman R, et al. Prevalence and predictors of selected risk factors of non-communicable diseases in Ghana: evidence from a sub-national survey. J Glob Health Sci. 2021;3(2).

Publisher's Note