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Original Research

Atherosclerotic cardiovascular disease risk among Ghanaians: A comparison of the risk assessment tools.

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ABSTRACT

Objectives: Risk stratification is a cornerstone for preventing atherosclerotic cardiovascular disease (ASCVD). Ghana has yet to develop a locally derived and validated ASCVD risk model. A critical first step towards this goal is assessing how the commonly available risk models perform in the Ghanaian population. This study compares the agreement and correlation between four ASCVD risk assessment models commonly used in Ghana.

Methods: The Ghana Heart Study collected data from four regions in Ghana (Ashanti, Greater Accra, Northern, and Central regions) and excluded people with a self-declared history of ASCVD. The 10-year fatal/non-fatal ASCVD risk of participants aged 40–74 was calculated using mobile-based apps for Pooled Cohort Equation (PCE), laboratory-based WHO/ISH CVD risk, laboratory-based Framingham risk (FRS), and Globorisk, categorizing them as low, intermediate, or high risk. The risk categories were compared using the Kappa statistic and Spearman correlation.

Results: A total of 615 participants were included in this analysis (median age 55 [Inter quartile range 46, 64]) years with 365 (59.3 %) females. The WHO/ISH risk score categorized 504 (82.0 %), 58 (9.4 %), and 53 (8.6 %) as low-, intermediate-, and high-risk, respectively. The PCE categorized 345 (56.1 %), 181 (29.4 %), and 89 (14.5 %) as low-, intermediate- and high-risk, respectively. The Globorisk categorized 236 (38.4 %), 273 (44.4 %), and 106 (17.2 %) as low-, intermediate-, and high-risk, respectively. Significant differences in the risk categorization by region of residence and age group were noted. There was substantial agreement between the PCE vs FRS (Kappa = 0.8, 95 % CI 0.7 – 0.8), PCE vs Globorisk (Kappa = 0.6; 95 % CI 0.6 – 0.7), and FRS vs Globorisk (Kappa = 0.6; 95 % CI 0.6 – 0.7). However, there was only fair agreement between the WHO vs Globorisk (Kappa = 0.3; 95 % CI 0.3–0.4) and moderate agreement between the WHO vs PCE and WHO vs FRS.

Conclusion: There are significant differences in the ASCVD risk prediction tools in the Ghanaian population, posing a threat to primary prevention. Therefore, there is a need for locally derived and validated tools.

1. Introduction

Atherosclerotic cardiovascular disease (ASCVD) is the leading cause of death worldwide, with over 80 % of deaths occurring in low and middle-income countries [1]. This includes coronary artery disease (CAD), stroke, transient ischaemic attack (TIA), peripheral artery disease (PAD), and aortic aneurysm (AA) [2]. A recent scoping review

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[1] All authors contributed significantly to this study's conception, data collection, and interpretation. FA, IKO, and FKA drafted the initial document. FA, FKA, LTA and SBN did the final analysis and presentation of the results. FA, FKA, KG, LTA made significant revisions and contributions to the final manuscript. All authors made significant revisions to the final document and approved the decision to publish this manuscript. No specific grant funding was received for this work.

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demonstrated a high burden of ASCVD in Ghana, mainly driven by stroke CAD [3]. Additionally, several traditional risk factors for ASCVD have been identified, including older age, male sex, current smoking, dyslipidemia, diabetes mellitus, hypertension, obesity, and physical inactivity [4]. These risk factors are incorporated into the current risk scoring systems.

Abbreviations

AA – Aortic aneurysm
ASCVD – Atherosclerotic cardiovascular disease
CAD – Coronary artery disease
CVD – Cardiovascular disease
FRS – Framingham risk score
GHS – Ghana Health Service
HDL – High-density lipoprotein
IQR – Interquartile range
JBS – Joint British Society
PAD – Peripheral artery disease
PAR – Population attributable risk
PCE – Pooled cohort equation.
PROCAM – Prospective cardiovascular Munster study
SCORE – Systematic coronary risk evaluation
T2DM – Type 2 diabetes mellitus
TIA – Transient ischemic attack
WHO/ISH – World health organization/International society of hypertension.

Risk assessment is an important first step in the primary prevention of ASCVD [5]. Calculating the ten-year ASCVD risk helps guide treatment with statins and antihypertensives in high-risk groups, which can greatly decrease the disease burden and prevent cardiovascular events [5]. This is especially important in low-income countries and resource-poor settings where timely intervention and affordability of treatment remain a challenge. Some ASCVD risk scores commonly used across the globe are the Framingham risk score (FRS) [6], the pooled cohort equation (PCE) [7], the SCORE [8], the Reynold's Risk Score [9], the QRISK 2 [10], JBS3 [11], and the World Health Organization/International Society of Hypertension (WHO/ISH) risk prediction charts [12]. A more recent scoring system, the Globorisk equation is country-specific and was found to predict ASCVD risk in national populations worldwide [13].

However, the applicability of these Risk assessment tools is largely dependent on the population from which they were derived and validated. These tools have been extensively tested in different populations and increasingly demonstrate the need for models tailored to local epidemiological data [14]. For example, the PCE has been widely validated in the US population but tends to underestimate risk in particular ethnic groups, in patients with lower socioeconomic status or chronic inflammatory disease, and tends to overestimate risk in patients with higher socioeconomic status or patients who have received preventative care [5]. In addition to this, the FRS has been criticized for an inaccurate prediction of risk in certain ethnic groups [15].

Although the Risk assessment tools have been widely tested in various geographic locations, the research in most countries in Sub-Saharan Africa is still sparse. This region has demonstrated the fastest rate of urbanization globally and an established epidemiological transition towards non-communicable diseases [16]. Furthermore, the average age of death from CVD in Sub-Saharan Africa is the youngest in the world, which stresses the need for more population-specific data [16].

Previous studies have demonstrated the main risk factors in the Ghanaian population to be dyslipidemia (34.4 %), hypertension (26.1 %), obesity (15.1 %), hyperuricemia (9.3 %), and diabetes mellitus (6.8 %) with the main lifestyle factors being alcohol use, physical inactivity, and inadequate fruit and vegetable intake [17]. It is worth noting that Smoking is not a considerable risk factor in the Ghanaian population (8.6 % of the population and 1.4 % among women) possibly due to a strong cultural dislike for smoking and religious influences [18].

Currently, since none of the risk algorithms were derived or have been validated in Ghana, different clinicians apply different risk scores in their practice. However, the maiden cardiovascular disease treatment guideline for Ghana recommends the use of the WHO/ISH risk assessment tool for uniformity [19]. This study is a cross-sectional study that aims to assess the level of agreement between the PCE, WHO/ISH laboratory-based risk tool, FRS, and Globorisk laboratory-based risk classification in the Ghanaian population using data from the Ghana Heart Study. This hopes to address the literature gap in the region and lay the groundwork for prospective studies in the future, assessing the accuracy of the risk assessment tools as well as developing our own ASCVD Risk algorithms and local guidelines.

2. Methods and materials

2.1. Study design, population, and inclusion criteria

We used data from the Ghana Heart Study (GHS) conducted in 2016 and 2017, and the first manuscript detailing the methodology was published in 2020 [17]. The study was registered at http://www.chictr.org.cn as ChiCTR1800017374. It was a community-based nationwide cross-sectional study that employed a stratified random sampling technique to recruit participants from four demographically different regions in Ghana. The first step involved a purposive selection of four out of the ten regions of Ghana to represent the northern, middle, and southern areas. The communities were then listed and one rural and one urban community were selected from each of the four regions (Ashanti, Greater Accra, Central, and Northern region) by simple random sampling. The second stage involved the selection of households using a systematic sampling technique after demarcating and enumerating all the households within the community. Three participants, aged 18 years and above, were then selected from each household by simple random sampling after listing all members in the household. The few household members who were selected but refused participation were replaced by other people from the same family.

2.2. Exclusion criteria

Household members who were below 18 years, pregnant, had type 1 diabetes mellitus, had self-declared history of established ASCVD (stroke, previous myocardial infarction, or peripheral artery disease), secondary hypertension, congenital heart disease, or who refused consent were excluded from the study [17].

2.3. Data collection and measurements

The participants were invited to a central location (schools, churches, mosques) by trained research assistants for structured interviews and data collection. This included demographic information such as age, sex, ethnicity, and residence. History of smoking, alcohol, exercise, and personal and family history of medical illness were also documented. All participants' weight, height, and blood pressure were checked following standard protocols. Three blood pressures were measured at 5-minute intervals using the OMRON M6–4,015,672,108,332 device, and the average of the last 2 measures was taken as the participant's blood pressure. An ISO-certified laboratory took a venous blood sample (10 mls) from the cubital fossa after 8–12 h overnight fast for measuring fasting serum lipids.

2.4. Definitions

Smoking was defined as the use of tobacco products such as cigarettes, cigars, and pipes, either daily or occasionally. Those who had quit smoking less than one year before the data was collected were categorized as smokers. Hypertension and T2DM were self-declared by the participants. The history of ASCVD was self-declared by patients as history of MI, stroke, TIA, or peripheral artery disease. Sex was categorized as binary (male/female) and defined as the designated sex assigned at birth. Ethnicity was self-declared by participants.

2.5. ASCVD risk calculations

The risk scores of all participants who were aged 40–74 years were calculated using the latest versions of electronic calculator applications on an Android mobile phone (SAMSUNG A32).

The PCE uses the following characteristics: age, race, sex, current smoking, T2DM, systolic blood pressure (sBP), use of antihypertensive medication, total cholesterol, HDL-C, LDL-C, and use of statins, to calculate the 10-year predicted risk. This score categorizes participants into four groups: <5 % (low risk), 5 % to <7.5 % (borderline risk), 7.5 % to <20 % (intermediate risk), and ≥20 % (high risk) [7]. For this study, the low risk and borderline risk were combined as low risk. Hence, the patients were categorized as low (<7.5 %), intermediate (7.5 % to <20 %), and high (≥20 %) risk.

The FRS uses information on age, sex, total and HDL cholesterol levels, sBP, smoking status, T2DM, and being under treatment for hypertension (HT). It is applicable to people aged between 30 and 79 years. The participants were categorized as low (<10 %), intermediate (10 to <20 %), and high (≥20 %) risk [6].

The Globorisk equation provides country-specific CVD risk scores to estimate the 10-year risk of fatal and non-fatal CVD based on data from 182 countries. The laboratory version is based on a person's country of residence, age, sex, smoking status, T2DM, sBP, and total cholesterol and applies to persons aged 40 to 74 years. The participants were categorized as low (<10 %), intermediate (10 to <20 %), and high (≥20 %) risk [20].

The WHO/ISH risk score, updated in 2019 applies to persons 40 to 74 years and it is based on the global region (region-specific). The derivation study used prospective cohorts for 21 sub-regions, mostly low- and middle-income countries, derived from the Emerging Risk Factors Collaboration [12]. There are two charts based on laboratory and non-laboratory models. The laboratory model is based on 6 variables (presence of diabetes mellitus, age, sex, smoking status, sBP, and total cholesterol), and predicts five risk categories (5 to <10 %, 10 to <20 %, 20 % to <30 %, 30 to <40 %, and ≥40 %). In this study, the participants were categorized as low (<10 %), intermediate (10 to <20 %), and high (≥20 %) risk [12,20,21].

2.6. Ethics, consent, and approval

Written informed consent was obtained from all participants. Ethical approval for this study was granted by the Kwame Nkrumah University of Science and Technology and the Komfo Anokye Teaching Hospital ethics review boards. The study was conducted in strict adherence to the protocol. The authors vouch for the fidelity of the data. Strict confidentiality was always maintained using a coded questionnaire.

2.7. Statistical analysis

Data was collected and entered in a pre-designed Microsoft Excel worksheet and regularly verified before analysis. The data was analyzed using R Statistical software tool version 4.2.0. None of the observations for the data required for this article were missing. All 615 records were retained and used for the final analysis. The ages were categorized into 40–49 years, 50–59 years, 60–69 years, and 70–74 years. The cardiovascular risks were determined using the Pooled cohort equation, WHO risk score, Framingham risk score, and Globorisk categories and expressed as Low-risk, Intermediate-risk, and High-risk groups. The derived risk categories were tabulated to determine their association with the sex, region of residence (Ashanti, Accra, Central, and Northern), community (Rural, Urban), and age grouping. These associations were determined using Pearson's chi-square test or Wilcoxon rank sum test for categorical and continuous variables. A Kruskal-Wallis rank sum test was used for the relationship between continuous variables and the four regions. Agreement between the various scores was done using the Cohen's Kappa statistic and categorized as follows: values </=0 indicate no agreement; values from 0.01 to 0.20 indicate poor/slight agreement; 0.21 to 0.40 indicate fair agreement; 0.41 to 0.60 indicate moderate agreement; 0.61 to 0.80 indicate good/substantial agreement; and 0.81 to 1.00 indicate very good/perfect agreement [22]. The Spearman correlation was further used to test agreement between the risk scores. A two-sided p-value of <0.05 was considered statistically significant for all analyses.

3. Results

A total of 615 participants were included in this analysis with a median age of 55 years (Interquartile range 46, 64), and a female preponderance of 365 (59.3 %). With regards to regional distribution, 191 (31.1 %), 182 (29.6 %), 106 (17.2 %), and 136 (22.1 %) participants were from Accra, Ashanti, Central, and Northern regions respectively. Age and sex distribution were similar in all the four regions. Of the analyzed population, 64 (10.4 %) were smokers, 166 (27 %) were on treatment for hypertension and 78 (12.7 %) were diabetic. The mean systolic blood pressure (sBP), total cholesterol, and low-density lipoprotein (LDL) cholesterol levels were 129 (116, 145) mmHg, 5.40 (4.70, 6.20) mmol/L, and 3.30 (2.20, 4.20) mmol/L, respectively. The mean sBP was significantly higher in males than females (133 versus 126 mmHg, respectively), whereas the mean total cholesterol was significantly higher in females than males (5.6 versus 5.3 mmol/L, respectively). Smoking was significantly higher in males than females (22.4 % versus 2.2 %). Furthermore, smoking was significantly higher in the Accra and Ashanti regions than the Central and Northern regions. Self-declared diabetes mellitus was similar in males and females as well as all four regions. The mean total cholesterol level was higher in participants from Accra and Ashanti than those from Central and Northern regions. The sex distribution (table 1) and regional distribution (table 2) of the participants are shown below.

Figs. 1, 2, and 3 show the calculated risk scores by region (Fig. 1),

Table 1
Clinical and demographic profile of study participants by sex.

Characteristic	Sex			
	Overall, (*N* = 615)[1]	Female, (*N* = 365)[1]	Male, (*N* = 250)[1]	p-value[2]
Age in years	55 (46, 64)	54 (47, 64)	56 (45, 64)	0.954
Smoking	64 (10.4)	8 (2.2)	56 (22.4)	<0.001
Type 2 Diabetes Mellitus	78 (12.7)	51 (14.0)	27 (10.8)	0.246
Systolic Blood Pressure (mmHg)	129 (116, 145)	126 (114, 143)	133 (120, 150)	<0.001
Treatment for hypertension	166 (27.0)	119 (32.6)	47 (18.9)	<0.001
Total Cholesterol (mmol/L)	5.40 (4.70, 6.20)	5.60 (4.80, 6.40)	5.30 (4.63, 6.00)	0.003
LDL Cholesterol (mmol/L)	3.30 (2.20, 4.20)	3.30 (2.30, 4.40)	3.20 (2.03, 3.98)	0.024
HDL Cholesterol (mmol/L)	1.30 (1.10, 1.60)	1.40 (1.20, 1.60)	1.30 (1.10, 1.50)	0.011

[1] Median (IQR); n (%).
[2] Wilcoxon rank sum test; Pearson's Chi-squared test. HDL = high density lipoprotein; IQR = interquartile range; LDL = low density lipoprotein.

Table 2
Clinical and demographic profile of study participants by community.

Characteristic	Region					p-value[2]
	Overall, (*N* = 615)[1]	Accra, (*N* = 191)[1]	Ashanti, (*N* = 182)[1]	Central, (*N* = 106)[1]	Northern, (*N* = 136)[1]	
Age in years	55 (46, 64)	55 (47, 64)	56 (46, 64)	54 (46, 60)	55 (47, 65)	0.410
Sex						0.068
Female	365 (59.3)	105 (55.0)	117 (64.3)	70 (66.0)	73 (53.7)	
Male	250 (40.7)	86 (45.0)	65 (35.7)	36 (34.0)	63 (46.3)	
Smoking	64 (10.4)	25 (13.1)	24 (13.2)	9 (8.5)	6 (4.4)	0.034
Type 2 Diabetes Mellitus	78 (12.7)	30 (15.7)	23 (12.6)	12 (11.3)	13 (9.6)	0.399
Systolic Blood Pressure (mmHg)	129 (116, 145)	129 (118, 149)	135 (122, 149)	124 (111, 141)	124 (114, 137)	<0.001
Treatment for hypertension	166 (27.0)	56 (29.5)	55 (30.2)	24 (22.6)	31 (22.8)	0.286
Total Cholesterol (mmol/L)	5.4 (4.7, 6.2)	5.50 (4.8, 6.4)	5.70 (4.8, 6.6)	5.20 (4.5, 6.0)	5.10 (4.6, 6.0)	<0.001
LDL Cholesterol (mmol/L)	3.3 (2.2, 4.2)	3.70 (2.8, 4.4)	3.50 (2.7, 4.5)	2.45 (−1.0, 3.8)	2.80 (−1.0, 3.5)	<0.001
HDL Cholesterol (mmol/L)	1.3 (1.1, 1.6)	1.40 (1.2, 1.7)	1.4 (1.23, 1.7)	1.25 (1.1, 1.5)	1.2 (1.0, 1.4)	<0.001

[1] Median (IQR); n (%).
[2] Kruskal-Wallis rank sum test; Pearson's Chi-squared test. HDL = high density lipoprotein; IQR = interquartile range; LDL = low density lipoprotein.

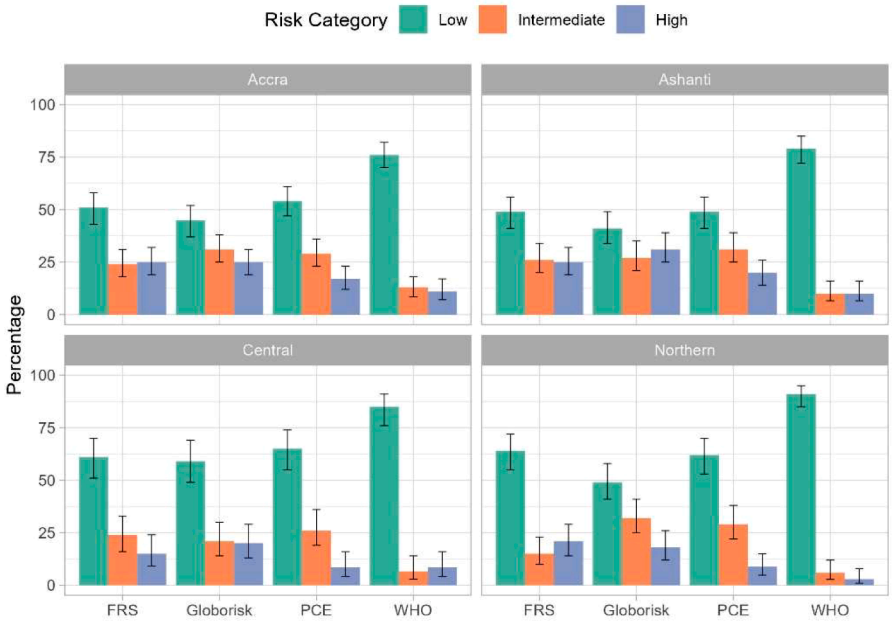

Fig. 1. Various risk assessment scores by region. FRS – Framingham risk score; PCE – pooled cohort equation; WHO – World Health Organization.

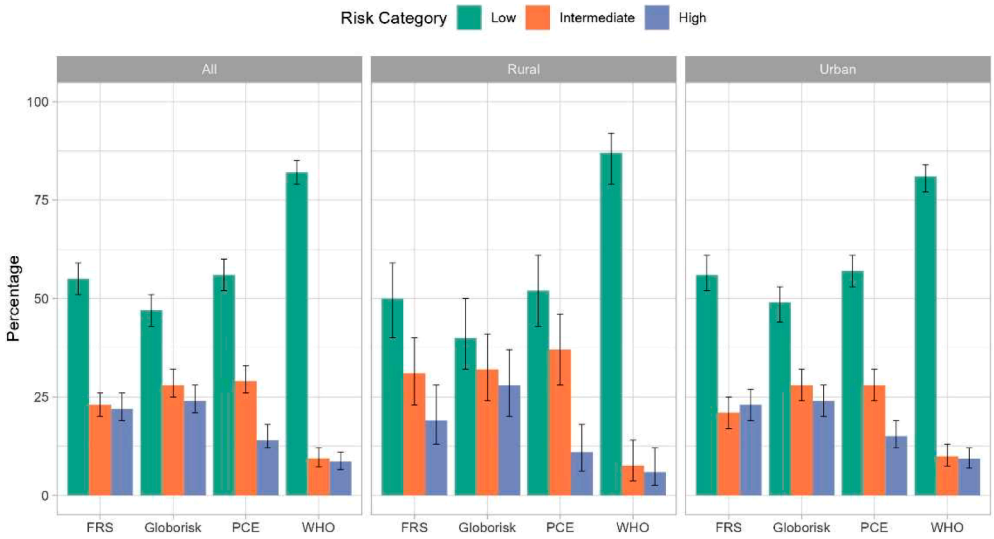

Fig. 2. Various risk assessment scores by residence (urban/rural). FRS – Framingham risk score; PCE – pooled cohort equation; WHO – World Health Organization.

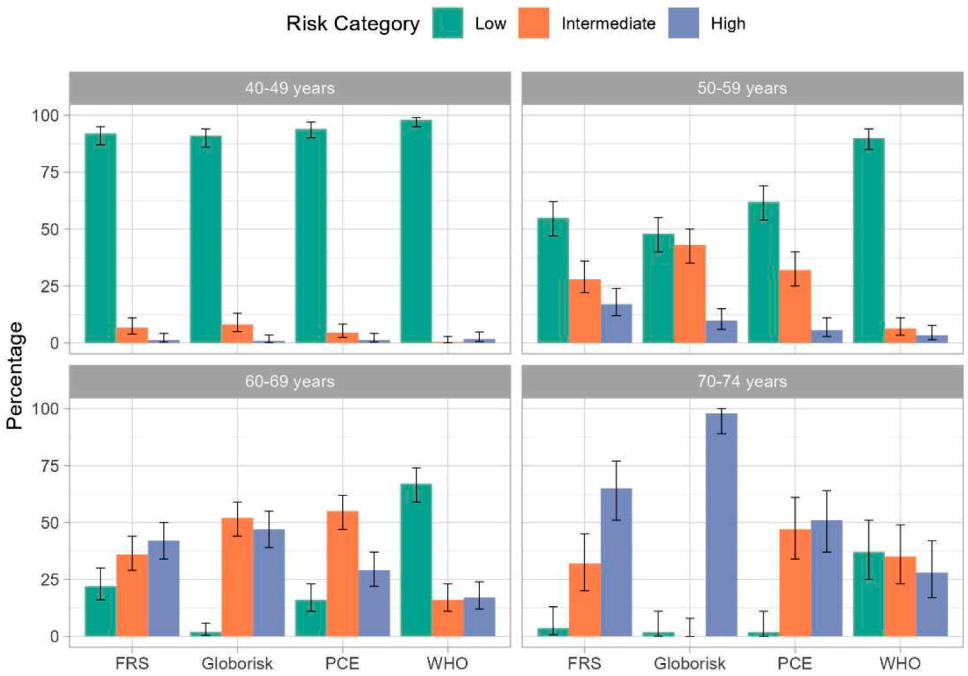

Fig. 3. Distribution of the various risk assessment scores by age category. FRS – Framingham risk score; PCE – pooled cohort equation; WHO – World Health Organization.

urban/rural residence (Fig. 2), and age category (Fig. 3). The PCE categorized 345 (56.1 %) as low-, 181 (29.4 %) as intermediate-, and 89 (14.5 %) as high-risk. The WHO risk score categorized 504 (82.0 %) as low-, 58 (9.4 %) as intermediate-, and 53 (8.6 %) as high-risk. The FRS categorized 338 (55.0 %) of participants as low-, 140 (22.8 %) as intermediate-, and 137 (22.3 %) as high-risk. The Globorisk categorized 236 (38.4 %) of the participants as low-, 273 (44.4 %) as intermediate-, and 106 (17.2 %) as high-risk. There were significant differences in the risk categorization by region of residence and age group (Figs. 1 and 3). All four risk scores showed higher high-risk categories in the Greater Accra and Ashanti regions than the other regions. Furthermore, the proportion of patients categorized as high risk progressively increased with advancing age group. The Globorisk particularly categorized almost all participants 70–74 years as high risk. However, there were no significant differences in the risk categorization by urban and rural residence.

The Fig. 4 and table 3 below show the comparison between the four risk modules in the studied Ghanaian population using the Kappa statistic (Fig. 4) and the Spearman correlation coefficient (table 3). There was substantial agreement between the PCE versus FRS, PCE versus Globorisk, and FRS versus Globorisk. However, there was only moderate agreement between the WHO versus PCE and WHO versus FRS and fair agreement between the WHO versus Globorisk. Significantly, the WHO risk score only had a moderate or fair agreement with all the other risk scores, whereas the Globorisk had a substantial agreement with all the other risk scores except the WHO risk score. Similarly, there was strong

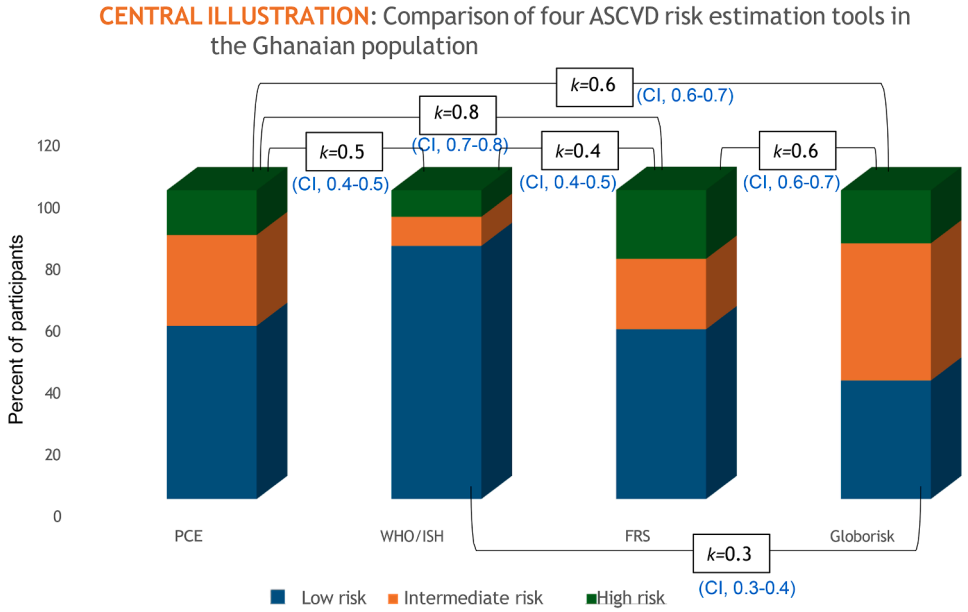

Fig. 4. Correlation matrix for various risk scores.

Table 3
Correlation coefficient between the four risk assessment modules.

var1	var2	cor	p
PCE	WHO	0.60	<0.001
PCE	FRS	0.93	<0.001
PCE	Globorisk	0.87	<0.001
WHO	FRS	0.41	<0.001
WHO	Globorisk	0.57	<0.001
FRS	Globorisk	0.81	<0.001

Key: cor – correlation coefficient; FRS – Framingham risk score; PCE – Pooled cohort equation; WHO – World Health Organization; var - variable.

correlation between the PCE and FRS; PCE and Glorisk; and FRS and Globorisk. Moderate correlation was found between PCE and WHO as well as between WHO and Globorisk; and a weak correlation between FRS and WHO. Whereas the Globorisk had strong correlation with all the other risk scores, the WHO had weak or moderate correlation with the other risk scores.

4. Discussion

Our analysis found substantial agreement between the PCE, FRS, and Globorisk in the population studied, with moderate agreement between the WHO/ISH risk tool and PCE and FRS and fair agreement between the WHO/ISH and Globorisk. Although ASCVD risk factors were prevalent, many participants were classified as low-risk or intermediate-risk. Calculated risk scores varied significantly across regions, with high-risk scores increasing with age. However, no differences were found in calculated risk scores between urban and rural populations.

The landmark Framingham Study highlighted several ASCVD risk factors and the notion of the cumulative effect of multiple risk factors [23]. This has formed the basis of the development of algorithms based on these risk factors to determine specific types of ASCVD risk such as relative and absolute risk; and 5 years, 10 years, or lifetime risk. These scores are relevant for standardized classification and risk-based recommendation that aids doctor-patient communication and preventive care [5].

An earlier publication, based on the population from which this study was derived, found that these traditional ASCVD risk factors were prevalent in the population with the highest age-standardized prevalence of known CVD risk factors being 26.1 % (95 % CI, 22.9 %–29.4 %) for hypertension, 15.1 % (95 % CI, 12.9 %–17.3 %) for obesity, 6.8 % (95 % CI, 5.1 %–8.5 %) for diabetes mellitus, and 9.3 % (95 % CI, 7.1 %–11.5 %) for hyperuricemia [17]. The participants selected for this current analysis were mainly middle-aged adults with about 70 % having dyslipidemia; 50 % being hypertensive; and less than 20 % having T2DM, hyperuricemia, or PAD. Male sex was also associated with more CVD risk factors such as smoking, low HDL, and untreated hypertension.

The age inclusion criteria for this study were set at 40 to 74 years to conform with most 10-year risk scores, as data on the performance and use of quantitative 10-year risk scores among adults <40 years of age is limited. This study had more females, making up 60 % of the sample. This partly explains why more than half of the participants were classified as low-risk, in contrast to an earlier study in the Ashanti region which categorized more than half of the participants as intermediate or high risk [24]. Moreover, the populations studied were completely different; the earlier study recruited participants attending cardiac clinics while this study recruited participants from the community. However, the Reynolds Risk Score [9], found to be more appropriate for females, was not included in the analysis. Our sample was representative of an urban/suburban population where CVD risk factors are more likely to be pronounced due to westernization, compared to a rural population. The performance of the various scores appeared to vary by region and community, however, this may be attributable to differences in sample characteristics such as proportionate differences in sex, differences in nutritional and behavioural risk factors, and other ASCVD risk factors. Given that the male sex was found to be associated with a higher prevalence of ASCVD risk factors, and the male sex predominated in the Greater Accra Region and Northern Region, there may be a strong association between the performance of some risk scores with sex. Of the scores assessed, the FRS was the only one to have a comparatively high-risk class in these two regions. Another risk variable with a significant association with predicted risk was dyslipidemia. Trend analysis showed that risk classification by most of the risk scores reflected the pattern of dyslipidemia, with populations with a high prevalence of dyslipidemia recording higher ASCVD risk.

Several relevant features should be considered in choosing a risk calculator for the assessment of ASCVD risk. These include derivation and validation, the specific variables used, predictive accuracy, applicability and understandability, and cost-effectiveness [25]. A pertinent problem with the various risk scores has been the significant impact of the characteristics of the derivation and validation cohort, as this affects generalizability. It has been demonstrated by several studies that risk can be overestimated or underestimated based on the disparity between the derivation and validation population and the population to which the tool is being applied. The current US-based ASCVD risk assessment tools – PCE, FRS, and Reynolds Risk Score- have uncertain utility in other racial/ethnic groups [5]. The PCEs have been found to underestimate risk in patients from certain racial/ethnic groups, those with lower socioeconomic status, or with chronic inflammatory diseases, while overestimating the risk in patients with higher socioeconomic status or who have been closely engaged with preventive healthcare services [5,26-28]. Similarly, the systematic coronary risk evaluation (SCORE) and QRISK calculators were also developed for Europe and Great Britain, respectively, with limited generalizability. The WHO/ISH Risk Estimator is the closest we have to a risk calculator designed with special consideration for the characteristics of the region within which Ghana is found [12].

Assessing the predictive performances of risk scores involves calibration, discrimination, clinical utility evaluation, and a longitudinal study design, which is beyond the scope of our primary study. This, however, helps to determine the consistencies of scores and their suitability for adoption and direct application in each population. In a study in rural China assessing the predictive value of the Prediction for ASCVD Risk in China (PAR) risk, PCE, and FRS, the authors concluded that none of them was suitable for direct application in this population, even after recalibration, and recommended that special risk equations be developed for that population [29]. A scoping review evaluating the accuracy of ASCVD risk calculators identified 17 eligible studies that assessed a wide range of risk calculators, including - FRS, ASSIGN, SCORE, QRISK, JBS3, PCE, WHO/ISH risk charts, Reynolds Risk Score, PROCAM, et cetera. It found the QRISK® to be the most accurate ASCVD risk calculator for several study populations, whereas the WHO/ISH risk scores were the least accurate [25].

The results of our study show that there is disparity in how the risk scores fared per region. This may be explained by ethnic and geographic impact on the individuals' ASCVD risk. The phenotypic susceptibility to ASCVD demonstrated by race/ethnicity is a function of genetics, where an aggregation of allelic variants produces significant pro-atherosclerotic genetic variations. This implies that total individual genetic risk burden for CAD is proportional to the number of genetic risk variants inherited [30]. This may introduce risk via the traditional risk factors and also emerging risk factors. For this reason, there are proponents of a genetic risk score to supplement ASCVD risk scores that further discriminate an individual's risk beyond traditional risk factors alone [30,31]. The impact of race on ASCVD risk estimators has been assessed and found to result in significant changes in risk classification [32]. This is because these risk calculators are mostly based on population-specific prospective cohort studies thus risk may be under- or over-estimated when used in a different race/ethnic group. Geographical location is also relevant because of the gene-environment correlations which impact genetic variants and traits as evidenced in

genome-wide association studies (GWASs). When studies controlled for regions or geographical location, genetic correlations with body mass index/body fat, sedentary behavior and substance use reduced which was attributed regional socio-economic effects and geographic clustering of DNA [33]. This environmental impact is further demonstrated when birthplace and current address were corrected for, suggesting both passive and active sources of gene–environment correlations as seen in non-migrant and migrant compatriots which is the rationale of the RODAM study [33,34]. Geographical location as a modifiable cardiovascular risk factor has been considered as a variable worthy of incorporation into risk calculators however the clinical utility gains is still controversial [35].

In our study, the FRS classified more people as high risk while the WHO/ISH risk estimator classified more people as low risk. Similar outcomes were seen in studies conducted in Iran and other Asian populations with significant underestimation of 10-year risk by the WHO/ISH score and overestimation of risk by the FRS [36–38]. The risk scores assessed were derived based on different but mostly Western data with only the PCE having a relatively higher proportion of blacks [5]. This brings into contention the recommendation by the Ghana CVD guidelines and other recommendations to use the WHO/ISH risk estimator for low and middle-income countries without population-derived risk scores.

Agreement between the risk scores was assessed using the kappa statistic and the Spearman correlation coefficient. The study found that the agreement between risk scores was generally substantial or moderate, except for the WHO/ISH and Globorisk models. Kappa statistics showed fair agreement between the WHO/ISH risk estimator and Globorisk Score, with the Globorisk model identifying more people as high risk. This contrasts with a cross-sectional study in Iran, which found good agreement and strong correlation between both laboratory-based and non-laboratory-based WHO models and the Globorisk models [20]. The Globorisk and WHO/ISH models are country-specific and region-specific, with similar variables like age, sex, and blood pressure, but population differences can significantly influence their outcomes. It's crucial to identify the population characteristic influencing the level of agreement between the two models, as seen in the Ghanaian population. The most substantial agreement between risk scores was found between PCE versus FRS, FRS versus Globorisk, and PCE versus Globorisk models. The agreement between Globorisk and FRS may imply a tendency to overestimate risk, in a similar pattern as seen in the latter. However, the Globorisk model generally had better agreement with other models except the WHO/ISH model. Both the WHO/ISH and Globorisk models have laboratory-based and non-laboratory (office--based) versions. Another study in Fasa County in Iran assessed the agreement between the laboratory and office-based versions of Globorisk and found moderate and substantial agreement with a strong positive correlation for kappa analysis done based on sex and age [39]. There may be a need to review the recommendations in the Ghanaian CVD Guidelines on the choice of risk assessment tool from the current WHO/ISH. Based on the performance of the Globorisk score, its similarities in terms of variables, and the availability of laboratory-based and office–based versions convenient for use in resource-deprived countries, the Globorisk model may be a viable alternative. The potential harm in misestimating risk with tools that have not been validated cannot be ignored. Any campaign to streamline the choice of risk assessment tool for the sake of uniformity must prioritize determining predictive performance, validation, and/or calibration to suit the population, at the earliest possible time. However, the best option remains to derive a risk tool from population-based prospective studies. In the interim, this should not discourage risk assessment. Clinicians should be educated on these tools' strengths and weaknesses to allow them to interpret risk based on the risk score and patient-specific risk factor profile, which may further modify the risk score.

Clinical utility is crucial when selecting an appropriate risk score. Despite the availability of ASCVD risk calculators, barriers to their implementation include time constraints, accessibility limitations, poor clinician uptake, patient fears, lack of documented workflows, staffing issues, concerns about out-of-pocket costs, and inadequate communication within the team [40]. In Yemen, a low-income country in West Asia, there was a highly positive attitude toward ASCVD risk assessment however, overall knowledge was low, and practices were suboptimal [41]. Persons with longer years in practice, specialization in cardiology, and compliance with specific guidelines were most associated with higher knowledge and better practices. Physicians with higher patient burdens were less likely to apply risk assessment. Considerations on the clinical utility and uptake by clinicians must be made, with appropriate stakeholder engagement. The goal is to have an ASCVD risk assessment tool that is more useful, accurate, accessible, and easy to use, based on the population and health system.

The strength of this study lies in the use of data from a community-based study with large sample size. However, the cross-sectional methodology limits the ability to assess the predictive performances of the various scores. A prospective cohort study will be more appropriate for such comparison. The reliance on participant self-report for excluding history of ASCVD could have introduced recall bias as some participants might have had challenges remembering their past-medical history. Additionally, Some of the risk assessment tools had five or more categories of risk. Categorizing these into three risk categories for easy comparison could have introduced categorization bias. Furthermore, it is worth noting that the PCE was derived from cohort studies that included black populations while the FRS included only white populations [5].

5. Conclusion

The current tools for predicting ASCVD risk in the Ghanaian population are inconsistent, posing a threat to primary prevention and socioeconomic consequences. This necessitates national longitudinal studies to design population-specific risk prediction tools or refine existing ones based on the unique characteristics of the Ghanaian population. Academia, governmental, and non-governmental organizations must collaborate to conduct large-scale multiregional, longitudinal studies to provide rich data for this urgently.

Declarations and acknowledgements

Ethics approval and consent to participate

Ethical approval for this study (CHRPE/AP/415/16) was provided by the Committee on Human Research, Publications and Ethics of the Kwame Nkrumah University of Science and Technology and the Komfo Anokye Teaching Hospital, Kumasi, Ghana. A written informed consent was obtained from all participants before inclusion.

Consent for publication

Not applicable. No individual patient data was included in this manuscript.

Data availability and sharing

The datasets generated and analysed during this study are available from the corresponding author upon reasonable request.

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CRediT authorship contribution statement

Francis Agyekum: Conceptualization, Data curation, Writing – original draft. **Florence Koryo Akumiah:** Data curation, Writing – review & editing. **Samuel Blay Nguah:** Formal analysis, Writing – review & editing. **Lambert Tetteh Appiah:** Data curation, Writing – review & editing. **Khushali Ganatra:** Writing – review & editing. **Yaw Adu-Boakye:** Data curation, Writing – review & editing. **Aba Ankomaba Folson:** Data curation, Writing – review & editing. **Harold Ayetey:** Data curation, Writing – review & editing. **Isaac Kofi Owusu:** Conceptualization, Data curation, Writing – original draft, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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