

Original Research Article

Risk prediction of cardiovascular diseases and comparison of two prediction models

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Received: 04 November 2019

Revised: 10 December 2019

Accepted: 17 December 2019

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ABSTRACT

Background: Cardiovascular diseases (CVD) are the world leading causes of death in non-communicable diseases. The aim of this study is to predict cardiovascular risk and compare two prediction models.

Methods: This cross-sectional study involved 440 sample size of beverage industrial participants. The 10-year prediction was processed by World Health Organization/International Society of Hypertension (WHO/ISH) score chart and Framingham general risk score. WHO stepwise questionnaire and biomedical forms was used. Data was collected and analyzed by SPSS 16.0 version.

Results: The overall CVD low risk prediction (<10%) by Framingham general risk score (FGRS) and WHO/ISH score chart was 74.5%, 95.4%, respectively while the CVD elevated risk ($\geq 10\%$) was 25.5%, 4.6%, respectively. Gender CVD risk ($\geq 10\%$) was 16.1% of male versus 9.3% of female by FGRS while 2.7% of male versus 1.5% of female classified by WHO/ISH. CVD risk increases in both of the models with age but very much in FGRS. 8.4% of employees versus 5.2% of spouses was classified as having the risk of 10-20% by FGRS while WHO/ISH classified 2.5% of employees and 0.9% of spouses as having the risk of 10-20%. FGRS classified 11.7% of all participant as having the risk above 20% while WHO/ISH classified only 1% as having the risk above 20%. Two model's kappa agreement level was fair or minimal interrater reliability with 0.25 with p value <0.001 and the correlated receiver operating characteristic curve (ROC) curve of FGRS and WHO/ISH of 0.887 area under the curve (AUC), 0.847AUC all with a p value <0.001, respectively.

Conclusions: FGRS predicted more risk in participants than WHO/ISH and was with minimal kappa agreement.

Keywords: Cardiovascular prediction models, Cardiovascular risk, Stroke, Heart failure, Peripheral vascular diseases, Myocardial infarction

INTRODUCTION

Cardiovascular diseases (CVDs) are the dominants NCDs leading causes of death with 30% of worldwide mortality and incur 80% of the related burden in low middle income countries and exasperate the working age population.¹⁻³ Its threat, morbidity and toll death are constantly rising in African countries due to the significant change of lifestyle factors such eating, mechanized transport, sedentary,

smoking and stressful environment in the working world demographic transition which made cardiovascular diseases remain the world leading causes of death in non-communicable diseases.⁴⁻⁸

Several studies raise the evidence voice in their findings that blacks are the most threatened by cardiovascular diseases with high premature mortality in comparison with other population in USA which may create a historical

comparison and lifestyle difference within American black and African black.^{4,9}

In North America one cardiac surgery hospital serve 120,000 people while one cardiac surgery hospital serves 33 million in Sub-Saharan Africa.¹ Which may be a lack of cardiac health services combined with lack of information on the increase of morbidity and mortality without knowing the cause. Cardiovascular diseases are an impediment in life of labor force, increase dependencies and lost working days.¹⁰ And WHO statistical profile, 2015 has shown that Rwanda has lost around 300 DALYs due to only cardiovascular diseases and diabetes. A recent multicenter stroke study in Rwanda showed a worse stroke burden where 2.1% of all received patients was due to stroke, where 61% died and 14.3% were tremendously disabled.¹¹

Cardiovascular diseases prediction models are now relevant individual tools to estimate the cardiovascular diseases risk level of fatal and non-fatal cardiovascular event (cerebro-vascular diseases, peripheral vascular diseases, coronary diseases and heart failure) and enable primary health care professionals to plan and improved preventive strategies and reversing changeable risk factors which could reduce burden of diseases.¹² This study aims to predict cardiovascular diseases risk and compare two prediction models performance and their level of agreement in employees and their spouses of sub-Saharan region in industrial workplace.

METHODS

The total target population of this research was 822 participants among others 503 was employees and 319 was spouses in two beverage industries within the study period of 2016 to 2018.

Inclusion criteria

All employees and their spouses or a retiree of the company within 30 years to 75 years old and consented to join the study.

Exclusion criteria

Clinically established cardiovascular diseases, who doesn't will to participate, casual workers and visitors.

Study design

This cross-section study design with quantitative data approach. Sample size was carried out by Cochran for large population sample.¹⁶

$$n = \frac{z^2 p q}{e^2}$$

where $p=50\%=0.5$, $q=1-0.5=0.5$ and $n=1.962 \times 0.5 \times 0.5 / 0.052^2 = 0.96040.0025 = 385 + 55 = 440$.

10% were added to the sample size to cover the bad filling of the instrument and 4.2% were added within the data collection period to get a total sample size of 440. Participants' selection was done by proportionate stratified random sampling mixed with simple random sampling for representativity.

$$nh = \left(\frac{Nh}{N} \right) * n$$

Study instruments

Three parts which consists of WHO Standardized questionnaire, FGRS and WHO/ISH score chart with clinical measures form and materials such as stethoscope for clinical examination, sphygmomanometer: microlife AG, 9443 Widnau/Switzerland, watch BP office, PB was measured three times and the mean BP was recorded.^{17,18} Humalyser 3500, Human GmbH, Max Pbg Ring 21, 65205 Miesbaden Germany ref: 16800 Vers: 2014.

Validity and reliability of study instruments

The validity and reliability of the instruments relied on the pre-validated models and WHO steps standardized questionnaire.¹⁵ FGRS calibration with Hosmer-Lemeshow test of $\chi^2=3.25$, $p=0.78$.¹⁹

Laboratory quality measurement for required predictors

The condition of blood sugar measures relied on the fasting blood sugar taken at morning. Blood samples was collected by venipuncture in the ante-cubital region after a 12-hour fast.²⁰

Data was coded and analyzed by SPSS 16.0 version. The comparison of FGRS and WHO/ISH was facilitated by four procedures which are: binary categorization of cardiovascular diseases risk level, predictive probability generation of the two models by binary status, multilevel categorization, status correlation and AUC comparison with predictive probability by a correlated status. Kappa test for model's agreement and ROC curve classification performance.²¹ Their observed difference was significant at p value <0.05 at 95% CI.

RESULTS

This study involved 440 participants with eight predictors among others gender was dominated by male with 56.6% versus 43.4% of female, treated systolic blood pressure were 17% versus 83% of not taking medication among others 32% have SBP, smokers were 6.8% versus 93.2% of untreated, diabetic were 11.1% versus 88.9% of non-diabetic, the mean age value was 44.92 years, the total cholesterol mean value was 165.9 mg/dl, the high-density lipoproteins (HDL) mean value was 145.9 mg/dl and triglyceride mean value was 49.9 mg/dl (Table 1).

The overall 10-year cardiovascular diseases risk prediction by FGRS classified 74.5% of the population as having low cardiovascular disease risk (<10%) and 25.5% of population with elevated cardiovascular diseases risk (≥10%) while WHO/ISH classified only the small portion of 4.6% as elevated cardiovascular diseases risk and 95.4%

as low risk (<10%). The gender proportion with cardiovascular risk above 10% was by FGRS classified 16.1% of male versus 9.3% of female while WHO/ISH classified male with 2.7% versus 1.5% of female. Cardiovascular diseases risk increases in both of the models with age but very much in FGRS (Table 2).

Table 1: Distribution of cardiovascular disease model predictors.

Variables	Proportion (%)
Gender	
Male	56.6
Female	43.4
Treated SBP	
Yes	17
No	83
Smoking	
Yes	6.8
No	93.2
Diabetic	
Yes	11.1
No	88.9
Variable	Mean value
Age (years)	44.92
Total cholesterol (mg/dl)	165.9
High density lipoprotein (mg/dl)	145.9
Triglyceride (mg/dl)	49.9

Table 2: Distribution of cardiovascular disease risk stratification by age and gender.

Models	Total	Male (years)			Female (years)		
		<40	40-50	>50	<40	40-50	>50
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
FGRS							
Low risk (<10%)	328 (74.5)	90 (27.4)	53 (16.1)	35 (10.6)	62 (18.9)	59 (17.9)	29 (8.8)
2nd level risk (10-20%)	60 (13.6)	2 (3.3)	12 (20.0)	19 (31.6)	2 (3.3)	14 (23.3)	11 (18.3)
3rd level risk (20-30%)	28 (6.3)	0 (0.0)	5 (17.8)	13 (46.4)	1 (3.5)	4 (14.2)	5 (17.8)
4th level risk (30-40)	24 (5.4)	0 (0.0)	3 (12.5)	17 (70.8)	0 (0.0)	1 (4.1)	3 (12.5)
5th level of risk (>40)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total	440 (100)	92 (20.9)	73 (16.5)	84 (19.0)	65 (14.7)	78 (17.7)	48 (10.9)
WHO/ISH							
Low risk (<10%)	420 (95.4)	91 (21.6)	69 (16.4)	76 (18.0)	65 (15.4)	72 (17.1)	47 (11.1)
2nd level risk (10-20%)	15 (3.4)	0 (0.0)	2 (13.3)	6 (40.0)	0 (0.0)	6 (40.0)	1 (6.6)
3rd level risk (20-30)	1 (0.2)	0 (0.0)	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	0 (0.0)
4th level risk (30-40)	3 (0.6)	1 (33.3)	1 (33.3)	1 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)
5th level of risk (>40)	1 (0.2)	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total	440 (100)	92 (20.9)	73 (16.5)	84 (19.0)	65 (14.7)	78 (17.7)	48 (10.9)

Ten year risk of fatal and non-fatal cardiovascular event prediction and classification by location and status was 44.5% of employees (20% for Kicukiro and 24.5% for Rubavu) versus spouses with 30% (14.3% for Kicukiro and 15.6% for Rubavu) are classified as having low cardiovascular diseases risk (<10%) by FGRS while WHO/ISH score chart classified 57.7% of employees (24% for Kicukiro and 33.6% for Rubavu) versus 37.7%

of spouses (15.6% for Kicukiro and 22% for Rubavu) as having low cardiovascular diseases risk (<10%). 8.4% of employees versus 5.2% of spouses are classified as having the risk of 10-20% by FGRS while WHO/ISH classified 2.5% of employees and 0.9% of spouses as having the risk of 10-20%. FGRS classified 11.7% of all participant as having absolute cardiovascular diseases risk above 20% while WHO/ISH classified only 1% as having absolute

cardiovascular diseases risk above 20% (Table 3) (Figure 1).

The level of agreement of FGRS and WHO/ISH score chart, was 0.25 which expressed a minimal or fair interrater reliability kappa agreement with a significant p value <0.001 (Table 4). While the ROC curve performance showed that the FGRS model predictive performance

receiver operating characteristic was perfect with 0.932 AUC versus 0.936 AUC of WHO/ISH, however the correlated predicted status by two models predictive probabilities result showed a slight discrepancy of 0.04 AUC difference with which FGRS performed above WHO/ISH score chart that was respectively 0.887 AUC, 0.847 AUC all with p value <0.001 (Figure 2).

Table 3: Distribution of cardiovascular disease risk level by study participant and location.

Models	Total N (%)	Gisenyi		Kigali	
		Employee N (%)	Spouse N (%)	Employee N (%)	Spouse N (%)
FGRS					
Low risk (<10%)	328 (74.5)	88 (26.8)	63 (19.2)	108 (32.9)	69 (21.03)
2nd level risk (10-20%)	60 (13.6)	16 (26.6)	6 (10.0)	21 (35.0)	17 (28.3)
3rd level risk (20-30%)	28 (6.3)	2 (7.1)	1 (3.5)	17 (60.7)	8 (28.5)
4th level risk (30-40)	24 (5.4)	4 (16.6)	1 (4.1)	14 (58.3)	5 (20.8)
5th level of risk (>40)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total	440 (100)	110 (25.0)	71 (16.1)	160 (36.3)	99 (22.5)
WHO/ISH					
Low risk (<10%)	420 (95.4)	106 (25.2)	69 (16.4)	148 (35.2)	97 (23.0)
2nd level risk (10-20%)	15 (3.4)	2 (13.3)	2 (13.2)	9 (60.0)	2 (13.2)
3rd level risk (20-30%)	1 (0.2)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
4th level risk (30-40%)	3 (0.6)	1 (33.3)	0 (0.0)	2 (66.6)	0 (0.0)
5th level of risk (>40%)	1 (0.2)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)
Total	440 (100)	110 (25.0)	71 (16.1)	160 (36.3)	99 (22.5)

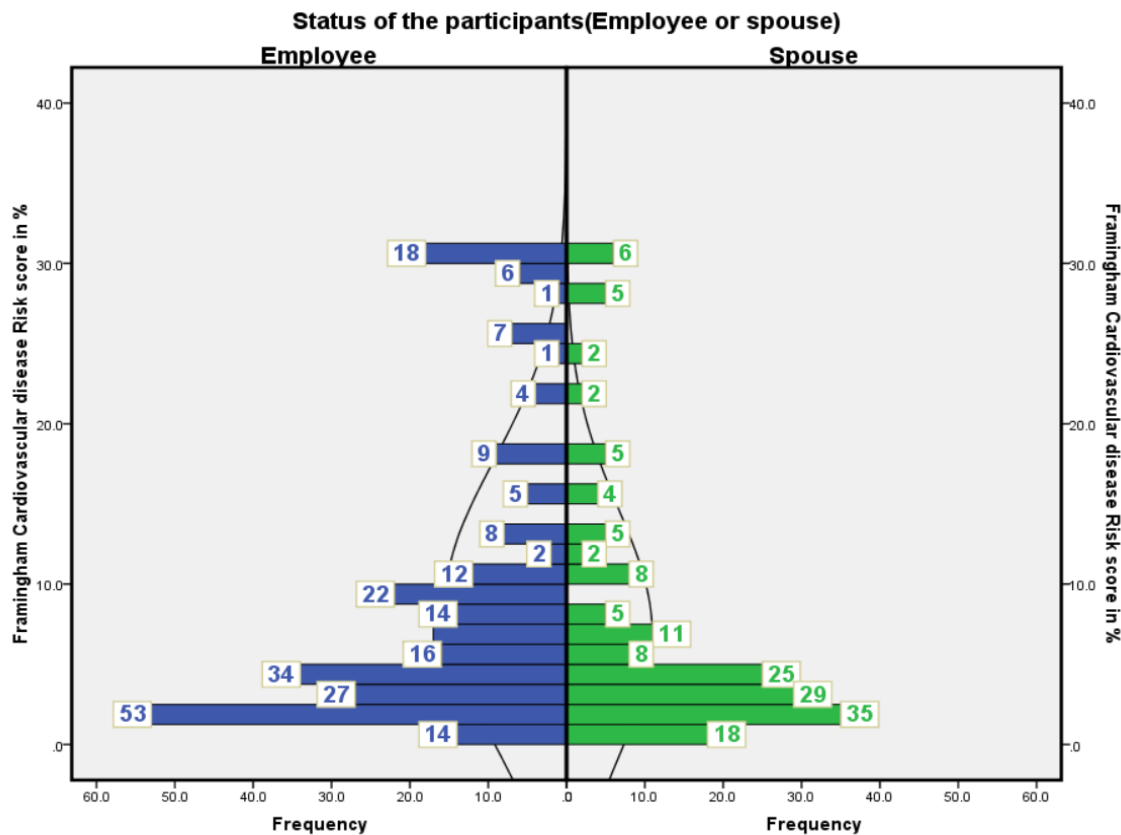


Figure 1: Cardiovascular diseases risk pyramid by status of participants.

Table 4: Distribution of agreement level of Framingham general risk prediction model and WHO/ISH model by Cohen kappa.

Symmetric measures of model agreement		Value	Asymp. Std. Error ^a	Approx. T ^b	Approx. Sig.
Measure of agreement	Kappa	0.250	0.047	7.928	0.000
No. of valid cases		440			

^aNot assuming the null hypothesis; ^bUsing the asymptotic standard error assuming the null hypothesis.

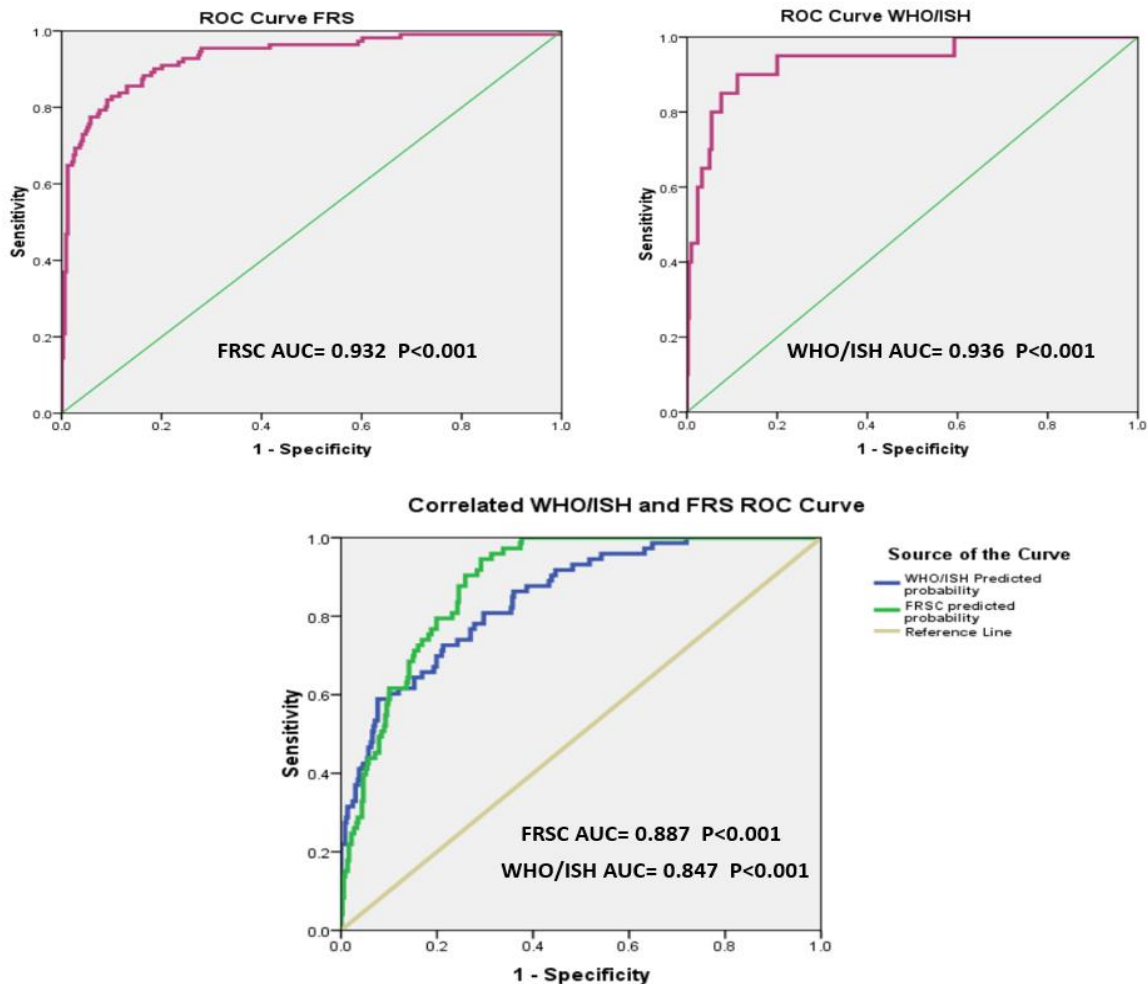


Figure 2: Distribution of comparison of ROC curve performance of two prediction models WHO/ISH and FRSC.

DISCUSSION

This study model predictors are the known traditional risk factors with incontrovertible evidence of being associated with cardiovascular diseases.²² In their selection showed how they are technically and economically crucial in area of the primary follow up study to accurately predict the needed result. However, a choice of local predictors that are associated with cardiovascular diseases outcome can be included for the future model creation. WHO/ISH score chart applied six, predictors’ age, gender, smoking, total cholesterol (TC), blood pressure (BP), diabetes and five predictors, where there is no cholesterol capacity measurement.²⁴⁻²⁶ While FGRS applied eight predictors which are age, gender, HDL, TC, untreated and treated

systolic blood pressure (SBP), smoking, diabetes.^{15,27} The use of all of these predictors are consisting with other studies that applied these two models, however there are other multiple studies that used different predictors to predict the future conditions and diseases of their local population.^{28,29}

The overall study result displayed a cardiovascular diseases risk which, respectively by FGRS and WHO/ISH, was high for men (16.1%), (2.7%) than for women (9.3%), (1.5%) and elevated for employees (16.8%), (3.6%) than for spouses (8.6%), (0.9%) and elevated for urban (18.6%), (3.1%) than rural (6.8%), (1.3%) which is consisting to some studies, however other studies exposed a CVDs transition such as stroke in US where rural and urban stroke

trend crosscut in 2007.^{30,31} Employees CVDs risk is high than risk in spouses and high in men than in women, such difference is due to gender specific, workplace and home stress increase for workers and accumulation of most of the cardiovascular diseases factors for urban than rural population.³²⁻³⁴ Moreover current most study's findings explain the rise of cardiovascular diseases risk factors in rural communities.³⁵

The study findings showed a minimal or fair level of agreement of 0.25 between FGRS and WHO/ISH score chart which is not acceptable in models prediction agreement by Cohen kappa due to models lack of discrimination capacity to fulfil the accuracy requirement of a test, a classifier or a model that requires the interrater reliability coefficient to be perfect at least 0.8 for the accurate agreement between used two models (FGRS and WHO/ISH score chart) to be both applied in Rwandan population. FGRS predicted 25.5% of the population to have elevated cardiovascular diseases absolute risk in coming 10 years ($\geq 10\%$) while WHO/ISH score chart predicted only 4.6% of the population to have elevated risk of ($\geq 10\%$) with a high predictable difference of 20.9% risk which underlined a suspect of under prediction of WHO/ISH score chart and Over prediction of FGRS.^{36,37} The correlated status of ROC curve performance with respectively, FGRS and WHO/ISH score chart of 0.887 AUC, 0.847 AUC all with a p value < 0.001 showed a perfect performance. However, their perfect ROC curve performance capacity of sensitivity and specificity with a prior low level of interrater agreement of 0.25 Cohen kappa coefficient which is inadequate agreement, demotes its ROC curve accuracy to underdiagnose or overdiagnose.^{21,36}

A recent multi-center study on the burden of stroke in Rwanda showed that 2.1% of all received patient suffered stroke where 61% of them died, while this study findings showed that the 10 year prediction absolute risk of fatal and non-fatal including stroke will between 4.6% and 25.5% of this study population by WHO/ISH and FGRS models which may be a good future indicator if applied to the whole population to early plan preventive measures for lessening the burden of stroke and other cardiovascular disease in Rwanda.¹¹ Although worldwide stroke and heart attack equate 85% of all deaths caused by cardiovascular disease, reaching the preventive strategy goal could only be possible by setting practical barriers to changeable risk factors, improving personal cardiovascular diseases awareness risk level, health seeking behavior for heightening early health service utilization, to reach the equipped stroke unit in due time.^{21,36,37}

Cardiovascular predictions models including other diseases prediction models are with great scientific current health events and conditions forecasting importance to create strategic countermeasures for improving the population quality of health, reduce the physical, psychosocial and economic burden of a diseases on low and middle-income countries (LMIC) including Rwanda with

around 300 DALYs according WHO, 2015 and 61% of death of all stroke received patients and 14% of worse disability.^{11,36}

CONCLUSION

Cardiovascular diseases models are the current necessity to proactively plan primary preventative strategies, to fight cardiovascular diseases occurrence and reoccurrences and understand the future healthy lifestyle toward the ideal cardiovascular health. This study showed a relative elevated cardiovascular risk to employees than spouses and to male than female which requires to set new preventative strategies to protect employees and to protect mostly men employees against these sub-Saharan emerging CVDs at workplace and in population at large.

Early cardiovascular diseases risk prediction models represent invaluable advances to minimize and classified behavioral barriers to four behavioral risk factors (smoking, lack of physical activity, BMI, poor diet) and three biological risk factors (blood pressure, blood glucose, cholesterol levels) plus other modifiable risk factors for maximizing cardiovascular health.

Although the ROC curve of Framingham risk score model and WHO/ISH is above 0.8 to a correlated rater, their level of agreement is minimal which bring an issue of overestimation in FGRS until a development of a local model will be designed basing on local population randomised control trial (RCT).

Suggestion

FGRS predicts well because of using more predictors but minimize the high risk above 30% while the Framingham risk cox formula show all levels of cardiovascular risk. WHO/ISH score chart underestimates cardiovascular risk and classifies high percentage of people under the risk of 10% which requires to make our own model with local population.

Contribution of the current study to the knowledge

This study informs local and regional scientists about CVDs risk and instruments availability limitation, hence raising an urgent need to create local population-based models to serve in clinical guideline for hypertension and cardiovascular diseases prevention and treatment to be able to lessen cardiovascular diseases burden in the region.

ACKNOWLEDGEMENTS

To almighty be the glory and deep gratitude to him. He endlessly and freely bestowed nature inspiration blessings to us. Second, sincere acknowledgement to Dr Kabarega Jean Pierre, the late prof peter Mwaniki, Mr. Felix Hagenimana, Dr Erigene, Dr Kabakambira Jean Damascene. Your advice and support were with tremendous contribution.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Rwanda National Ethic Committee

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Cite this article as: Nsanzabera C, Ndengo M, Sagwe DN. Risk prediction of cardiovascular diseases and comparison of two prediction models. *Int J Community Med Public Health* 2020;7:455-62.