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Research Article

Cardiovascular risk predictors in Primary Health Care: reflections on the adoption of non-laboratory models

Preditores de risco cardiovascular na Atenção Primária à Saúde: reflexões sobre a adoção de modelos não laboratoriais

Predictores de riesgo cardiovascular en la Atención Primaria de Salud: reflexiones sobre la adopción de modelos no laboratoriales

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Abstract

Introduction: Cardiovascular diseases (CVD) are multifactorial and represent the leading cause of morbidity and mortality in Brazil. Therefore, early identification and management of chronic conditions that act as risk factors are essential. Consequently, cardiovascular risk (CVR) stratifiers were developed to predict the probability of an individual experiencing cardiovascular events over a 10-year period. These tools are important in preventive, therapeutic, and epidemiological contexts, especially in Primary Health Care (PHC). **Objective:** To discuss the use of CVR stratifiers in PHC, comparing the laboratory-based and non-laboratory-based versions of predictive models (the Framingham Risk 90 Score for Cardiovascular Disease [FRS-CVD] and the HEARTS program calculator, respectively). **Methods:** This is a cross-sectional, exploratory, and epidemiological study conducted between March 2022 and June 2024, using a convenience sample. The sample included individuals aged 40 to 75 years, with hypertension and/or diabetes, without a history of cardiovascular events, and users of the municipality's PHC services in São João del Rei (Minas Gerais, Brazil). Participants were required to have serum cholesterol tests performed within the past year. Data from 89 patients were collected and analyzed using Cohen's kappa coefficient. **Results:** The sample was predominantly female (68.5%), aged over 60 years (50.5%), and non-smokers (88.75%). A predominance of intermediate/high risk was observed in both scores, with the HEARTS calculator classifying more individuals as high risk. In contrast, only the FRS-CVD classified patients into very high- or critical-risk categories. The study found minimal agreement between the two tools when assessing the CVR of the same patient. **Conclusions:** CVR assessment is fundamental in PHC. Clinically, it guides preventive, therapeutic, and educational actions based on patient risk. At the population level, understanding CVR by region helps the formulation of more effective public health policies. However, discrepancies between laboratory and non-laboratory scores may hinder clinical decision-making. Therefore, it is essential to use tools appropriate to the context and develop instruments tailored to the clinical and epidemiological profile of the Brazilian population. This ensures better resource allocation in PHC and greater efficiency in cardiovascular care withing this setting.

Keywords: Primary Health Care; Longitudinal Studies; Framingham Heart Study; Cardiovascular Risk.

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Resumo

Introdução: As doenças cardiovasculares (DCV) são multifatoriais e configuram a principal causa de morbimortalidade no Brasil. A identificação precoce e o manejo de doenças crônicas que atuam como fatores de risco são, portanto, fundamentais. Consequentemente, foram criados estratificadores de risco cardiovascular (RCV) que auxiliam na predição da probabilidade de ocorrência de eventos cardiovasculares em um período de 10 anos. Essas ferramentas são importantes nos contextos preventivo, terapêutico e epidemiológico, sobretudo na Atenção Primária à Saúde (APS). **Objetivo:** Discutir a aplicação de estratificadores de RCV na APS, comparando a versão laboratorial e não laboratorial de modelos preditivos (Escore de Risco Global [ERG] de Framingham e a calculadora do programa HEARTS, respectivamente). **Métodos:** Trata-se de um estudo transversal, exploratório e de caráter epidemiológico, realizado entre março de 2022 e junho de 2024, com amostragem de conveniência. Foram incluídos na amostra indivíduos entre 40 e 75 anos, hipertensos e/ou diabéticos, sem histórico de agravos cardiovasculares e usuários da APS do município. Estes deveriam apresentar exames séricos de colesterol datados de, no máximo, um ano. Os dados de 89 pacientes foram obtidos e analisados pelo coeficiente kappa de Cohen. **Resultados:** Observou-se uma amostra majoritariamente feminina (68,5%), com indivíduos com mais de 60 anos (50,5%) e não tabagistas (88,75%). Notou-se predomínio do risco intermediário/alto em ambos os escores, sendo que a calculadora HEARTS classificou mais indivíduos como alto risco. Em contrapartida, apenas o ERG estratificou pacientes em faixas de risco muito alto ou crítico. Na amostra do estudo, houve uma concordância mínima entre os dois instrumentos na avaliação do RCV de um mesmo paciente. **Conclusões:** A avaliação do RCV é fundamental na APS. No âmbito clínico, permite direcionar ações preventivas, terapêuticas e educativas conforme o risco do paciente. Em nível populacional, conhecer o RCV por território auxilia na formulação de políticas públicas mais eficazes. Entretanto, a divergência entre escores laboratoriais e não laboratoriais pode prejudicar decisões clínicas. Sendo assim, é essencial utilizar ferramentas adequadas ao contexto e desenvolver instrumentos calibrados ao perfil clínico-epidemiológico da população brasileira. Isso garante melhor direcionamento dos recursos na APS e maior eficiência no cuidado cardiovascular nesse contexto.

Palavras-chave: Atenção Primária à Saúde; Estudos Longitudinais; Framingham Heart Study; Risco Cardiovascular.

Resumen

Introducción: Las enfermedades cardiovasculares (ECV) son multifactoriales y constituyen la principal causa de morbimortalidad en Brasil, por lo que la identificación precoz y el manejo de enfermedades crónicas que actúan como factores de riesgo son fundamentales. En este contexto, se han creado estratificadores de riesgo cardiovascular (RCV) que ayudan a predecir la probabilidad de que un individuo presente eventos cardiovasculares en un plazo de 10 años, siendo herramientas importantes en los contextos preventivo, terapéutico y epidemiológico, especialmente en la Atención Primaria de Salud (APS). **Objetivo:** Este artículo discute la aplicación de estratificadores de RCV en la APS, comparando las versiones con y sin pruebas de laboratorio de modelos predictivos (Escala de Riesgo Global – ERG – de Framingham y la calculadora del programa HEARTS, respectivamente). **Métodos:** Se trata de un estudio transversal, exploratorio y de carácter epidemiológico, realizado entre marzo de 2022 y junio de 2024, con muestreo por conveniencia. Se incluyeron individuos entre 40 y 75 años, hipertensos y/o diabéticos, sin antecedentes de eventos cardiovasculares y usuarios de la APS del municipio de São João del Rei (Minas Gerais, Brasil). Los participantes debían presentar análisis séricos de colesterol con fecha de hasta un año. Se recopilaron y analizaron datos de 89 pacientes mediante el coeficiente Kappa de Cohen. **Resultados:** La muestra fue mayoritariamente femenina (68,5%), con personas mayores de 60 años (50,5%) y no fumadoras (88,75%). Se observó un predominio del riesgo intermedio/alto en ambos modelos, siendo que la calculadora HEARTS clasificó a más individuos como de alto riesgo. En cambio, solo el ERG estratificó pacientes en categorías de riesgo muy alto o crítico. En la muestra del estudio, hubo una concordancia mínima entre los dos instrumentos en la evaluación del RCV de un mismo paciente. **Conclusiones:** La evaluación del RCV es fundamental en la APS. A nivel clínico, permite orientar acciones preventivas, terapéuticas y educativas según el riesgo del paciente. A nivel poblacional, conocer el RCV por territorio ayuda en la formulación de políticas públicas más eficaces. Sin embargo, la discrepancia entre modelos con y sin laboratorio puede perjudicar la toma de decisiones clínicas. Por lo tanto, es esencial utilizar herramientas adecuadas al contexto y desarrollar instrumentos ajustados al perfil clínico-epidemiológico de la población brasileña. De este modo, se optimiza la asignación de recursos en la APS y se mejora la eficacia del cuidado cardiovascular en este contexto..

Palabras clave: Atención Primaria de Salud; Estudios Longitudinales; Framingham Heart Study; Riesgo Cardiovascular.

INTRODUCTION

Cardiovascular diseases (CVD) are the leading cause of morbidity and mortality in Brazil.[1] Among their main risk factors are systemic arterial hypertension and diabetes mellitus. In 2021, 382,507 deaths from CVD were recorded in Brazil,[2] with systemic arterial hypertension associated with a mortality rate of 18.7 deaths per 100,000 inhabitants — the highest figure recorded in the last 10 years.[3] As for diabetes mellitus, the country ranks 4th in the world in terms of disease prevalence, with approximately 13 million affected adults.[4]

For the prevention and management of these and other chronic diseases, it is essential to identify individuals while they are still in the asymptomatic stage. To this end, calculators have been developed to estimate patients' cardiovascular risk (CVR) in order to guide appropriate treatment goals and strategies for each risk category, such as in the prescription of statins (type and dose of medication), the establishment of blood pressure targets, and the selection of antidiabetic agents with cardiovascular benefits. It is also important to consider the use of these tools alongside non-pharmacological interventions (health education, nutritional recommendations, encouragement of physical activity, smoking cessation, and reduction of alcohol consumption), which support multidisciplinary management and continuous monitoring. In general, stratification scores are used to predict, according to sex, the probability of events such as Acute myocardial infarction, stroke, or death from cardiovascular causes occurring over a 10-year period.[5]

In the presented study, two CVD risk stratifiers are analyzed: the Framingham Risk 90 Score for Cardiovascular Disease (FRS-CVD) and the non-laboratory version of the HEARTS risk calculator.

The FRS-CVD, developed in 2008, is the most widely used risk stratification tool worldwide, recommended by the Brazilian Society of Cardiology in an adapted version.[6] It estimates the risk of developing coronary artery disease, stroke, heart failure, and peripheral obstructive arterial disease over a ten-year period.[7] Meanwhile, the HEARTS calculator is part of the "HEARTS in the Americas" program, developed by the Pan American Health Organization (PAHO), the regional office of the World Health Organization (WHO) for the Americas. In 2021, Brazil became a signatory to the initiative, committing to implement it as public policy through the Cardiovascular Health Strategy within the context of Primary Health Care (PHC).[8]

Based on these two tools, this paper addresses the relationship between the use of laboratory and non-laboratory parameters for assessing CVD risk in PHC. In the HEARTS program model, given the unavailability of serum parameters, CVR can be measured using non-laboratory markers, replacing information on cholesterol (HDL and total cholesterol) with body mass index (BMI). This substitution makes the stratification of CVR more applicable in low- and middle-income countries with limited resources and high demand for healthcare.[9,10]

The analyses presented here are based on empirical research conducted in the medical program at São João del Rei Federal University, Dom Bosco campus, as part of the "CardioRisco" project. The study evaluated the performance of the FRS-CVD and the HEARTS calculator in estimating CVR among primary care patients in the municipality of Minas Gerais with known hypertension and/or diabetes.

Cardiovascular risk stratification tools

Most risk stratification tools share similarities regarding the information they require. Age, sex, systolic blood pressure, smoking status, diabetes, and cholesterol levels are variables that appear in nearly all assessment tools. Table 1 compiles information on the main tools used worldwide for calculating CVR.

The Framingham Heart Study is a cohort study conducted in the city of Framingham, Massachusetts, in the United States. Initiated in 1948 and still active today, it has aided in the development of effective treatments for CVD and contributed to a paradigm shift in the field: the focus shifted from treating individuals with established disease to identifying those most likely to suffer cardiovascular events — a perspective that began to guide early interventions as a prevention strategy.[11,12] The score derived from this study, the

Table 1. Data on the main stratification tools used worldwide.

Stratification tools	Variables (CVR calculation)	Age group	Country of origin of the study	Outcomes assessed
Systematic Coronary Risk Estimation (SCORE)	Age Sex SBP Cholesterol DM Previous cardiovascular events	Men >40 years Women >50 years or postmenopausal	Europe	10-year absolute risk of fatal cardiovascular disease
Framingham Score (in Brazil, Global *Risk Score* - ERG)	Age Gender Cholesterol (Total and HDL) SPB Treatment of Hypertension Smoking DM	Men and Women >45 years	U.S.	10-year risk of AMI, coronary artery disease, angina, stroke, PAD, heart failure
HEARTS	Country History of CVD CKD Age Gender SBP DM Total cholesterol or, in its absence, BMI (weight and height) Smoking	Men and Women >40 years	Overall - multicenter studies	10-year risk for AMI, stroke, and cardiovascular death

Stroke: cerebrovascular accident; POAD: peripheral obstructive arterial disease; DM: diabetes mellitus; CKD: chronic kidney disease; SBP: systolic blood pressure; HDL: high-density lipoprotein; AMI: acute myocardial infarction; BMI: body mass index; CVD: cardiovascular disease; U.S.: the United States.
Source: Prepared by the authors.

FRS-CVD,[13,14] is widely used even in populations ethnically distinct from those evaluated by the original cohorts.[7,15–17] In Brazil, the first SBC guideline to recommend the FRS-CVD dates from 2013. However, the FRS-CVD was already recommended by the Ministry of Health for CVR assessment,[14] although there were no national studies validating this tool for the Brazilian population.

In turn, the HEARTS risk calculator was created within the context of the "Global Hearts" initiative, launched in 2016 by the WHO with the aim of reducing the rising incidence of CVD worldwide. The program's objective is to improve preventive clinical services in PHC, both from the perspective of public health management and individual clinical management.[18,19] In this context, PAHO-WHO developed the "HEARTS in the Americas" program, with the goal of making it the model for CVD care in the Americas by 2025.[19,20] Since 2022, approximately 22 countries, including Brazil, have been implementing the HEARTS initiative at different stages of development.[21] In Brazil, according to information from the Ministry of Health obtained through the Brazil's Access to Information Law, the HEARTS program's CVR calculator is in the process of being integrated into the Citizen Electronic Health Record within the e-SUS Primary Care system.

METHODS

The "CardioRisco" project was a cross-sectional, exploratory, and epidemiological study conducted between March 2022 and June 2024 in São João Del Rei (Minas Gerais, Brazil), using non-probabilistic convenience sampling. The study aimed to compare the performance of CVR stratification using the FRS-CVD and the non-laboratory version of the HEARTS calculator in hypertensive and/or diabetic patients treated in the municipality's primary care system.

For sample selection in the study, inclusion criteria included men and women residing in São João Del Rei, aged 40 years or older, diagnosed with systemic arterial hypertension and/or diabetes mellitus, and who had serum cholesterol test results dated no more than one year prior. These criteria resulted in an initial sample of 116 patients. Individuals over 75 years of age and those with a history of cardiovascular diseases were excluded. The CVDs considered exclusionary were stroke, transient ischemic attack, acute myocardial infarction, coronary artery disease, peripheral obstructive arterial disease, heart failure, and chronic kidney disease. It is worth noting that the adoption of these criteria took into account previous studies using both stratifiers, in which the validation of these instruments was studied and conducted in individuals aged 40 to 74 years with no history of the aforementioned CVDs.[7,22] A final sample of 89 patients was obtained. The composition of the sample can be seen in Figure 1.

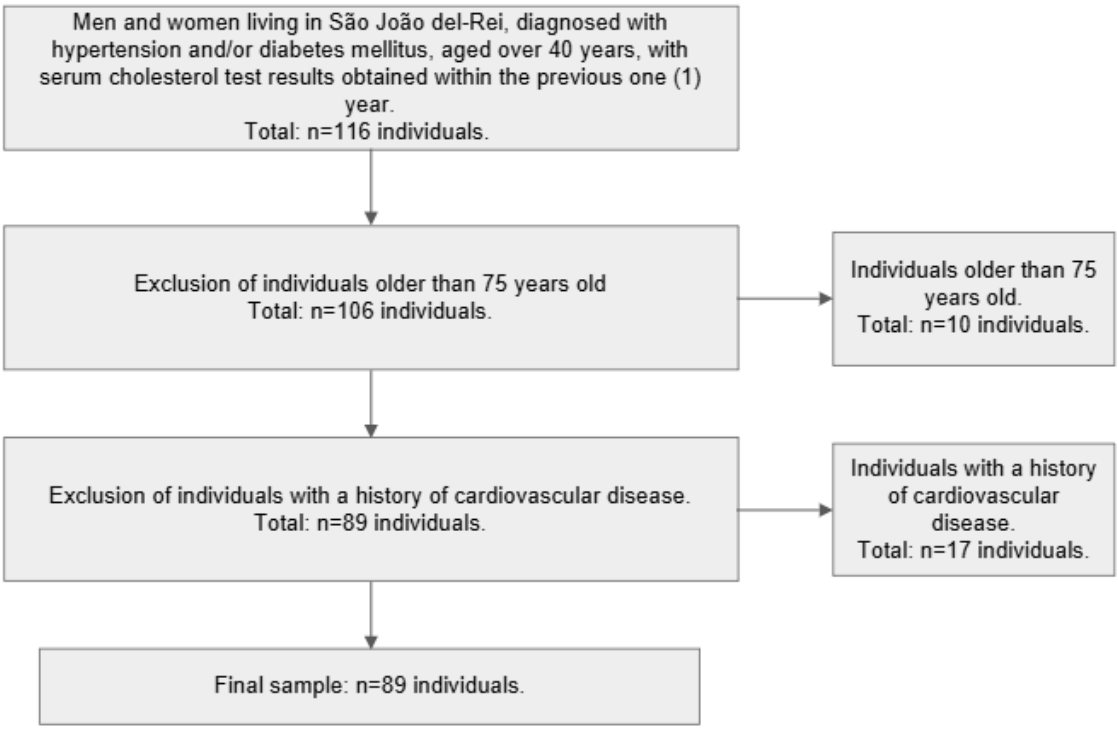

Figure 1. Sample composition criteria (inclusion and exclusion).

A standardized data collection protocol was developed to obtain the data. This document includes, in addition to a manual containing information about the study and the collection methods, a form for recording each patient's data, with all the information necessary for stratifying CVR on both scales evaluated by the project. All data were collected directly by the responsible researchers, in accordance with the Informed Consent Form (ICF), between March and November 2023.

To establish a quantitative measure of the degree of agreement between the scores, Cohen's kappa coefficient was used, which ranges from -1 to +1, according to the following classification: <0 poor agreement; 0–0.20 minimal agreement; 0.21–0.40 fair agreement; 0.41–0.60 moderate agreement; 0.61–0.80 substantial agreement; 0.81–1 almost perfect agreement.

The coefficient is the tool of choice for assessing the degree of agreement between two raters or two assessment instruments when classifications are categorical, as in the case of this study.[23] Sample size calculations for applying the kappa coefficient vary according to the study design and the parameters defined for the analysis. In this study, considering the sampling limitations, an 80% confidence interval and a margin of error of 0.10 were adopted — criteria indicating that the sample is adequate for estimating kappa within these parameters.[24,25]

RESULTS

The sample was predominantly female (68.5%), consisting of individuals over 60 years of age (50.5%), and non-smokers (88.75%). The sample profile is best illustrated in Tables 2 and 3.

Table 2. Profile of the study sample (n=89), distributed by continuous variables.

Continuous variables	Mean (±standard deviation)
Age	59.3 (±8.67)
SBP	137.92 mmHg ±18.49)
BMI	28.88 (±6.09)

BMI: body mass index; SBP: systolic blood pressure.
Source: Prepared by the authors.

Table 3. Profile of the study sample (n=89), distributed by categorical variables.

Categorical variables	Total (%)
Gender Female	61 (68.50)
Smokers	10 (11.25)
Hypertensives	45 (50.50)
Diabetics	11 (12.35)
Hypertensives and diabetics	33 (37.00)

Source: Prepared by the authors.

Based on the collected data, participants' CVR, as determined by the FRS-CVD and the HEARTS calculator, was classified into the following categories: low risk (<5%); intermediate risk (5 to <10%); high risk (10 to <20%); very high risk (20 to <30%); and critical risk (≥30%).

A predominance of intermediate/high risk was observed in both scores, with the HEARTS calculator showing a higher proportion of individuals classified as high risk (57.3% *vs*. 44.95%). In contrast, only the FRS-CVD stratified patients into very high or critical risk categories. Furthermore, both generated the same percentage of patients in the intermediate risk category (25.8%). The overall risk stratification by both scales, in absolute patient numbers and as a percentage of the sample, is shown in Table 4.

The kappa coefficient calculation yielded κ=0.06, demonstrating that, in the study sample, there was minimal agreement between the two instruments in the simultaneous assessment of the same patient's CVR.

Table 4. Cardiovascular risk stratification of the sample.

	Overall risk stratification		
Risk	**Risk range (%)**	**Framingham (%)**	**Hearts (%)**
Low	<5	4 (4.5)	15 (16.85)
Intermediate	5 to <10	23 (25.85)	23 (25.85)
High	10 to <20	40 (44.95)	51 (57.3)
Very high	20 to <30	15 (16.85)	0
Critical	≥30	7 (7.85)	0

Source: Prepared by the authors.

The data from the "CardioRisco" study were subjected to descriptive statistical analysis and bivariate analysis using the chi-square test, with the results previously published.[26] The two studies have complementary scopes but involve analyses with distinct biases, albeit within the same thematic area.

DISCUSSION

When the "CardioRisco" project was proposed, a concern motivated the research group: in assessing CVR in PHC, is it possible to replace laboratory scales with non-laboratory parameters measured exclusively at the time of the medical consultation? From a public health perspective, an assessment model that is more accessible and less dependent on additional tests offers advantages in terms of its scope and practicality, especially in resource-constrained settings. On the other hand, scientific studies that made a similar comparison showed some degree of variation in the performance of each stratification system, with most of these analyses conducted in contexts different from the Brazilian reality.

In 2008, a prospective cohort study conducted in the U.S., using data from the National Health and Nutrition Examination Survey (NHANES), compared the FRS-CVD to a variant that replaced serum data with BMI and found high agreement between the two tools.[9] The same result was supported by a new study, conducted in 2016, which compared the non-laboratory score derived from NHANES to four other laboratory-based scales in a sample involving nine countries (including South American countries, but not Brazil).[10] On the other hand, in 2019, a study by the WHO CVD Risk Chart Working Group, affiliated with the WHO, compared the laboratory and non-laboratory scales used by the HEARTS program and found moderate agreement between the risks proposed by both models.[22]

Based on the question of how the risk stratifiers would perform in the Brazilian context, the methodology for the "CardioRisco" project was developed, and its results demonstrated minimal agreement between the risk classification performed by the FRS-CVD and the non-laboratory version of the HEARTS calculator in the analyzed sample.

Another point for consideration is the specificity of the population analyzed by the project, a sample with a moderate-to-high CVR profile. The study assessed the CVD risk of individuals aged 40 to 74 years diagnosed with hypertension and/or diabetes — that is, a population that already presented at least one CVR factor.

In this context, the behavior of the laboratory and non-laboratory scales tends to show greater discrepancies. Malta et al.,[27] based on a national analysis of various risk stratifiers — all in laboratory versions — concluded that there was high agreement in lower risk strata (low and moderate) and low agreement in identifying high-risk individuals.

In this regard, it is important to highlight the low discriminatory power of the HEARTS program's non-laboratory scale for high-risk patients in the "CardioRisco" project sample. While in the FRS-CVD, 22 patients (24.7%) were classified into very high and critical risk strata, the HEARTS calculator did not identify any individuals in these categories.

The significant participation of diabetic patients in the study (44 participants; 49.35%) should also be considered. Previous studies had already pointed to the poor performance of the HEARTS non-laboratory model in diabetic patients, since this tool classifies all diabetic patients as individuals at high cardiovascular risk.[22] Again, this is not the case with the FRS-CVD, which assesses diabetic patients across different risk categories.

In this context, a clinical underestimation of patients with diabetes mellitus is evident in almost all stratification tools. While hypertensive patients are assessed based on measured blood pressure and medication use, diabetic patients — regardless of whether they have effective glycemic control — receive the same risk classification based solely on the presence of the diagnosis (with the exception of the Reynolds Score, which, among other parameters, assesses glycated hemoglobin).

In this sense, by failing to distinguish between patients with more or less severe conditions, the tool loses its purpose as a stratification mechanism among diabetic individuals. This finding points to the need to reevaluate the Clinical Protocol and Therapeutic Guidelines for diabetes mellitus type 2, dated February 28, 2024,[28] which recommends the use of the HEARTS Strategy CVR Calculator in the management of diabetic patients.

Furthermore, regarding the minimum degree of agreement among the risk stratifiers, it should be noted that this result does not imply the superiority of one scale over another. For such an assessment, a longitudinal study would be necessary to expand and follow the study population to the point of correlating future events with risk predictions. In Brazil, the ongoing cohort study Longitudinal Study of Adult Health (ELSA)-Brasil[29] is a pioneering effort in evaluating the calibration and discrimination of different CVR stratifiers in South American countries. Its results, published in 2024, indicate poor performance of the evaluated stratifiers for white women and a general overestimation of CVD risk by up to twofold compared to observed values. Among the stratifiers analyzed, the WHO CVD score—the basis for the HEARTS program's risk calculator in its laboratory version, recalibrated for Tropical America — showed the highest agreement between predicted risk and observed outcomes.

Understanding the limitations of tools not developed from their own prospective cohorts may stimulate research in this area. After all, CVR has increasingly been shown to be a multifactorial product, modulated by ethnic-biological, behavioral, socioeconomic, and cultural circumstances — which imply greater or lesser access to resources, qualified healthcare teams, and clinical follow-up.

Still regarding the need for investment in research, it is worth noting that other non-laboratory parameters could be utilized to calculate CVR, in addition to BMI, such as the waist-to-hip ratio and abdominal circumference. The assessment of these parameters is not included in the risk analysis of any stratifier; however, when combined with BMI, these measurements could aid in identifying patterns related to fat distribution. The NHANES III study, for example, showed higher overall mortality among individuals with normal BMI and central obesity compared to those with the same BMI but without central adiposity.[30]

Regarding the adoption of non-laboratory models in PHC, the validity of the instrument as a screening policy is reinforced. The large-scale use of non-laboratory models can serve as a kind of triage or pre-selection tool to direct laboratory tests toward individuals with the highest probability of risk.

Taking the HEARTS calculator as a reference, it is evident that the stratification it performs has some limitations that must be considered during the consultation, depending on the patient's profile. Individuals with notably high CVR due to the presence of comorbidities, such as diabetics, should be evaluated based on laboratory parameters, particularly because, in this patient group, the measurement of serum markers is expected during longitudinal follow-up.

Furthermore, the use of risk scales serves as a therapeutic tool within the clinical relationship. In this regard, the HEARTS strategy deserves special mention for incorporating within its scope various initiatives aimed at promoting cardiovascular health within the context of PHC. Beyond the mathematical tool itself, the full set of proposed actions and the specificity of their approaches as public health strategies should be considered.

In this regard, CVR stratifiers should be understood not only as diagnostic tools but also as health education devices capable of raising awareness and promoting changes in harmful habits. A practical example of this motivational use would be the calculation of CVR and the associated risk reduction for a smoking patient when considering smoking cessation and the improvement of other parameters, such as blood pressure.

CONCLUSION

Assessing CVR in PHC allows for the classification of patients into specific risk groups, thereby enabling the application of appropriate preventive and therapeutic strategies and promoting health education. Recognizing risk factors (such as weight, glycemic and cholesterol levels, blood pressure, and smoking) and perceiving them as dynamic agents helps build patient autonomy.

From a public health perspective, understanding population-level CVR by geographic area and the impact of different risk factors enables better management of PHC investments through the creation of more targeted health policies. To achieve this, more robust health information systems and programs specifically designed for CVR monitoring are required.

However, discrepancies between laboratory and non-laboratory CVR scores reveal methodological limitations that can negatively influence clinical decisions in PHC, leading to inappropriate interventions, under- or overdiagnosis, and implications for the allocation of resources. Therefore, it is important to distinguish between the use of tools for broad population screening — which are more feasible but potentially less accurate — and those designed for clinical monitoring in higher-risk groups, such as people with diabetes.

CONFLICTS OF INTEREST

Nothing to declare.

AUTHORS' CONTRIBUTIONS

KOGR: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Visualization, Writing – original draft. MSA: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Visualization, Writing – original draft. RFD: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources,

Visualization, Writing – original draft. VOR: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Visualization, Writing – original draft. BPOA: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Visualization, Writing – review & editing. JVRSG: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Visualization, Writing – review & editing. MHF: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Visualization, Writing – review & editing. LCMD: Project administration, Supervision, Validation.

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