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Ideal cardiovascular health at ELSA-Brasil: non-additivity effects of gender, race, and schooling by using additive and multiplicative interactions

Saúde cardiovascular ideal na ELSA-Brasil: efeitos não-aditivos de gênero, raça e escolaridade através do uso de interações aditivas e multiplicativas

Salud cardiovascular ideal en ELSA-Brasil: efectos no aditivos de género, raza y educación a través del uso de interacciones aditivas y multiplicativas

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Abstract

This study aims to assess the non-additivity effects of gender, race, and schooling on ideal cardiovascular health among participants of the Brazilian Longitudinal Study of Adult Health – *ELSA-Brasil. This is a cross-sectional study using data from the baseline of ELSA-Brasil, conducted from 2008 to 2010. The American Heart Association defined a score of ideal cardiovascular health (ICH) as the sum of indicators for the presence of seven favorable health factors and behaviors: non-smoking, ideal body mass index, physical activity and healthy diet, adequate levels of total cholesterol, normal blood pressure, and absence of diabetes mellitus. Multiplicative and additive interactions between gender, race, and schooling were assessed using the Poisson regression model to discuss intersectionality. The mean cardiovascular health score was 2.49 (SD = 1.31). This study showed a positive interaction between gender and schooling (women with high school and higher education) in both additive and multiplicative scales for the score of ideal cardiovascular health. We observed a trend towards higher mean values of cardiovascular health for increased schooling, with a marked difference among women. The lowest cardiovascular health scores observed reinforce the importance of understanding the psychosocial experiences that influence health attitudes, access to health care, and healthy lifestyle choices, which affect ICH, to reduce inequities in health and propose more adequate public policies that assist and prevent cardiovascular diseases.*

Intersectionality; Heart Diseases; Cardiovascular Diseases; Risk Factors; Cross-sectional Studies

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Introduction

The main causes of mortality among adults worldwide and in all Brazilian regions are cardiovascular diseases (CVDs) [1,2]. In 2010, the American Heart Association (AHA) defined a strategy to reduce the number of deaths from CVDs and promote health prevention entitled "ideal cardiovascular health" (ICH). This indicator goes beyond determining the absence of CVDs and identifies seven positive attributes of health factors or behaviors: diet, physical exercise, body mass index (BMI), smoking, blood pressure, fasting blood glucose, and cholesterol levels [3].

ICH is defined by the sum of the seven positive health indicators, which are well-known in the literature. The ICH has been applied in several countries, particularly those with low prevalence of the combined seven ICH attributes [4,5]. Using data from the latest *Brazilian National Health Survey* (PNS), a study found that only 0.34% of Brazilian adults had ideal levels of cardiovascular health in a sample with participants from different regions of Brazil [6]. Nevertheless, 7.8% of participants in the *Brazilian Longitudinal Study of Adult Health* (ELSA-Brasil), conducted among workers of Brazilian public universities and research institutions from six cities, had five or more ideal cardiovascular health metrics [7].

Older men self-reported as black tend to have less ideal metrics [8]. Most studies focus on morbidity and risk factors separately [9]. The discussion about risk factors for CVDs is lacking since these factors are interrelated, do not seem to have unidirectional associations, and are related to health inequalities. Therefore, considering their co-occurrence (e.g., given by their joint presence) and describing their relationships with the social, cultural, and economic processes which affect them is essential [10,11]. Many health and disease studies that assess the heterogeneities of effects and causes of health inequalities use an intersectional approach to address the non-additive effects of sex/gender and race/ethnicity, to assess different intersections of identity, social position, processes of oppression or privilege, and policies or institutional practices, and to contribute to populational health research by improving validity to heterogeneous population effects and causal processes [12]. Cardiovascular health assessment should thus consider both theoretical and methodological aspects as a proxy of intersectionality.

Most studies on cardiovascular health do not address intersectionality. When they do, the discussion is based on the hierarchy of major axes of social differentiation [6,7,9]. Research has been increasingly using the intersectional approach in their designs and/or analytical methods, including qualitative studies [13] and quantitative studies using probabilistic measures of association [14], regression models with stratification or interactions using cross-coded categories of the intersectional factors [15], or multilevel models [16].

Methodological challenges often limit the use of the intersectional approach in health studies; however, in regression models, using interaction terms could capture how discrimination relates to health and help reduce health disparities [17]. Research on cardiovascular diseases usually focuses on the disease's risk factors (main effects only), which might cause an exaggerated simplification and neglect differences within and between groups on etiology, trajectory, search for, and access to healthcare [18]. To our knowledge, although CVD is still a major public health problem, with the highest mortality rate in Brazil and worldwide [2], only one study of CVD approached intersectionality [19]. Bey and collaborators assessed race and gender differences in experiences of racial and gender discrimination in cardiovascular health, showing that white men were most susceptible to the negative effects of multiple forms of perceived discrimination in ICH [19]. The intersectional approach should be recognized as a valuable resource to rethink existing methods, research models, practices, and health policies [11].

Including intersectionality in health analyses involves methodological challenges, leading to a new perspective to understand health inequalities, the complexity of human life within a society, and the struggle for fairer public policies. This study thus aims to assess the non-additivity effects of gender, race, and schooling on ideal cardiovascular health score among ELSA-Brasil participants at baseline.

Methodology

This is a cross-sectional study performed with the baseline data of ELSA-Brasil, conducted from 2008 to 2010. ELSA-Brasil is a multicenter study including 15,105 active and retired workers, aged from 35 to 74 years , of both sexes, from six public universities and research institutions [located in São Paulo, Belo Horizonte (Minas Gerais State), Porto Alegre (Rio Grande do Sul State), Salvador (Bahia State), Rio de Janeiro, and Vitória (Espírito Santo State)]. The study was submitted to and approved by the Brazilian National Ethics Research Committee and all ethics committees of the six institutions involved (Federal University of Bahia – UFBA; Federal University of Espírito Santo – UFES; Federal University of Minas Gerais – UFMG; Oswaldo Cruz Foundation – Fiocruz; Federal University of Rio Grande do Sul – UFRGS; University Hospital of the São Paulo University – USP). More details are described in Aquino et al. [20] and Schmidt et al. [21].

Our exclusion criteria were participants who reported stroke (n = 197), myocardial infarction (n = 248), prior cardiac (n = 130) surgery, prior bariatric surgery (n = 103), and participants who self-reported as Asian (n = 356) or Indigenous (n = 145). To clarify, the first three exclusion criteria were considered because of the definition of ICH (which prevents the occurrence of CVDs), the fourth because of possible interference in the diet metrics, and the last two due to the low prevalence of these populations in ELSA-Brasil. This study sample included 13,926 participants.

Variables

To define the ideal cardiovascular health score, the AHA [3] considered the simultaneous presence of four favorable health behaviors (non-smoking, ideal BMI, physical activity, and healthy diet) and four favorable health factors (non-smoking, adequate levels of total cholesterol, normal blood pressure, and absence of diabetes mellitus). and the absence of CVD (including coronary heart disease, stroke, and heart failure, among others). Considering the importance of smoking abstinence and cessation to promote health, the AHA included non-smoking in the list of both health factors and health behaviors. The AHA's committee thus indicated seven different behaviors and health factors which define ideal cardiovascular health indicators besides the absence of CVD. The response variable (ICH score) in this study is defined by the sum of the presence indicator (yes = 1/no = 0) of the seven ideal behaviors and health factors, resulting in a score from 0 to 7 where the higher the score, the better the cardiovascular health.

The ideal criteria for each metric are defined as follows. The *Food Frequency Questionnaire* [22] was used to assess the five components of the diet of ELSA-Brasil participants. The AHA criteria [23] of the ideal diet considered the consumption of four or five items of a healthy diet: ≥ 4 servings of fruit and vegetables per day, ≥ 7oz of fish per week (preferably oily fish), ≥ 2 servings of high-fiber whole grains per day, ≤ 450Kcal of sugar-sweetened beverages per week, and < 1,500mg of sodium per day. Sodium intake was corrected for total energy intake.

Ideal physical activity was assessed using the leisure and transportation domains of the *International Physical Activity Questionnaire* (IPAQ) [24]. According to AHA criteria, ideal physical activity (active individuals) is defined by ≥ 150minutes/week of moderate-intensity activity or ≥ 75minutes/week of vigorous-intensity activity or the two combined [25].

Smoking abstinence was considered as when individuals reported "never smoking" or quitting smoking at least two years before the age they were at the study evaluation. BMI was calculated by dividing weight by height squared, where BMI< 25kg/m^2 was defined as ideal. Anthropometric measurements in ELSA-Brasil were assessed using standard techniques [26]. Blood pressure was measured after a five-minute rest, with the participant sitting in a quiet room whose temperature was controlled with a validated device. Blood samples were collected for fasting glucose and total cholesterol [27].

The criteria for ideal BMI, blood pressure (< 120/< 80mmHg), fasting plasma glucose (< 100mg/dL), and total cholesterol (< 200mg/dL) were equal to those proposed by the AHA [3]. The last three metrics were classified as ideal only when there is no reported use of antihypertensive, hypoglycemic, and lipid-lowering drugs, respectively, according to the Anatomical Therapeutic Chemical Classification code [28].

Cardiovascular health was assessed according to gender (men and women), self-reported race (black, brown and white), and self-reported schooling level (incomplete middle school, middle school, high school and college or above).

Statistical analysis

Descriptive data analysis was conducted to assess the distribution of the participants according to their characteristics of interest. The behavior of the cardiovascular health score was described using histograms and boxplots. The normality of ICH distribution was tested using the Shapiro-Wilk test. Multiplicative and additive interaction analyses [12,29,30,31,32] were explored to incorporate an intersectionality perspective in the ICH assessment [19], considering gender, race, and schooling level.

The ICH is asymmetric, measured on a discrete scale (ranging from 0 to 7), and underdispersed. Poisson and quasi-Poisson regression models [33,34] were therefore fit for ICH and compared using Akaike information criterion (AIC), Bayesian information criterion (BIC), and likelihood ratio tests when possible. To select the final model for assessment of the multiplicative interaction, the complete model (with all two-way and three-way interactions of gender, race, and schooling) was compared to smaller models, removing the interactions one by one and using the likelihood-ratio test. All models were adjusted by age. Using the estimates from the final model, the mean (predicted) ICH values were calculated for all combinations of gender, race, and schooling, with corresponding 95% confidence intervals (95%CI). Estimates of relative risk (RR and 95%CI) for the effects of intersectionality on ICH were also determined [35,36]. The predictions considered the mean age of 51.7 years.

The measures estimated to describe the additive interaction were "relative excess risk due to interaction" (RERI), attributable proportion to interaction (AP), and synergy index (SI) [37,38]. These measures are defined below considering notation for the analysis of two binary variables (coded as 0 or 1). Assuming that an individual is only exposed to one risk factor (RR10 or RR01, separately) or is doubly exposed to these factors (RR11), we have:

$$RERI = RR11 - RR10 - RR01 + 1$$
$$AP = (RR11 - RR10 - RR01 + 1)/(RR11)$$
$$SI = (RR11 - 1)/[(RR10 - 1) + (RR01 - 1)]$$

RR denotes the relative risk and the indexes inform the corresponding category of each binary variable.

SI assesses the RR from both exposures in relation to the RR from each of the exposures separately [37]. In turn, AP measures the proportion of risk from interaction in the subset of individuals who are exposed to both factors, creating a derivative measure of the excess relative risk due to interaction, so that AP > 0 if and only if RERI > 0. As a measure for public health, the RERI is relevant in the direction but not in the magnitude of the interaction [37,38]. RERI > 0 and SI > 1 indicate a positive additive interaction. This approach is limited since it cannot assess three-way or higher-order interactions nor include multiple two-way interactions [37,39,40]. The discussion of additive interaction in our study is thus limited to three two-way interaction models: gender-race, gender-schooling, or race-schooling.

The estimates were compared by adopting additive and multiplicative scales using the two-way interaction Poisson model. The mean ICH was estimated for each exposure category and the RRs were estimated in relation to the reference category (black man for the gender-race two-way interactions and man with incomplete middle school for the gender-schooling two-way interactions) using Poisson regression with robust variance. The mean observed ICH was compared with the ICH expected in the absence of interaction (AI) in the additive and multiplicative scales [41,42], which can be defined, respectively, by:

$$\text{Expected value multiplicative scale} = \text{mean ICH for the reference category} * RR01 * RR10$$
$$\text{Expected value additive scale} = \text{mean ICH for the reference category} * (RR01 + RR10 - 1)$$

The expected ratio in the AI was also estimated for multiplicative and additive scales [41,42], being defined as:

$$\text{Ratio}_{\text{multiplicative scale}} = \text{RR11}/(\text{RR01} * \text{RR10})$$
$$\text{Ratio}_{\text{additive scale}} = \text{RR11}/(\text{RR01} + \text{RR10} - 1)$$

Ratios greater than 1 indicate positive interaction in both scales, implying a higher proportion of cases than expected. The literature has reported other measures to describe multiplicative and additive interactions, such as the proportions attributable to each of the factors separately and to the two-way interaction [42], defined as:

$$(\text{RR01} - 1)/(\text{RR11} - 1)$$
$$(\text{RR10} - 1)/(\text{RR11} - 1)$$
$$\text{RERI}/(\text{RR11} - 1)$$

A 5% significance level was adopted for all analyses. Data management and analysis was performed using the Stata version 14 software (http://www.stata.com).

Results

This study population included 13,926 workers, of whom 54.5% were female, 54.2% self-reported as white and 16.7% as black, 52.9% had a college degree or above, 32.5% reported being diagnosed with hypertension and 8.0% reported diabetes, 68.3% reported having health insurance plan, and 81.3% self-reported as having good health. Participants' mean age was 51.7 years (standard deviation – SD = 9.0 years). Only 0.04% had an ideal cardiovascular health score (7 points; n = 6) whereas 1.26% scored 6 points (n = 170).

The mean ICH score was 2.49 (SD = 1.31). Among the criteria for the ideal metric, non-smoking was the most prevalent (82%) whereas healthy diet was the less prevalent (1.3%). Men had higher prevalence of non-ideal blood pressure (77.6% vs. 49.4%) and non-ideal fasting plasma glucose (78.8% vs. 60.9%) than women. Individuals who self-reported as white had higher schooling level than brown and black participants, regardless of gender. Men also had the highest proportion of individuals with incomplete middle school (8.20% men vs. 5.27% women) (data not shown).

The analyses including additive interactions between gender, race, and schooling on ICH score reveal positive interactions, with RERI > 0 and synergy index > 1. Some synergy indices were not presented since they are difficult to interpret when one or both exposures have RR < 1 [42]. Statistically significant interaction terms in the Poisson model were white women (race-gender interaction), women with high school degree and women with college degree (gender-schooling interaction), and white with college degree (race-schooling interaction) (Table 1). The highest AP was between gender and schooling (women with college degree or above – 17%) and between race and schooling (white with college degree or above – 11%). For women with college education, the mean observed ICH considering the additive interaction was about 2.8 times higher than the expected value in AI (Table 1). These results indicate that the mean observed ICH values are higher than expected in both additive and multiplicative scales in all two-way interaction models.

The Poisson and quasi-Poisson models were compared to assess under/overdispersion including multiplicative interactions. As expected, the estimates of the parameters were equal, but the standard errors using the quasi-Poisson technique were slightly lower because of the underdispersion in these data (Table 2). Nevertheless, no significant differences were found in the conclusions between these models. To compare models using the likelihood ratio test, further analyses were conducted using the Poisson model. The Poisson model selected as best included interaction terms between gender-race and gender-schooling, but not the three-way interaction term or the two-way interaction race-schooling (Table 2).

Table 1

Additive interaction measures using the Poisson model for ideal cardiovascular health (ICH) score. ELSA-Brasil, 2008-2010.

Interaction	RERI *	AP	SI
Gender-Race			
Brown/Woman	0.03 (-0.03; 0.09)	0.03 (-0.02; 0.07)	1.19 (0.82; 1.72)
White/Woman	**0.10 (0.04; 0.15)**	**0.07 (0.03; 0.11)**	**1.41 (1.09; 1.83)**
Gender-Schooling			
Woman/Middle school	0.10 (-0.01; 0.21)	0.09 (-0.01; 0.20)	-
Woman/High school	**0.15 (0.06; 0.24)**	**0.13 (0.05; 0.21)**	**-**
Woman/College or above	**0.24 (0.16; 0.32)**	**0.17 (0.11; 0.24)**	**2.77 (1.22; 6.29)**
Race-Schooling			
Brown/Middle school	0.03 (-0.11; 0.16)	0.03 (-0.11; 0.16)	2.12 (0.00; 1763.01)
Brown/High school	0.05 (-0.06; 0.16)	0.05 (-0.06; 0.15)	2.14 (0.08; 60.38)
Brown/College or above	0.09 (-0.02; 0.20)	0.07 (-0.02; 0.17)	1.54 (0.67; 3.52)
White/Middle school	0.04 (-0.11; 0.19)	0.04 (-0.10; 0.17)	2.19 (0.01; 465.38)
White/High school	0.07 (-0.05; 0.19)	0.06 (-0.05; 0.17)	2.12 (0.17; 26.23)
White/College or above	**0.15 (0.03; 0.27)**	**0.11 (0.02; 0.21)**	1.78 (0.80; 3.97)

AP: attributable proportion to interaction; RERI: relative excess risk due to interaction; SI: synergy index.
Note: bold – statistically significant results.
* Reference categories: men, black, and with incomplete middle school.

Table 2

Estimates for the assessment of multiplicative two-way interaction using the Poisson model for cardiovascular health metrics. ELSA-Brasil, 2008-2010.

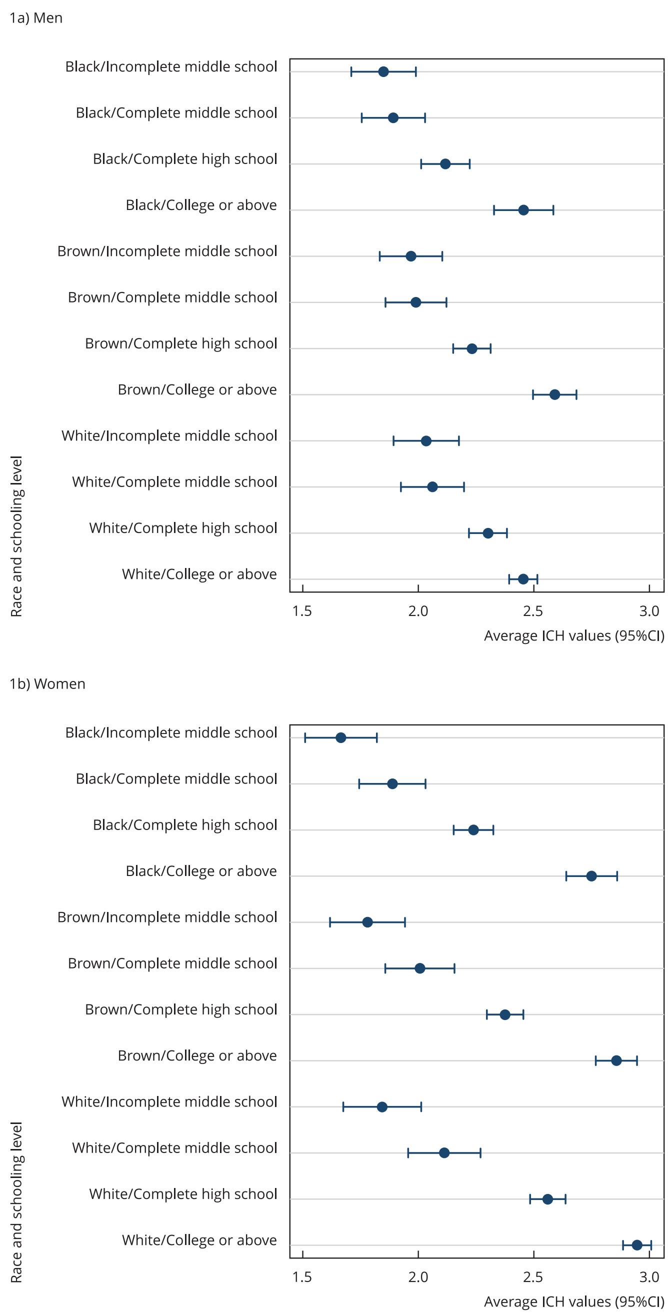
Characteristic	Final model		
	Estimate (β)	SE	
		Poisson	Quasi-Poisson
Gender			
Men	Reference		
Women	-0.065	0.061	0.048
Race			
Black	Reference		
Brown	0.047	0.028	0.022
White	**0.070**	0.027	0.021
Schooling level			
Incomplete middle school	Reference		
Complete middle school	-0.022	0.046	0.036
Complete high school	0.021	0.037	0.028
College or above	**0.146**	0.036	0.028
Two-way interactions			
Gender-Race			
Brown/Woman	0.009	0.036	0.028
White/Woman	0.051	0.034	0.026
Gender-Schooling level			
Woman/Middle school	0.097	0.074	0.058
Woman/High school	**0.140**	0.060	0.046
Woman/College or above	**0.180**	0.059	0.046

SE: standard error.
Note: adjusted by age. Bold – statistically significant results ($p < 0.05$).

The influence of schooling on the ICH is clearly described regarding its predicted means (additive interaction approach) and RR (multiplicative interaction approach). The mean ICH increases with higher schooling, being relatively higher for women. Schooling influences cardiovascular scores in women, especially white women (see predicted ICH using multiplicative interaction approach) (Figures 1 and 2).

Figure 1

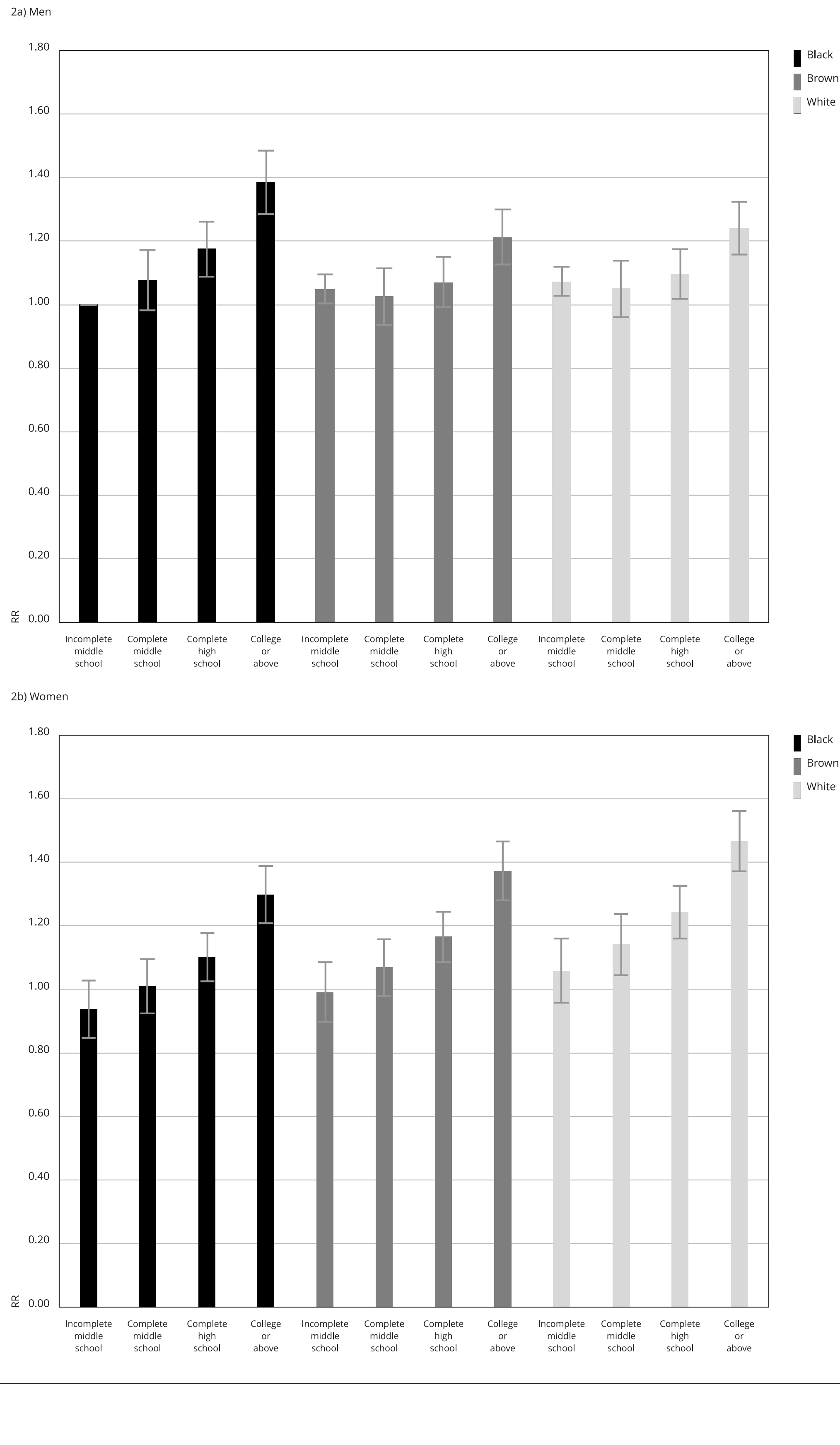
Mean cardiovascular health values according to sex, race, and schooling using the Poisson model. ELSA-Brasil, 2008-2010.



95%CI: 95% confidence interval; ICH: ideal cardiovascular health.

Figure 2

Relative risk (RR) of ideal cardiovascular health score estimated by the final Poisson model. ELSA-Brasil, 2008-2010.



Considering the expected ratio in the AI regarding RR and RERI, respectively, estimated for multiplicative and additive scales using the Poisson model, ratios greater than 1 indicate positive interaction between gender-race and gender-schooling in both scales. The ratios for white women were 1.7 for the additive scales and 1.6 for multiplicative scales; for women with college education or above, their corresponding ratios were 1.22 and 1.23.

The average observed ICH scores were higher than expected in the AI corroborating the positive interaction. For instance, the mean ICH for white women was 2.8, whereas its expected scores (in AI) were 2.7 and 2.6, respectively, in the multiplicative and additive scales (Figure 3). The proportions attributable to the interaction between gender and race in cardiovascular health scores for white women (compared to black men) were 29% for being a woman, 41% for being white, and 29% for the interaction term white-woman. On the other hand, the proportion of the effect of interaction on ICH was 16% for brown women.

We found that in the model including the two-interaction term gender-schooling, the mean observed ICH for women with college education or above was 2.3, whereas its expected scores (in the AI) were around 2.2 for both scales (Figure 3). Moreover, the proportion of the effect on ICH due to both exposure categories for this two-way interaction term (women and college/further education) is 63% in relation to the reference level (men with up to incomplete middle school).

Discussion

This study identified a statistically significant additive and multiplicative interaction effect between gender and schooling when modeling ICH score for a group of Brazilian workers. We analyzed the predicted scores and RRs using the Poisson model with two-way interactions terms in the multiplicative scale, finding that cardiovascular health scores increased with higher schooling levels. Moreover, these differences were mostly prevalent among women. In both scales, the observed ICH scores were higher than those expected in the AI, indicating positive interaction between gender and schooling. The difference between the proportion attributable to the interaction between men with incomplete middle school and women with college education or above is 63%. Furthermore, we found that the two-way interaction terms for the effects of gender-race and race-schooling were statistically significant via the additive scale.

Our results show that assessing the great axes of social differentiation in isolation – such as gender, color/race, and income and education – as proxies of social class is insufficient to understand and describe their relationships, the process of their mutual construction, and the inequality between them [11]. In turn, analyses with an intersectional approach refute the enclosing and hierarchization of these axes, considering the simultaneous interactions between the different aspects of social categories and the impact of systems and processes of oppression and domination to determine health in population groups and geographical contexts [43].

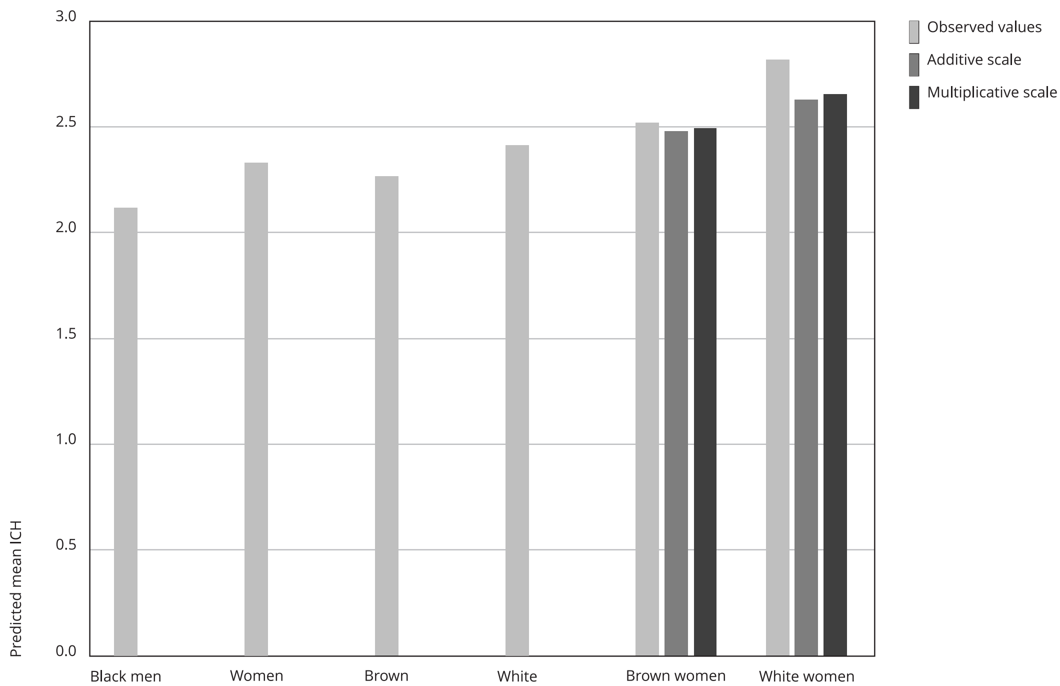
Although the statistical method most appropriate to incorporate intersectionality into quantitative analysis is still undefined, many proposals can achieve correspondence between the statistical theory and the intersectional research framework. In the article by Crenshaw [44], who coined the term intersectionality, the author particularly referred to the "interaction between race and gender". Cross-product terms (interactions) can thus be included in a model to assess intersectionality, producing estimates with potentially different interpretations and implications [45]. One possible limitation of using regression models with interaction terms is the assessed effect only among the most disadvantaged individuals, such as black women, whereas those who are privileged (e.g., white men) or mixtures of privilege and disadvantage (e.g., white women and black men) have no observed interaction effect, reinforcing the social primacy of the privileged [16]. Our research, however, evaluated different intersectional groups.

Using additive interaction combined with the main effects is more consistent with the biological/social causes and more relevant to promote population health and prevent diseases [12,46]. Our study showed a ratio 2.8 times higher between the observed and expected excess risk for women with college education and above if the results were simply a function that adds the excess risks for each

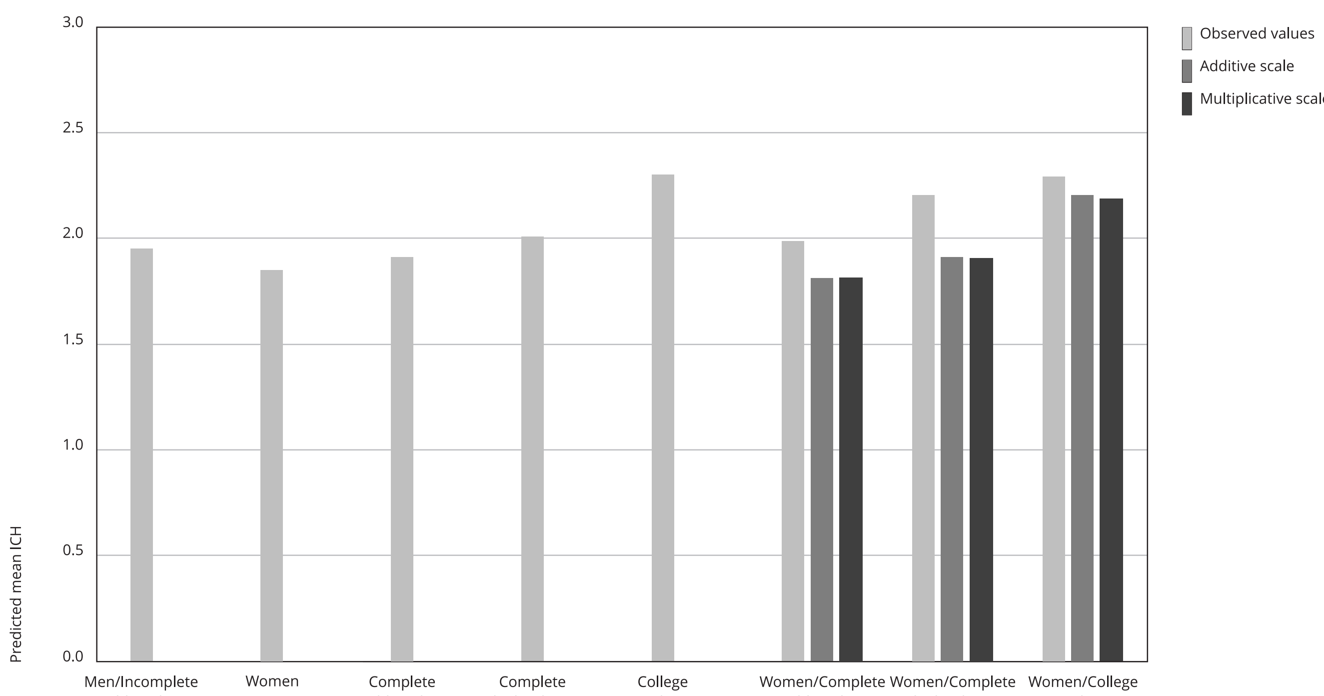
Figure 3

Observed mean and expected ideal cardiovascular health (ICH) scores using the additive and multiplicative scales to assess the interaction between sex and race and between sex and schooling in the final Poisson model. ELSA-Brasil, 2008-2010.

3a) Interaction between sex and race



3b) Interaction between sex and schooling level



variable separately (gender and schooling). Multiplicative scale analyses require additional effort for result interpretation, such as estimating mean values and RRs, as described in the previous section.

Differently from most studies on cardiovascular diseases, our study focused on the ICH of the population, who has a low prevalence of ideal metrics. In our study, only 0.04% and 1.26% of the participants had, respectively, the seven and six ideal metrics. Countries such as Switzerland or Finland [47,48] have ideal ICH metrics above 25%, showing the importance of an intersectionality analysis in a developing country to understand health inequities in ICH.

We also found that schooling level influenced the mean scores and RR of ICH mostly among women, corroborating other studies. An analysis with data from a Chinese province identified a positive association between ICH and schooling for women but not for men, showing that women with college education and income pay more attention to a healthy diet, weight reduction, and physical activity [9]. Another study also identified an inverse association between the behavioral factors of ICH and material deprivation, mostly among women [5]. Furthermore, the study found that although men had a higher risk of ischemic heart disease, the risk significantly increased among women. Though these results are similar to ours, they do not explicitly contrast all groups with each other and therefore do not clarify the differences between combinations of gender, race, and schooling. We found that women with low income had a 2.2 times greater cardiovascular risk than women with high income, while this risk was 69% higher in men. Combined patterns of domination and subordination thus seem to contribute to the unequal distribution of cardiovascular disease in the population [49].

Several other studies indicate that women are more vulnerable to the effects of risk factors and to a low socioeconomic status, which partly explains the greater health inequality that can contribute to the persistence of cardiovascular diseases. Women usually have higher workload than men (unpaid work at home, besides their regular job) as well as greater job insecurity, lower wages, fewer leadership positions, and more work in secondary jobs, or lower access to quality health care [30,50]. Significant associations between work-family conflicts and ideal ICH were identified using ELSA-Brasil data, with ICH scores significantly lower for women considering the health behaviors with frequent interference in family-based work, frequent family interference based on work, and a frequent lack of time for personal care and leisure [51].

Using the multiplicative interaction approach, a study found that poor black people with incomplete high school [32] and poor black women in Canada [50] had a higher probability of hypertension than wealthier, university-educated, and white Canadians. In a study with adults living in New York city, United States, non-Latino black women had significantly higher risk of being overweight or obese, hypertensive, and diabetic and of having higher total cholesterol [31]. Our study corroborates these relationships considering the two-way interaction models using both additive and multiplicative scales. Each factor – particularly being a woman, being black, and having low schooling levels – presents unique psychosocial experiences that influence attitudes toward health, access to health care, and healthy lifestyle choices, which affect ICH. This emphasizes that being a black woman is more than just the sum of being a woman and being black. Intersectionality diverges from the prevailing point of view that women are a homogeneous category sharing the same life experiences [31].

Although these racial inequalities are still often theorized considering biological components alone, social aspects such as racism, family structure, diet, or even poverty can contribute to the debate [12,46,52]. We must seek to understand how processes of oppression affect health and how privileges and social inclusion can facilitate and protect health, recognizing that we cannot simply add up the factors – which are shaped by processes that produce different experiences for those who are at different intersections [12,46,53].

In practice, changing factors at the macro or intermediate levels, which allow or limit choices and behaviors, is more plausible than conducting interventions focused on the individual level [49]. Characteristics that are difficult to modify, such as gender and race, must be considered since they may lead to specific prevention strategies. Moreover, including modifiable social categories, such as schooling, in the intersectional approach is essential so that the analysis does not remain fundamentally descriptive, regardless of the simplicity or complexity of the methods and interpretation [46].

Racism, sexism, and classicism form interconnected systems of oppression that shape individuals' experiences with their multidimensional social categories so that population groups cannot be treated as homogeneous. They operate in an integrated way, producing health inequalities that structure the relative positions that individuals occupy in society. These positions are shaped by interactions between various locations and levels of power, including institutions such as families, governments, laws, policies, and broader processes of globalization and neoliberalism [18,54,55].

Very general population-level prevention strategies should be questioned when intersectional studies indicate large heterogeneities [49] since each subgroup has specific needs, and cultural and social values could influence education and treatment. Interventions should thus be directed at the individual and political level, determining broader programmatic changes to provide health services to communities. These health policies can also be integrated with other sectors, such as finance and education, to reform social and environmental structures for equity in health and well-being [56].

Limitations and strengths

A methodological limitation of this study is that interactions using the additive scale can only be analyzed in two-way interaction models. Moreover, we used the term gender because of the discussion involving intersectionality, but our evaluation was limited to sex. Although sex/gender is the only intersectoral variable considered in all studies, most studies still use sex to assess intersectionality and in this study the variable was operated exclusively as binary [45]. Furthermore, gender is usually combined with race, but rarely with schooling level, income, or other variables.

Although our analyzes were conducted using Poisson models, which facilitate comparability with other studies, the truncated Poisson model could be more appropriate to incorporate the actual structure of the response variable, which is defined by counting the number of positive items, ranging from 0 to 7 [57,58]. In our study, the data would be truncated to the right, from the value not included in this scale (value 8). We compared the estimates using several Poisson and Poisson truncated models for data analysis and the results were quite similar. However, since our final model did not converge using the truncated Poisson model, we presented the results from Poisson models only.

One strength of our analyses was encompassing intersectionality and including schooling as a proxy for socioeconomic position. Furthermore, interactions were analyzed using both the additive and multiplicative scales. Intersectionality is a theoretical concept which still presents methodological and statistical difficulties and limitations to epidemiology for a wider approach. Public health researchers, however, do not have to wait for these challenges to be solved to incorporate the concept of intersectionality into their theoretical frameworks, projects, analyses, and interpretations.

Contributors

R. S. Freitas contributed to the study conceptualization, data curation and analysis, methodology, writing, and review. I. S. Santos, S. M. A. Matos and E. M. L. Aquino contributed to the study conceptualization, writing, and review. L. D. A. F. Amorim contributed to the writing of the study, data analysis, methodology, and review.

Additional informations

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Resumo

Este estudo visa avaliar a não-aditividade dos efeitos de gênero, raça e escolaridade na saúde cardiovascular ideal entre os participantes do Estudo Longitudinal de Saúde do Adulto *– ELSA-Brasil. Trata-se de um estudo transversal utilizando dados da linha de base do ELSA-Brasil, realizado entre 2008-2010. A Associação Americana do Coração definiu a pontuação de saúde cardiovascular ideal (ICH) como a soma dos indicadores da presença de sete fatores e comportamentos favoráveis à saúde: não fumante, índice de massa corporal ideal, atividade física e dieta saudável, níveis adequados de colesterol total, pressão arterial normal e ausência de diabetes mellitus. Interações multiplicativas e aditivas entre gênero, raça e escolaridade foram avaliadas usando o modelo de Poisson, como uma abordagem para discutir a interseccionalidade. A pontuação média de saúde cardiovascular foi de 2,49 (DP = 1,31). Este estudo encontrou uma interação positiva entre gênero e escolaridade (mulheres com Ensino Médio e Superior), tanto na escala aditiva quanto na escala multiplicativa, para a pontuação de saúde cardiovascular ideal. Houve tendência para maiores valores médios de saúde cardiovascular com o aumento da escolaridade, com diferença acentuada entre as mulheres. As pontuações mais baixas de saúde cardiovascular observadas reforçam a importância de compreender-se as experiências psicossociais que influenciam as atitudes em relação aos serviços de saúde, ao acesso à saúde e às escolhas de estilo de vida saudável, que afetam a ICH, para reduzir as desigualdades em saúde e propor políticas públicas mais adequadas como uma estratégia de assistência e prevenção das doenças cardiovasculares.*

Interseccionalidade; Cardiopatias; Doenças Cariovasculares; Fatores de Risco; Estudos Transversais

Resumen

Este estudio tiene como objetivo evaluar los efectos no aditivos de género, raza y educación en la salud cardiovascular ideal entre los participantes del Estudio Longitudinal de Salud del Adulto *–ELSA-Brasil. Se trata de un estudio transversal realizado a partir de datos de línea de base de ELSA-Brasil entre 2008-2010. La Asociación Americana del Corazón definió el puntaje ideal de salud cardiovascular (ICH) como la suma de indicadores de la presencia de siete factores y comportamientos favorables a la salud: no fumador, índice de masa corporal ideal, actividad física y alimentación saludable, niveles adecuados de colesterol total, presión arterial normal y ausencia de diabetes mellitus. Las interacciones multiplicativas y aditivas entre género, raza y educación se evaluaron utilizando el modelo de Poisson como un enfoque para discutir la interseccionalidad. La puntuación media de salud cardiovascular fue de 2,49 (DE = 1,31). Este estudio encontró una interacción positiva entre el género y la educación (mujeres con educación secundaria y universitaria), tanto en la escala aditiva como en la escala multiplicativa, para puntajes ideales de salud cardiovascular. Hubo una tendencia a valores medios más altos de salud cardiovascular conforme aumenta el nivel de educación, con una marcada diferencia entre las mujeres. Los puntajes más bajos de salud cardiovascular refuerzan la importancia de comprender las experiencias psicosociales que influyen en las actitudes hacia la salud, el acceso a la salud y la elección de un estilo de vida saludable, que inciden en el ICH, para reducir las desigualdades en salud y proponer políticas públicas más adecuadas como estrategia de asistencia y prevención de enfermedades cardiovasculares.*

Interseccionalidad; Cardiopatías; Enfermedades Cariovasculares; Factores de Riesgo; Estudios Transversales

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