

Factors associated with high LDL-Cholesterol in the Brazilian adult population: National Health Survey

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Abstract *The study analyzed factors associated with high LDL-Cholesterol in Brazilian population. This is a cross-sectional study with laboratory data from 8,534 individuals collected in National Health Survey were analyzed. The prevalence levels of LDL-Cholesterol <130 and ≥ 130 mg/dL were calculated. The outcome variable was high LDL-Cholesterol (≥ 130 mg/dL) and explanatory variables were sociodemographic, anthropometric, lifestyle, chronic diseases and self-rated health. To Poisson regression was used and estimated prevalence ratios (PR) with 95% confidence levels (CI) to verify associations. The prevalence of high LDL-Cholesterol was 18.58%. In the final multivariate model were associated with the outcome: 30 to 44 years (PR 1.99; CI 1.58–2.54), 45 to 59 years (PR 2.89; CI 2.29–3.64), 60 years or more (PR 2.90; CI 2.29–3.68), living in the Northeast Region (PR 1.16; CI 1.02 – 1.32), overweight (PR 1.32; CI 1.15–1.51), obesity (PR 1.41; CI 1.19–1.65) or anemia (PR 0.66; CI 0.54–0.80). The LDL-Cholesterol was associated with aging, overweight, obesity, live in the Northeast and anemia. The monitoring of LDL levels is relevant, due to the increased risk with age, and can guide the adopting healthy lifestyles and diagnosis in places with lower access.*

Key words *Cholesterol, LDL, Dyslipidemias, Health surveys, Risk factors, Laboratory test*

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Introduction

The Brazilian and global adult population is exposed to the conditions of illness resulting from high cholesterol levels. Evidence that elevated serum cholesterol levels increased the risk of acute myocardial infarction (AMI)¹ was presented in the 1960s. Since then, research has confirmed an association between high cholesterol levels, not only with the risk of AMI but also with peripheral arterial diseases and strokes².

Abnormal concentrations of lipids, or lipoproteins, circulating in the bloodstream, especially cholesterol and triglycerides (TG), are defined as dyslipidemia, which develops with or without repercussions on the vascular territory and is associated with other clinical manifestations that may increase the risk of cardiovascular diseases^{3,4}. Dyslipidemia can be the result of genetic abnormalities, underlying diseases, or environmental factors⁵.

Elevated low-density-lipoprotein cholesterol (LDL-cholesterol) levels mainly contribute to atherosclerotic cardiovascular diseases (CVD)^{6,7}. Lipoproteins are responsible for the transport and solubilization of lipids. They consist of lipids and proteins called Apolipoproteins (Apo). One of the lipoproteins classes is rich in cholesterol and includes low-density-lipoproteins (LDL), which is the primary cholesterol carrier in the circulation to peripheral tissues⁸. LDL is directly related to the pathogenesis of atherosclerosis, which is the basis of most cardiovascular events⁹. Thus, this lipoprotein is identified as the best predictor of cardiac risk² and has been a therapeutic target to reduce CVD risks¹⁰.

The latest report from the World Health Organization (WHO) in 2009 showed that increased serum cholesterol levels caused 2.6 million deaths and 29.7 million years of life lost due to premature death and disabilities¹¹. Specifically, for the risks attributed to increased LDL-cholesterol, in 2017, estimates pointed to the occurrence of 4.3 million global deaths, corresponding to 7.7% of all deaths and 94.9 million years of Disability-Adjusted Life Years (DALYs) lost^{12,13}. In Brazil, the significant burden of death and disability attributed to high LDL-cholesterol is also evident. A total of 99,315 deaths (7.36% of the total deaths) and the loss of 2,335,294.99 DALYs were estimated in 2017 alone¹³.

This scenario shows the importance of public policies aimed at controlling modifiable factors such as dyslipidemia. Especially as a strategy to reduce morbimortality due to CVD, considered

the main cause of death worldwide^{9,14-18}. From this perspective, knowledge of dyslipidemia by the analysis of the lipid profile is essential, since it aims to identify isolated or combined changes^{5,15} of total cholesterol (TC) levels, TG, LDL-cholesterol fraction, and high-density-lipoprotein (HDL-cholesterol) cholesterol fraction¹⁴. Factors associated with dyslipidemia are sociodemographic factors, such as gender, age^{15,19-21}, schooling²², place of residence^{15,19,20}, lifestyles¹⁹⁻²¹, overweight, obesity^{15,16,19,20}, chronic diseases, such as hypertension and diabetes^{15,20}, and poor self-rated health¹⁹.

In Brazil, epidemiological surveys monitoring the prevalence of dyslipidemia are scarce and mostly use self-reported data^{19,23}. In this context, aiming at monitoring the risk indicators for NCDs, the National Health Survey (PNS) collected biological material that included measurements of cholesterol and fractions²⁴⁻²⁶ and allowed to monitor dyslipidemia in the Brazilian population through laboratory tests²⁶.

Thus, considering the relevance above of the negative repercussions on health caused by increased LDL-cholesterol levels and that, in clinical practice, these circulating molecular structures have been so important²⁷, it is necessary to conduct studies investigate factors associated with increased LDL-cholesterol in Brazil.

In this sense, this study innovated by making unprecedented analyses of factors associated with high LDL-cholesterol in Brazilian adults through laboratory tests of the broadest health survey in Brazil: the PNS²⁸. Furthermore, the research advances by bringing novelty concerning relevant information on the population diagnosis of increased LDL-cholesterol and its associated factors in the face of public health challenges for detecting cardiovascular risk and prevention of CVD. Also, this work supports actions to prevent dyslipidemia and improve the health situation of the Brazilian population.

Thus, this study aimed to analyze the factors associated with the distribution of high LDL-cholesterol in the Brazilian adult population.

Methods

This is a cross-sectional study that employed the PNS laboratory tests' database between 2014 and 2015. PNS is a nationwide and home-based survey conducted by the Brazilian Institute of Geography and Statistics (IBGE), in partnership with the Ministry of Health (MS). The research used

a probabilistic sample in three stages in which interview records were obtained from 64,348 households^{24,25}, and the collection of biological material was planned in a subsample of 25% of surveyed census tracts²⁴⁻²⁶ to conduct the PNS laboratory tests.

PNS laboratory analyses were selected from a subsample consisting of 8,952 individuals. A total of 418 samples were excluded due to insufficient material, hemolysis, and sample loss. Altogether, 8,534 blood samples from the selected individuals were chosen for this analysis. Due to losses and aiming to reduce representation bias, the study adopted post-stratification weightings by gender, age, schooling, and region, to establish estimates for the Brazilian adult population²⁵. Peripheral blood was collected at any time of the day²⁶, and the study followed the protocol that dispenses with fasting for cholesterol measurement⁸. LDL-cholesterol samples were collected in gel tubes. Clot retraction lasted 30 minutes, after which samples were centrifuged and sent under refrigeration at 2-8°C and temperature control throughout the steps. This parameter was measured by an automated enzymatic-colorimetric method²⁶. Further methodological details and PNS laboratory collections are available in other publications²⁴⁻²⁶.

This study included variables related to the LDL-cholesterol fraction (measured in laboratory tests), sociodemographic, lifestyles, and chronic diseases²⁹. The outcome variable was having high LDL-cholesterol or not. Thus, a dichotomous analysis was performed, defined by the LDL cutoff point ≥ 130 mg/dL, as recommended by the National Cholesterol Education Program (NCEP-ATPIII)³⁰. The explanatory variables were:

a) Sociodemographic: gender (male and female); age (adults over 18 years old); education (categorized as illiterate and incomplete elementary school, complete elementary and incomplete high school, complete high school and over); skin color (white and others that corresponded to yellow and indigenous; black and brown); Brazilian regions (North, Northeast, Southeast, South, and Midwest).

b) Anthropometric: Body Mass Index (BMI) calculated from weight and height measurements in the PNS²⁸. BMI was classified according to the World Health Organization (WHO), as normal/underweight (BMI < 25 kg/m²), overweight (BMI between 25 and 29 kg/m²) and obesity (BMI ≥ 30 kg/m²)³¹.

c) Lifestyle: consumption of fatty red meat. The following question was asked for construct-

ing this indicator: "When you eat red meat, do you usually remove the excess visible fat or eat it with fat?" Answers were categorized as "yes" and "no" for reporting consumption of fatty red meat; the consumption of alcoholic beverages was assessed by the questions: "How many days a week do you usually drink alcohol?"; "In general, on the day you drink, how many doses of alcohol do you drink?" (one dose of alcoholic beverage is equivalent to one can of beer, one glass of wine or one dose of cachaça, whiskey, or any other distilled alcoholic beverage). The construction of this indicator was based on alcohol abuse and frequent consumption. Thus, we used the concept of "heavy drinking" proposed by the CDC³². This study classified consumption into no consumption (never or less than once a week), light/moderate (1-7 weekly doses for women and 1-14 weekly doses for men³²) and abuse (weekly intake equal or higher than eight doses for women and 15 for men³²). Tobacco use indicator was built with the following question: "Do you currently smoke any tobacco product?" with answer options "Yes, daily"; "Yes, less than daily"; "I don't currently smoke". Those who answered positively to the question were considered smokers.

d) Chronic noncommunicable diseases (NCDs): kidney failure. This indicator was calculated using PNS laboratory test data. The glomerular filtration rate (GFR) was less than 60 mL/min/1.73 m² in the blood test, and the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation³³ was used for the calculation. In this study, ethnicity adjustment was not used as recommended by most methods³³. We used the value of glycated hemoglobin $\geq 6.5\%$ ^{34,35} dosed by a blood test in the PNS and the self-reported diagnosis of the disease for the construction of the diabetes variable, considering the positive answer to the question: "Has any doctor ever diagnosed you with diabetes?" (Categorized as "yes" or "no"). Regarding arterial hypertension, the self-reported diagnosis for the disease was used to make this indicator, assessed by the questions: "Has any doctor ever diagnosed you with arterial hypertension – high blood pressure? (Categorized as "yes" or "no"); "In the past two weeks, have you taken any medications because of arterial hypertension (high blood pressure)?" (Categorized as "yes" or "no"). Blood pressure measurements measured in the PNS were also used, where arterial hypertension was defined as systolic pressure ≥ 140 and diastolic pressure ≥ 90 mmHg, according to the criteria of the Seventh Brazilian Guideline on Hypertension³⁶.

e) Self-rated health: for the construction of this indicator, we used the question: “In general, how do you rate your health?” Categorized as “very good”/“good”, “fair” and “very poor”/“poor”.

Sociodemographic, gender, age, schooling, skin color, and region variables were also evaluated as possible confounding factors.

The descriptive analysis of the explanatory variables and the prevalence of LDL-cholesterol < 130 mg/dL (optimal threshold)³¹ and ≥130 mg/dL (high threshold) were presented in proportions (%) with 95% confidence intervals (95% CI). Regarding the associated factors concerning the outcome, the analysis considered the causal determination blocks proposed by the theoretical model of Bergmann et al.³⁷ and other studies^{15,16,19-21}. The choice of the theoretical model³⁷ is justified because it is a national study in which the authors built the model, but other research with adults^{15,19-21} that investigated all the variables present in this study were also considered.

Each of the explanatory variables’ entry occurred according to the hierarchical theoretical model, which considered five blocks of causal determination (Figure 1).

Association analyses were examined using the prevalence ratios (PR) and respective 95% CI and were calculated using the Poisson regression model with robust variance. PRs above 1 indicated a risk factor, and PRs below 1 indicated a protective factor.

Three regression models were built. In model 1, bivariate analyses between the outcome variable and each explanatory variable were considered, and the estimated crude PR (PR_{crude}) was estimated. In model 2, the analysis adjusted for gender, schooling, skin color, and the region was performed, and the adjusted PR (PR_{adj}) was calculated; the age variable was excluded, as it pointed out that, using this adjustment, some variables accepted by the scientific community as factors associated with dyslipidemia¹⁹⁻²² lost their statistical significance. In model 3 (final model), a multivariate analysis adjusted for all explanatory variables was performed, and variables with $p < 0.20$ in bivariate analyses were selected and included in the model. In this analysis, the PR_{adj} ^b were estimated, and the explanatory variables that presented a value of $p \leq 0.05$ were considered as factors associated with high LDL-cholesterol. Confounding variables were tested considering aspects of the literature^{8,15,16,19-21,38-42}.

For all analyses, the sample structure and post-stratification weightings were considered.

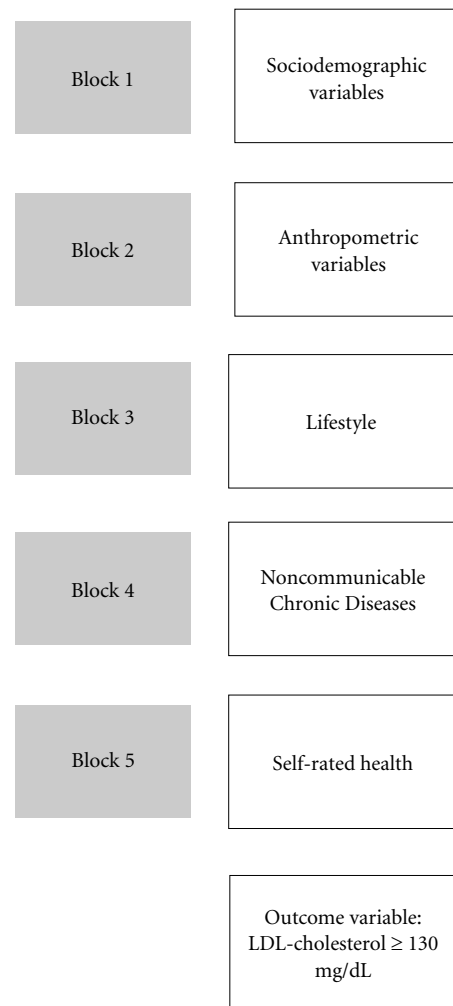


Figure 1. Hierarchical theoretical model of factors associated with high LDL-cholesterol.

Data were analyzed using the Data Analysis and Statistical Software (Stata), version 14, using commands for analyzing data from surveys with a complex sample (survey).

The laboratory database and PNS questionnaires are available on the PNS website of the Oswaldo Cruz Foundation (www.pns.fiocruz.br). The PNS was approved by the National Research Ethics Commission (CONEP) of the National Health Council (CNS), MS, under N° 328.159, of June 26, 2013. Adult participation in the research was voluntary, and information confidentiality was guaranteed. The selected individuals signed the Informed Consent Form and were instructed

on receiving the report containing the results of the examinations²⁸.

Results

The prevalence of increased LDL-cholesterol was 18.58% in the adult population and was higher in individuals aged 30 and over (17.55%), reaching approximately 25% in those aged 60 years and over, the less educated, such as the illiterate and with incomplete elementary education (21.53%), those overweight (21.10%), obesity (23.30%), arterial hypertension (23.27%), diabetes (24.72%) and those who self-rating their health as very poor/poor (24.24%) and fair (22.05%). Anemic individuals had a lower prevalence of increased LDL-cholesterol (13.29%) (Table 1).

In Table 2, the factors associated with increased LDL-cholesterol were analyzed. The results presented show that the magnitude of the associations varied according to the factors analyzed.

In the bivariate analysis (model 1), the protective factors were schooling, complete elementary and incomplete high school (PRb = 0.78; 95% CI 0.66–0.93); complete high school and more (PRb = 0.77; 95% CI 0.68–0.88); black and brown skin color (PRb = 0.87; 95% CI 0.77–0.97) and anemia (PRb = 0.69; 95% CI 0.56–0.83). Risk factors were: female gender (PRb = 1.16; 95% CI 1.03–1.30); age, 30–44 years (PRb = 1.99; 95% CI 1.60–2.49), 45–59 years (PRb = 2.90; 95% CI 2.34–3.59), 60 years and over (PRb = 2.78; 95% CI 2.24–3.46); regions: Northeast (PRb = 1.22; 95% CI 1.08–1.38) and South (PRb = 1.23; 95% CI 1.05–1.45); overweight (PRb = 1.53; 95% CI 1.34–1.75) and obesity (PRb = 1.69; 95% CI 1.45–1.96); arterial hypertension (PRb = 1.34; 95% CI 1.18–1.51), kidney failure (PRb = 1.24; 95% CI 1.01–1.51) and diabetes (PRb = 1.38; 95% CI 1.18–1.61); self-rated fair (PRb = 1.33; 95% CI 1.18–1.50) and very poor/poor health (PRb = 1.47; 95% CI 1.22–1.76). The other variables such as consumption of fatty red meat ($p = 0.433$), light/moderate alcoholic beverage consumption ($p = 0.501$) and alcohol abuse ($p = 0.154$), and tobacco use ($p = 0.218$) were not significant.

In model 2, in the analysis adjusted for gender, schooling, skin color, and region, all associations found in model 1 were maintained, except for kidney failure (PR_{adj}^a = 1.11; 95% CI 0.91–1.37) and South region (PR_{adj}^a = 1.21; CI95% 0.94–1.33), which lost statistical significance.

Table 3 shows model 3. In the multivariate regression analysis, some of the variables lost statistical significance when analyzed together and were not included in the final model. The factors associated with increased LDL-cholesterol were anemia, protective concerning the outcome (PR_{adj}^b = 0.66; 95% CI 0.54–0.80); and among the risk factors, the following remained: increasing age 30–44 years PR_{adj}^b = 1.99 (95% CI 1.58–2.54), 45–59 years PR_{adj}^b = 2.89 (95% CI 2.29–3.64), 60 years and over PR_{adj}^b = 2.90 (95% CI 2.29–3.68), Northeast region (PR_{adj}^b = 1.16; 95% CI 1.02–1.32), overweight (PR_{adj}^b = 1.32; 95% CI 1.15–1.51), and obesity (PR_{adj}^b = 1.41; 95% CI 1.19–1.65).

Discussion

LDL-cholesterol measured by laboratory analysis in the PNS was elevated in one-fifth of the Brazilian adult population. In model 2, factors associated with increased LDL-cholesterol were female, age group above 30 years, schooling, black and brown skin color, Northeast region, altered BMI, arterial hypertension, diabetes, and anemia. In the final model, the factors associated with the outcome were age over 30, overweight and obesity, living in the Northeast, and anemia. In this study, the factors associated with increased LDL-cholesterol are in agreement with the literature^{15,19–21,37}.

This study's limitations were the impossibility of attesting a causal relationship and the possibility of reverse causality. On the one hand, we were unable to attest to the causal relationship between the variables examined due to the study's cross-sectional nature. Because the outcome and its causes are analyzed in a single moment, the associations described here may result from lifestyle changes and other changes regarding treatment. On the other hand, it is worth mentioning the possibility of reverse causality between the NCDs studied here and high LDL-cholesterol. Thus, these results should be interpreted with caution. However, to control this bias, the methodological analyses were carried out critically, and we attempted to control this situation using a multivariate model, following the hierarchy of causal determination blocks based on the scientific literature^{15,16,19–22,37}.

High LDL-cholesterol in adults over 30 years of age identified in this research can be explained by the lipid changes resulting from the gradual aging process, as likelihood increases with age.

Table 1. Prevalence of LDL-cholesterol optimal (< 130 mg/dL) and increased (\geq 130 mg/dL) thresholds, and 95% CI in adults (\geq 18 years), according to sociodemographic, anthropometric, lifestyle, chronic noncommunicable diseases, and self-rated health. National Health Survey, Brazil, 2014-2015.

LDL-cholesterol Variables	n*	Optimal threshold		High threshold	
		%	95% CI	%	95% CI
Total	8,534	81.42	80.34-82.45	18.58	17.55-19.66
Gender	8,534				
Male		82.87	81.24-84.38	17.13	15.62-18.76
Female		80.13	78.67-81.52	19.87	18.48-21.33
Age group in years	8,534				
18-29		91.19	89.33-92.75	8.81	7.25-10.67
30-44		82.45	80.43-84.30	17.55	15.70-19.55
45-59		74.45	72.10-76.67	25.55	23.33-27.90
60 years and over		75.49	72.97-77.84	24.51	22.16-27.03
Schooling	8,534				
Illiterate/Elementary incomplete		78.47	76.83-80.03	21.53	19.97-23.17
Elementary complete/High school incomplete		83.14	80.28-85.66	16.86	14.34-19.72
High school complete and over		83.34	81.64-84.91	16.66	15.10-18.36
Skin color	8,532				
White and other		80.06	78.32-81.69	19.94	18.31-21.68
Black and brown		82.74	81.41-83.99	17.26	16.01-18.59
Region	8,534				
North		83.78	82.08-85.34	16.22	14.66-17.92
Northeast		80.21	78.71-81.63	19.79	18.37-21.29
Southeast		82.13	80.05-84.04	17.87	15.96-19.95
South		79.98	77.36-82.37	20.02	17.63-22.64
Midwest		82.23	79.5-84.59	17.77	15.41-20.41
Body Mass Index	8,441				
Underweight/normal		86.19	84.69-87.57	13.81	12.43-15.31
Overweight		78.90	77.04-80.66	21.10	19.34-22.96
Obesity		76.70	74.07-79.14	23.30	20.86-25.93
Fatty red meat consumption	8,054				
Yes		82.03	79.93-83.96	17.97	16.04-20.07
No		81.06	79.73-82.33	18.94	17.60-20.27
Alcoholic beverage consumption	8,534				
Light/moderate		82.05	79.26-84.54	17.95	15.46-20.74
Abuse		84.16	79.99-87.59	15.84	12.41-20.01
No		81.04	79.80-82.21	18.96	17.79-20.20

it continues

Aging mechanisms affect tissues and organs, resulting in changes in the hepatic endothelium, increased insulin resistance, decreased androgen in men and hormones in women resulting from menopause and post-climacteric phase³⁸. Similar results were also found in other studies in Brazil^{23,43} and other countries, such as China⁴⁴ and the U.S.⁴⁵.

The population with altered BMI had a higher prevalence of increased LDL-cholesterol, and these data confirm that overweight and obesity,

especially abdominal adiposity, contribute to the occurrence of dyslipidemia³⁹. Insulin resistance is the most common metabolic disorder in obesity. It is related to increased cholesterol because of elevated levels of free fatty acids (FFA), which culminates in reducing the degradation of ApoB100, which is the main component of very-low-density lipoproteins (VLDL) and greater hepatic secretion of VLDL. As a result, TG increase (their excess is secreted as VLDL), leading to hypertriglyceridemia. Also, VLDL metabolizes into small,

Table 1. Prevalence of LDL-cholesterol optimal (< 130 mg/dL) and increased (\geq 130 mg/dL) thresholds, and 95% CI in adults (\geq 18 years), according to sociodemographic, anthropometric, lifestyle, chronic noncommunicable diseases, and self-rated health. National Health Survey, Brazil, 2014-2015.

LDL-cholesterol Variables	n*	Optimal threshold		High threshold	
		%	95% CI	%	95% CI
Tobacco use	8,527				
Yes		79.75	76.60-82.58	20.25	17.42-23.40
No		81.69	80.53-82.79	18.31	17.21-19.47
Anemia	7,917				
Yes		86.71	84.06-88.97	13.29	11.03-15.94
No		80.62	79.40-81.79	19.38	18.21-20.60
Arterial hypertension	8,157				
Yes		76.73	74.35-78.96	23.27	21.04-25.65
No		82.61	81.35-83.80	17.39	16.20-18.65
Kidney failure	8,534				
Yes		77.33	72.71-81.36	22.67	18.64-27.29
No		81.66	80.55-82.73	18.34	17.27-19.45
Diabetes	8,306				
Yes		75.28	71.53-78.68	24.72	21.32-28.47
No		82.03	80.88-83.12	17.97	16.88-19.12
Self-rated health	8,527				
Very good/good		83.46	82.12-84.73	16.54	15.27-17.88
Fair		77.95	75.90-79.87	22.05	20.13-24.10
Very poor/poor		75.76	71.47-79.59	24.24	20.41-28.53

* The total sample value is 8,534 participants, but missing data has not been presented. 95% CI confidence interval.

dense LDL-cholesterol particles, generating its accumulation³⁹.

Living in the Northeast Region was a risk factor for increased LDL-cholesterol. A possible explanation for this would be the care gaps evidenced by the lower prevalence of medical visits reported in the last 12 months, which contributes to underdiagnosis and late treatment, especially in the Northeast and North regions, when compared to other regions⁴⁶. Another hypothesis is the increase in risk factors, such as obesity, which has shown a growing trend in the last 11 years⁴⁷. While PNS data show improvements and advances in access and use of health services, regional gaps are still observed in the country⁴⁶. All explanations lack empirical and theoretical evidence and must be further investigated.

Individuals with anemia had a lower prevalence of high LDL-cholesterol. Low plasma cholesterol values are described in several types of acquired and hereditary anemias (megaloblastic, iron deficiency, aplastic, associated with liver disease, hereditary spherocytosis, sickle cell, and thalassemia)⁴⁰, which is due to the greater use of plasma cholesterol, determined by the renewal

of erythrocyte lipids in cases of lower survival or increased hemolysis and the more significant dilution of serum cholesterol due to the increase in plasma volume secondary to low hematocrit and hemoglobin values⁴⁰. In sickle cell anemia and thalassemia, the hepatic dysfunction reduces endogenous cholesterol production and increases the lipid profile changes in patients with low TC, LDL, and HDL levels⁴⁰.

The female gender was a risk factor in the bivariate and adjusted analyses. The difference between gender and the prevalence of dyslipidemia is not well established in the literature¹⁹. However, the high prevalence of dyslipidemia in women during menopause⁴⁸ and post-climacteric phase⁸ has been documented, probably due to the loss of hormonal protection in these life stages⁴⁹.

Black and brown skin color was a protective factor in the bivariate and adjusted analyses, in agreement with the ELSA-Brasil study results and other research conducted in the U.S.^{50,51}, which indicated a lower prevalence of dyslipidemia among blacks⁵². A possible reason for this finding can be that socioeconomic status, dietary pattern, and other environmental factors vary wide-

Table 2. Factors associated with high LDL-cholesterol (≥ 130 mg / dL) in adults ≥ 18 years old, crude (regression model 1) and adjusted (regression model 2) prevalence and their respective 95% CI, according to the variables selected. National Health Survey, Brazil, 2014-2015.

Variables	PRcru	95%CI	p	PRadj ^a	95%CI	p
Gender						
Male	1			1		
Female	1.16	1.03–1.30	0.013	1.16	1.03–1.30	0.011
Age group in years						
18-29	1			1		
30-44	1.99	1.60–2.49	< 0.01	1.98	1.58–2.48	< 0.01
45-59	2.90	2.34–3.59	< 0.01	2.87	2.31–3.56	< 0.01
60 years and over	2.78	2.24–3.46	< 0.01	2.72	2.17–3.41	< 0.01
Schooling						
Illiterate/Elementary incomplete	1			1		
Elementary complete/High school incomplete	0.78	0.66–0.93	0.006	0.78	0.66–0.93	0.007
High school complete and over	0.77	0.68–0.88	< 0.01	0.75	0.66–0.85	< 0.01
Ethnicity/skin color						
White and other	1			1		
Black and brown	0.87	0.77–0.97	0.012	0.82	0.73–0.93	0.003
Region						
North	1			1		
Northeast	1.22	1.08–1.38	0.002	1.18	1.05–1.34	0.007
Southeast	1.10	0.95–1.28	0.208	1.05	0.90–1.22	0.49
South	1.23	1.05–1.45	0.01	1.12	0.94–1.33	0.199
Midwest	1.09	0.92–1.30	0.3	1.07	0.90–1.27	0.412
Body Mass Index						
Underweight/normal	1			1		
Overweight	1.53	1.34–1.75	< 0.01	1.51	1.32–1.73	< 0.01
Obesity	1.69	1.45–1.96	< 0.01	1.63	1.41–1.91	< 0.01
Fatty red meat consumption						
No	1			1		
Yes	0.95	0.83–1.08	0.433	0.97	0.85–1.11	0.688
Alcoholic beverage consumption						
No	1			1		
Light/moderate	0.95	0.81–1.11	0.501	1.01	0.86–1.19	0.897
Abuse	0.84	0.65–1.07	0.154	0.87	0.70–1.12	0.291
Tobacco use						
No	1			1		
Yes	1.10	0.94–1.29	0.218	1.09	0.92–1.28	0.282
Anemia						
No	1			1		
Yes	0.69	0.56–0.83	< 0.01	0.66	0.54–0.80	< 0.01
Arterial hypertension						
No	1			1		
Yes	1.34	1.18–1.51	< 0.01	1.25	1.10–1.42	< 0.01
Kidney failure						
No	1			1		
Yes	1.24	1.01–1.51	0.037	1.11	0.91–1.37	0.287
Diabetes						
No	1			1		
Yes	1.38	1.18–1.61	< 0.01	1.29	1.10–1.50	0.001

it continues

Table 2. Factors associated with high LDL-cholesterol (≥ 130 mg / dL) in adults ≥ 18 years old, crude (regression model 1) and adjusted (regression model 2) prevalence and their respective 95% CI, according to the variables selected. National Health Survey, Brazil, 2014-2015.

Variables	PRcru	95%CI	p	PRadj ^a	95%CI	p
Self-rated health						
Very good/good	1			1		
Fair	1.33	1.18–1.50	< 0.01	1.26	1.11–1.43	< 0.01
Very poor/poor	1.47	1.22–1.76	< 0.01	1.32	1.09–1.60	0.004

PRcru: Crude prevalence ratio (regression model 1); PRadj^a: Adjusted prevalence ratio (regression model 2) adjusted by gender, schooling, skin color, and region; 95%CI: 95% confidence interval

Table 3. Factors associated with high LDL-cholesterol (≥ 130 mg/dL) in adults ≥ 18 years old, adjusted prevalence ratio (regression model 3) and their respective 95% CI, according to the selected variables. National Health Survey, Brazil, 2014-2015.

Variable	PR _{adj} ^b	95%CI	p
Gender			
Male	1		
Female	1.08	0.96–1.22	0.177
Age group in years			
18-29	1		
30-44	1.99	1.58–2.54	< 0.01
45-59	2.89	2.29–3.64	< 0.01
60 years and over	2.90	2.29–3.68	< 0.01
Region			
North	1		
Northeast	1.16	1.02–1.32	0.028
Southeast	0.94	0.80–1.10	0.474
South	1.06	0.89–1.25	0.5
Midwest	0.97	0.82–1.16	0.762
Body Mass Index			
Underweight/normal	1		
Overweight	1.32	1.15–1.51	< 0.01
Obesity	1.41	1.19–1.65	< 0.01
Anemia			
No	1		
Yes	0.66	0.54–0.80	< 0.01

PR_{adj}^b: Adjusted prevalence ratio (regression model 3/final model) adjusted by all the explanatory variables with a p-value < 0.20 in the bivariate analysis (PR_b); 95%CI: 95% Confidence Interval.

ly by ethnicity⁵¹. However, additional research is required to explore the theme in Brazil further.

As for education, the bivariate and adjusted analyses showed that individuals with less education had a higher prevalence of increased

LDL-cholesterol. We emphasize that cardiovascular risk factors are more prevalent among individuals with low socioeconomic status, including schooling, which may be due to higher access to health services and promotion practices in a highly-educated population⁵³.

Diseases such as high blood pressure and diabetes were risk factors for LDL-cholesterol but lost statistical significance in the final model due to age adjustment. It is noteworthy that these variables are more frequent among older adults, which could justify these results. It is also worth noting that the NCDs studied here are associated with higher LDL levels due to the pathophysiological mechanisms of these diseases^{8,41,42}.

The relationship between NCDs and dyslipidemia is documented, as is that these diseases are at increased risk for atherosclerotic CVD^{8,41,42}. In kidney failure, lipoprotein metabolism changes occur due to inadequate enzyme activity and metabolic pathways that result in dyslipidemia⁴¹. Dyslipidemia is a common metabolic abnormality in diabetes due to factors such as insulin deficiency or resistance, adipocytokines, and hyperglycemia, which, when chronic, results in a more significant accumulation of dense LDL particles⁴². In hypertension, aggression to the vascular endothelium causes endothelial dysfunction, culminating in increased permeability of plasma lipoproteins, favoring the retention of LDL particles⁸.

In the lifestyle block, none of the variables remained in models 2 and 3. However, the evidence for the importance of dietary patterns and adopting a healthy lifestyle as control and prevention measures for dyslipidemia is well established^{8,54,55}. It is recommended to reduce sugars and include lean meats, fruits, grains, and vegetables in the diet⁸. Physical exercise reduces cardiovascular morbimortality by improving HDL functioning, increasing resistance to LDL oxidation, and in-

creasing the flow of cholesterol⁸. The consumption of alcoholic beverages is not recommended for individuals with hypertriglyceridemia due to the combination of ethanol and saturated fatty acids, potentiating the increase in TG⁸ levels.

On the other hand, moderate alcohol consumption (acceptable consumption $\leq 10\text{g/day} - 1$ unit) increases HDL's plasma concentration, curbs LDL concentrations, and is associated with reduced CVD risk⁵⁵. Concerning tobacco use, smoking harms the arterial endothelium and increases the levels of TC and LDL, decreasing HDL. Thus, smoking cessation is beneficial at any life stage^{8,55}.

The data from this study also point to the relevance of self-rated health. This variable is a predictor of morbimortality² and, thus, should be studied. The results presented here were similar to the PNS data survey, which showed a strong

association between self-assessment and dyslipidemia for those who had a poor self-rated health status¹⁹.

High LDL-cholesterol in the Brazilian population is associated with aging, overweight, obesity, living in the Northeast, and anemia. These data reinforce the importance of monitoring the lipid profile in adults – due to elevated LDL levels, because of aging and changes in BMI – and the diagnosis in places with lower access by the Brazilian population. Also, Brazil has regional, cultural, and socioeconomic differences. Thus, it is essential to know these characteristics to identify and address health inequities. Moreover, this study reinforces the importance of actions for the control and prevention of dyslipidemia, such as adopting measures of healthy lifestyles, which include diet and maintenance of BMI within the recommended levels in Brazilian adults.

Collaborations

ACMGN Sá participated in the study design, planning, design, statistical analysis, data interpretation, paper drafting, prepared the first version of the manuscript, and approved the version to be published. IE Machado participated in the planning, statistical analysis, and critical review of the paper. RTI Bernal participated in statistical analysis and data interpretation. DC Malta participated in designing and planning the PNS laboratory study, design, data interpretation, critical review, and approved the final version of the manuscript.

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