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Prevalence of the Metabolic Syndrome and its components in the Brazilian adult population

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Abstract *We estimated the prevalence of the Metabolic Syndrome (MetS) and its components in the Brazilian population according to sociodemographic factors. This is a cross-sectional population-based study that used laboratory data from the National Health Survey. We estimated the prevalence of MetS and its components with 95% confidence intervals and the unadjusted and adjusted prevalence ratio (PR) with the Poisson regression. MetS prevalence ratio was 38.4%. High waist circumference (WC) (65.5%) and low HDL cholesterol (49.4%) were the most prevalent components, including in the youngest people. MetS and its components were more frequent among women (41.8%), individuals with low schooling (47.5%), and older adults (66.1%). In the adjusted analysis, females (PR = 1.16; 95% CI 1.08-1.24), older adults (PR = 3.69; 95% CI 3.26-4.17), and low schooling (PR = 1.32; 95% CI 1.17-1.49) were associated with MetS. MetS was prevalent in the Brazilian population, especially among women, individuals with low schooling, and older adults. High WC and low HDL cholesterol were the most prevalent components, with the aggravating high prevalence factor in young adults. These findings reveal the need to consider laboratory data for a more accurate analysis of this condition, which can be challenging at the national level.*

Key words *Metabolic syndrome, Waist circumference, Dyslipidemias, Risk factors, Chronic disease*

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Introduction

Metabolic Syndrome (MetS) is characterized by complex metabolic changes and has been widely studied worldwide for its adverse repercussions on individual health and its strong association with cardiovascular diseases[1] and type 2 diabetes[1,2]. It involves the aggregation of arterial hypertension, abdominal obesity, dyslipidemia, and impaired glucose metabolism[3]. In general, studies estimate the prevalence of MetS from the consensus defined by the Adult Treatment Panel III (ATP III)[4], although a recommendation for standardized criteria and better comparison of studies[3] is already in place.

The MetS phenotype enables easy identification of individuals at risk for NCDs[5,6], which are the leading cause of the Brazilian population's morbimortality, responsible for 76% of deaths in 2017 in the country[7]. Also, the risk of MetS-related adverse outcomes is known to be synergistically higher than if its component factors are estimated separately[6].

A MetS prevalence of 29.6%[6] was recorded in the Brazilian adult population, reaching more than 40% in the age groups older than 60 years[8]. A Brazilian cohort also showed a MetS prevalence of 44%[9]. The lowest prevalence (9%) was estimated in a survey with national representativeness, well below that observed in most publications[10].

Some of the components were self-reported in these studies, leading to an underestimated prevalence of MetS and its components[10,11]. Measuring blood pressure, waist circumference (WC), and three other factors (triglycerides, HDL cholesterol, and fasting glucose) requires direct measurements to obtain more accurate and reliable estimates. Studies with direct measures were only carried out in restricted populations and small samples with or without random sampling[8,12]. Another relevant aspect found was that population subgroups that were more vulnerable from the sociodemographic viewpoint and with inadequate lifestyles had higher MetS[10,11,13].

Obtaining more reliable estimates of the prevalence of MetS in the Brazilian adult population depends on the use of biochemical and anthropometric data with national representation. However, few population studies use these types of data. Besides the scarcity of studies, we note the use of different criteria to define MetS in the scientific literature, hindering comparability between different populations.

Another aspect to be considered in this context is the high estimated global burden of NCDs in the country[14], which requires measuring the magnitude of MetS and its distribution according to sociodemographic factors, such as gender, age, schooling, and household situation, to assess possible inequalities in this condition. Thus, this study aimed to estimate MetS prevalence in the Brazilian population according to sociodemographic factors, using a consensus standardized by several committees and accepted internationally[3].

Methods

Design and study population

This is an analytical cross-sectional study that used data from the 2013 National Health Survey (PNS), including data on laboratory tests collected between 2014 and 2015. The National Health Survey carried out in 2013 was a nationwide home-based survey developed in a partnership between the Ministry of Health, the Oswaldo Cruz Foundation (Fiocruz), and the Brazilian Institute of Geography and Statistics (IBGE). The PNS sample was selected by clusters in three stages through simple random sampling: census tracts, a fixed number of private households, and a resident aged 18 years or older were selected for each household, with an equiprobability of selection among individuals residing in the same household, to answer the individual questionnaire[15,16]. A total of 81,167 households was visited, of which 69,994 had residents[16]. In all, 64,348 household interviews and 60,202 individual interviews with the selected household residents[16,17] were conducted.

A subsample of 25% of the census sectors surveyed was planned to collect biological material from the residents selected in the third stage of the PNS. In this study, it consisted of 8,952 people. This sample included post-stratification weights by gender, age, schooling, and region to obtain population estimates and establish representativeness of the Brazilian adult population[17].

Data collection

In 2013, the selected adults were informed about blood and urine collection and measurements. In the first phase, weight, height, blood pressure, WC were measured for all subjects selected for individual interviews. In 2014 and 2015, a new visit was made to the participants' homes selected for the collection of biological material. The biological material was collected

by employees of partner laboratories of the Ministry of Health, accredited in the context of the Proadi-SUS (Support Program for Institutional Development of the Unified Health System)[17].

Study variables

MetS prevalence was estimated by the simultaneous presence of at least three of the five factors defined based on an international committee's criteria[3]. HDL cholesterol <50mg/dl female / < 40mg/dl male; blood pressure ≥ 130/85 mmHg, WC ≥80cm female/ ≥ 90cm male[3] were considered. In this study, instead of fasting blood glucose, we used the values of glycated hemoglobin ≥ 5.6 mmol/L[18], and total cholesterol ≥ 200 mg/dl, replacing triglycerides[4], since fasting was not required to perform PNS laboratory collection, a necessary condition for serum fasting glucose and triglyceride levels. Besides the diagnosis of MetS, these components and their simultaneous occurrence were analyzed individually.

Blood pressure

The most appropriate cuff was used for blood pressure measurement, according to the individual's left arm circumference, by measuring the midpoint between the acromion and olecranon bones[19]. A digital device routinely calibrated (G-TECH model MA 100) was employed. Measurements were carried out with individuals at rest, who had not smoked or ingested any drink, except water, in the 30 minutes before the measurement, and had not performed any physical activity during one hour before the measurement. Also, individuals were asked to empty their bladder before measurement. BP measurements were taken with the subjects in a seated position after resting for at least five minutes. The subjects were instructed to remain relaxed and supported against the back of the chair, without crossing their legs and leaving their left arm bare and supported at their chest or heart level. Three BP measurements were performed with two-minute intervals[19].

Waist circumference

WC was measured at the midpoint between the last rib and the iliac crest with a measuring tape, with no clothing around the waist. The respondent remained with arms flexed and crossed in front of the chest, feet apart, and abdomen relaxed. The respondent was asked to inhale and release the air from the lungs, remaining so until the measurement was taken[19].

Blood collection

Blood collection was performed according to the Brazilian Society of Clinical Pathology Laboratory Medicine recommendations for collecting venous blood, whose technique is available on the research website on the biological material collection page[20]. Peripheral blood was collected at any time of the day, without fasting[17]. Glycated hemoglobin was determined using high-performance liquid chromatography (HPLC) of a sample collected in a tube containing ethylenediaminetetraacetic acid (EDTA). Samples for analysis of total cholesterol and fractions were collected in serum gel tubes, waiting 30 minutes for clot retraction and subsequent centrifugation. An automated colorimetric enzymatic method performed the evaluation.

Data analysis

The prevalence of MetS and its components was estimated according to sociodemographic characteristics, and 95% confidence intervals were calculated. The sociodemographic variables were gender (male and female), age (18-39, 40-59, and 60 and over), schooling in years of study (12 or more, 9-11, and 0-8), ethnicity/skin color (white, yellow/indigenous, and black/brown) and place of residence (urban and rural). MetS prevalence ratio unadjusted and adjusted by sociodemographic variables was estimated using Poisson regression[21]. All analyses were performed using the Stata 14.0 statistical program, Survey module, considering the sample weight for population estimates.

Ethical aspects

The PNS was approved by the National Research Ethics Committee of the National Health Council, Ministry of Health[16]. Adult participation in the research was voluntary, and the confidentiality of information was assured. The individuals selected for the research provided informed consent for all research procedures, including interviews and blood and urine collection[17].

Results

The mean age of the studied population was 45.6 years (95% CI 45.1-46.0), with 52.9% (95% CI 51.5-54.3) females, 49.3% (95% CI % 47.9-50.7) reported 0-8 years of study, followed by 33.8% (95% CI 32.5-35.2) with 9-11 years of study, and

21.0% (95% CI 19.9-22.1) lived in rural areas.

Table 1 shows the prevalence of the components individually, the number of simultaneous factors, and the MetS by gender. MetS prevalence in the Brazilian population was 38.4% (95% CI 37.0-39.8). More than 70% of women had high WC (74.1%; 95% CI 72.4-75.7), and more than half had low HDL cholesterol (55.2%; 95% CI 53.4-57.1). These prevalence levels were higher than those found for men with elevated WC (56.0%; 95% CI 53.8-58.2) and low HDL cholesterol (42.9%; 95% CI 40.7-45.1). Women also had a higher prevalence of hypercholesterolemia and glycated hemoglobin ≥ 5.6 mmol/L. There was no difference in the prevalence of blood pressure ≥ 130/85 mmHg by gender. Women had a higher MetS prevalence (PR = 1.20 95% CI 1.12-1.30) than men (Figure 1). Women had a higher MetS prevalence (PR = 1.16 95% CI 1.08-1.24) than men, even after adjusting for gender, age, schooling, ethnicity/skin color, and place of residence (Figure 1).

When analyzing MetS prevalence by age, we observed that the older the age, the greater the prevalence of MetS: 18-39 years (16.7%; 95% CI 15.0-18.6), 40-59 years (45.7%; 95% CI 43.5-48.0), 60 years or older (66.1%; 95% CI 63.5-68.6) (Table 2). The PR among individuals aged 40-59 years and 60 years and over was 2.73 (95% CI 2.42-3.08) and 3.95 (95% CI 3.52-4.44) compared to younger individuals (18-39 years), respectively. After adjustments, this relationship remained with little attenuation (Figure 1).

We observed that the lower the level of education, the higher the prevalence of MetS components. The prevalence of pressure values ≥ 130/85mmHg was almost twice in individuals with 0-8 years of study (41.9%; 95% CI 40.1-43.7) compared to those with 9-11 years (23.7%; 95% CI 21.7-25.9) and 12 years and over (21.4%; 95% CI 18.6-24.4). The less educated group had a higher MetS prevalence (47.5%; 95% CI 45.6-49.4), followed by 9-11 years (30.6%; 95% CI 28.3-33.1) and 12 years and over (27.4%; 95% CI 24.3-30.7) (Table 3). People with less schooling (0-8 years of study) had almost twice the prevalence of MetS than those with more schooling (12 years of study and over) (PR=1.73; 95% CI 1.53-1.96). In the fully adjusted model, this relationship remained at around 30% higher occurrence (PR = 1.32; 95% CI 1.17-1.49) (Figure 1).

Regarding ethnicity/skin color, no significant difference was noted in the prevalence of MetS among white 39.7% (95% CI 37.5-41.9), black/brown 37.3% (95% CI 35.5-39.0), and yellow/indigenous 31.2% (95% CI 20.8-43.8) (p = 0.6515)

Table 1. Prevalence of individual components, number of simultaneous factors, and diagnosis of the metabolic syndrome in the adult Brazilian population according to gender, PNS 2013, and PNS Laboratory 2014-2015.

MetS components	Total		Gender		P-value[b]
			Female	Male	
	n	%a (95% CI)	%a (95% CI)	%a (95% CI)	
Blood pressure ≥ 130/85 mmHg	8,858	32.3 (31.0-33.6)	31.2 (29.6-32.9)	33.6 (31.6-35.6)	0.076
Waist Circumference ≥ 80cm female / ≥ 90cm male	8,854	65.5 (64.1-66.9)	74.1 (72.4-75.7)	56.0 (53.8-58.2)	< 0.0001
HDL cholesterol < 50mg/dl female / < 40mg/dl male	8,512	49.4 (48.0-50.8)	55.2 (53.4-57.1)	42.9 (40.7-45.1)	< 0.0001
Total cholesterol ≥ 200mg/dl	8,526	32.8 (31.5-34.1)	35.1 (33.4-36.9)	30.1 (28.1-32.1)	0.0002
Glycated Hemoglobin ≥ 5.6 mmol/L	8,552	30.0 (28.7-31.3)	31.5 (29.8-33.2)	28.3 (26.4-30.3)	0.017
Number of simultaneous factors	8,199				< 0.0001
0		12.1 (11.1-13.2)	7.6 (6.6-8.7)	17.2 (15.4-19.1)	
1		22.3 (21.1-23.6)	21.3 (19.7-22.9)	23.5 (21.6-25.5)	
2		27.2 (25.9-28.5)	29.4 (27.7-31.1)	24.8 (22.9-26.7)	
3		22.2 (21.1-23.4)	22.9 (21.4-24.5)	21.5 (19.7-23.4)	
4		13.0 (12.1-13.9)	14.5 (13.2-15.8)	11.3 (10.0-12.7)	
5		3.2 (2.8-3.7)	4.4 (3.8-5.2)	1.8 (1.4-2.5)	
Metabolic syndrome	8,199	38.4 (37.0-39.8)	41.8 (40.0-43.6)	34.6 (32.5-36.7)	< 0.0001

[a] Population estimate; [b] Pearson's chi-square test; 95% CI: 95% confidence interval; HDL: High Density Lipoprotein.

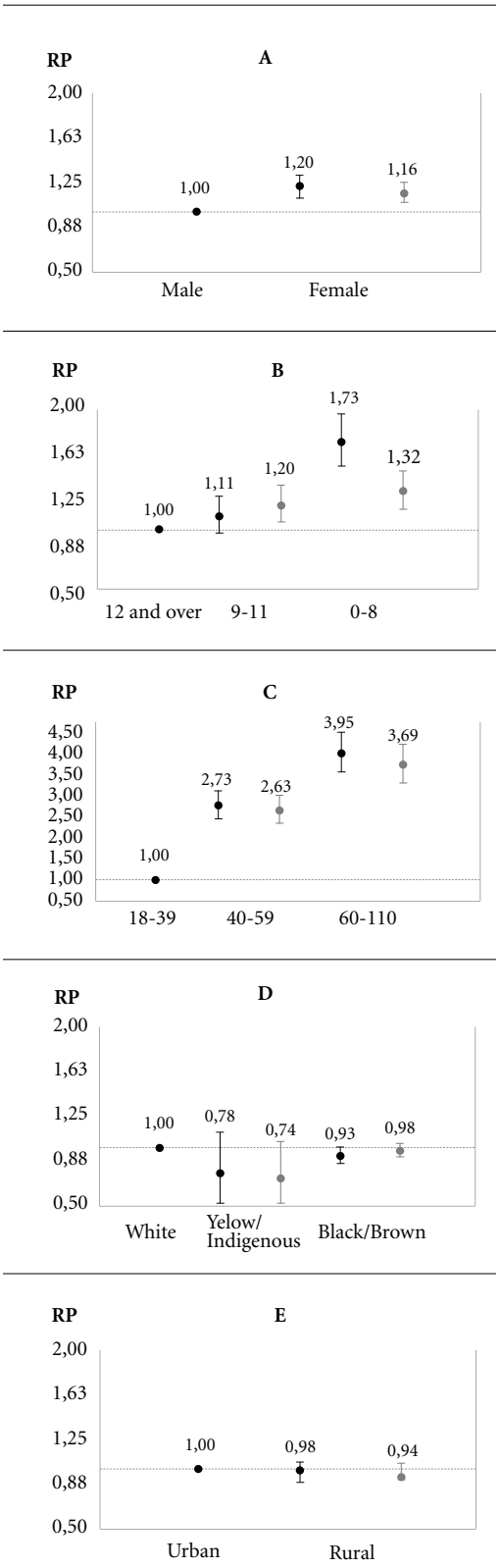

Figure 1. Unadjusted (black) and adjusted (gray) Prevalence Ratio (PR) for Metabolic syndrome according to gender (A), and schooling (B), age (C), ethnicity/skin color (D), and place of residence (E), PNS 2013 and PNS Laboratory 2014-2015.

(Table 4). The same was observed for place of residence, with MetS prevalence of 38.5% (95% CI 37.0-40.1) in the urban area and 37.7% (95% CI 34.9-40.7) in the rural area (data not shown, available on request).

Discussion

In this study, we estimated that one of every three Brazilians has MetS, and this proportion is even higher among women, less educated individuals, and those with more advanced age, even after adjustments for all the sociodemographic variables studied. It is also noteworthy that the most prevalent factor was high WC – significant abdominal obesity and metabolic deterioration marker[22,23], commonly used in population studies[1,11,12], followed by low HDL cholesterol, a significant predictor of cardiovascular risk[4].

MetS prevalence in this study was higher than that found in populations in other Latin American countries, such as in Colombia, Venezuela, Peru, and Mexico[5], and in the Asia-Pacific region[24], and higher than that found in local studies with specific populations at the national level, such as one study with adults in southern Brazil (24.3%)[25], with the quilombola population (25.8%)[26] and the rural population (14.9%)[13]. Our findings also show a higher magnitude than previous studies with representative samples of the Brazilian population[10,11]. However, our MetS estimate was close to that found by the ELSA study (44%)[9] and by the consensus on harmonizing MetS components (35% and 40%)[9].

The differences found could be justified by the different methods used to define MetS[27], but mainly by using measured and self-reported data to estimate the underpinning MetS factors. Self-reported data are knowingly subject to underestimating the prevalence of the MetS underlying biochemical factors and, consequently, of MetS itself, which could explain the proximity of our findings to those of the ELSA study, which also used biochemical data to assess the phenotype.

A relevant aspect to be highlighted in this study was the collection of biological material with national representation. We believe it is a significant advance for health assessment at the national level since many metabolic disorders have a prolonged sub-clinical phase, and delayed diagnoses can be inconvenient in preventing more severe events. For example, it is noteworthy that dyslipidemias underpinning MetS are

Table 2. Prevalence of individual components, number of simultaneous factors, and diagnosis of the metabolic syndrome in the Brazilian adult population according to age group, PNS 2013, and PNS Laboratory 2014-2015.

MetS components	Age (in years)			P-value[b]
	18-39	40-59	60-110	
	%a (95% CI)	%a (95% CI)	%a (95% CI)	
Blood pressure ≥ 130/85 mmHg	11.7 (10.2-13.4)	38.7 (36.6-41.0)	60.6 (58.0-63.1)	< 0.0001
Waist Circumference ≥ 80cm female / ≥ 90cm male)	50.4 (48.0-52.8)	73.7 (71.7-75.6)	80.4 (78.2-82.4)	< 0.0001
HDL cholesterol <50mg/dl female / <40mg/dl male	47.0 (44.6-49.5)	50.3 (48.1-52.6)	52.3 (49.6-55.0)	0.011
Total cholesterol ≥ 200mg/dl	21.5 (19.7-23.5)	39.7 (37.5-41.9)	42.7 (40.1-45.4)	< 0.0001
Glycated Hemoglobin ≥ 5.6 mmol/L	13.5 (11.9-15.2)	33.0 (30.9-35.1)	56.4 (53.8-59.1)	< 0.0001
Number of simultaneous factors				< 0.0001
0	21.7 (19.6-23.9)	7.4 (6.3-8.8)	2.3 (1.7-3.2)	
1	33.0 (30.7-35.4)	17.4 (15.8-19.2)	10.6 (9.0-12.4)	
2	28.6 (26.4-30.8)	29.4 (27.4-31.5)	21.0 (18.9-23.3)	
3	12.9 (11.3-14.7)	27.1 (25.2-29.2)	31.4 (28.9-34.0)	
4	3.4 (2.7-4.4)	15.1 (13.5-16.8)	27.1 (24.7-29.5)	
5	0.4 (0.2-1.0)	3.5 (2.8-4.4)	7.7 (6.4-9.2)	
Metabolic syndrome	16.7 (15.0-18.6)	45.7 (43.5-48.0)	66.1 (63.5-68.6)	< 0.0001

[a] Population estimate; [b] Pearson's chi-square test; 95% CI: 95% confidence interval; HDL: High Density Lipoprotein.

Table 3. Prevalence of individual components, number of simultaneous factors, and diagnosis of the metabolic syndrome in the Brazilian adult population according to education, PNS 2013 and PNS Laboratory 2014-2015.

MetS components	Schooling (in years)			P-value[b]
	12 and over	9-11	0-8	
	%a (95% CI)	%a (95% CI)	%a (95% CI)	
Blood pressure ≥ 130/85 mmHg	21.4 (18.6-24.4)	23.7 (21.7-25.9)	41.9 (40.1-43.7)	< 0.0001
Waist Circumference ≥ 80cm female / ≥ 90cm male)	64.3 (60.6-67.8)	63.0 (60.4-65.5)	67.2 (65.8-69.4)	0.0122
HDL cholesterol < 50mg/dl female / < 40mg/dl male	42.2 (38.6-45.8)	48.2 (45.6-50.9)	52.7 (50.9-54.6)	< 0.0001
Total cholesterol ≥ 200mg/dl	29.3 (26.1-32.6)	30.3 (28.0-32.7)	35.7 (33.9-37.4)	0.0002
Glycated Hemoglobin ≥ 5.6 mmol/L	21.0 (18.3-24.1)	23.8 (21.7-26.1)	37.3 (35.5-39.1)	< 0.0001
Number of simultaneous factors				< 0.0001
0	16.2 (13.3-19.5)	14.0 (12.1-16.2)	9.4 (8.3-10.7)	
1	26.9 (23.6-30.5)	26.2 (23.9-28.6)	18.1 (16.6-19.6)	
2	29.5 (26.3-33.0)	29.2 (26.9-31.6)	25.0 (23.4-26.7)	
3	18.1 (15.4-21.0)	19.5 (17.5-21.6)	25.6 (24.0-27.3)	
4	8.1 (6.4-10.0)	9.2 (7.8-10.8)	17.3 (15.9-18.7)	
5	1.3 (0.7-2.2)	2.0 (1.4-2.7)	4.8 (4.0-5.5)	
Metabolic syndrome	27.4 (24.3-30.7)	30.6 (28.3-33.1)	47.5 (45.6-49.4)	< 0.0001

[a] Population estimate; [b] Pearson's chi-square test; 95% CI: 95% confidence interval; HDL: High Density Lipoprotein.

related to a higher risk of cardiovascular diseases (CVD), including stroke[28,29]. Studies with laboratory data allow estimating the prevalence of health problems in subclinical stages and populations with less access to health services, and therefore, still without diagnosis and treatment.

Table 4. Prevalence of individual components, number of simultaneous factors, and diagnosis of the metabolic syndrome in the adult Brazilian population according to ethnicity/skin color, PNS 2013, and PNS Laboratório 2014-2015.

MetS components	Ethnicity/Skin color			P-value[b]
	White	Yellow/indigenous	Black/brown	
	%a (95% CI)	%a (95% CI)	%a (95% CI)	
Blood pressure ≥ 130/85 mmHg	34.4 (32.3-36.4)	27.8 (16.9-42.1)	30.5 (28.9-32.2)	0.0123
Waist Circumference ≥ 80cm female / ≥ 90cm male	69.8 (67.7-71.8)	50.0 (37.2-62.9)	61.8 (60.0-63.6)	<0.0001
HDL cholesterol < 50mg/dl female / < 40mg/dl male	48.2 (46.0-50.4)	39.2 (28.0-51.6)	50.7 (48.9-52.6)	0.0591
Total cholesterol ≥ 200mg/dl	33.9 (31.9-36.0)	23.3 (14.8-34.6)	31.8 (30.2-33.5)	0.0780
Glycated Hemoglobin ≥ 5.6 mmol/L	29.3 (27.4-31.3)	35.5 (23.9-49.1)	30.5 (28.9-32.2)	0.4237
Number of simultaneous factors				0.1674
0	11.3 (9.8-13)	18.8 (9.0-35.2)	12.8 (11.5-14.3)	
1	21.6 (19.8-23.6)	24.1 (15.9-34.8)	23.0 (21.4-24.6)	
2	27.4 (25.5-29.5)	25.9 (15.6-39.7)	27.0 (25.4-28.7)	
3	22.3 (20.5-24.2)	24.8 (15.3-37.6)	22.1 (20.7-24.7)	
4	14.1 (12.7-15.6)	6.1 (3.3-11.2)	12.0 (10.9-13.2)	
5	3.3 (2.7-4.1)	0.2 (0.0005-1.2)	3.1 (2.6-3.7)	
Metabolic syndrome	39.7 (37.5-41.9)	31.2 (20.8-43.8)	37.3 (35.5-39.0)	0.1138

[a] Population estimate; [b] Pearson's chi-square test; 95% CI: 95% confidence interval; HDL: High Density Lipoprotein.

For example, recent studies with PNS laboratory data have already shown a high prevalence of chronic renal failure[30] and diabetes[15], compared to self-reported measures.

The most prevalent MetS components were high WC followed by low HDL cholesterol in both genders, but with higher prevalence among women and any age group. High WC measurements are associated with a higher risk for cardiovascular diseases and reliable predictors of excess visceral fat and, therefore, of general obesity[22]. Normal HDL cholesterol levels can promote the efficient transport of excess circulating cholesterol so that its low levels increase cardiovascular risk[31]. Physical activity is one of the main options to increase plasma HDL[32] levels. In women, the proportion of high WC and low HDL could be explained by the reduced estrogen levels with advancing age, which influences dyslipidemia's appearance by reducing liver receptors and a more significant abdominal fat deposition with increased cardiovascular risk[33]. Another possible explanation for low HDL is that women are less physically active than men[34].

Our study also found a higher occurrence of MetS in more advanced age groups, an expected result, since aging is an essential factor of metabolic deterioration and the accumulation of risk factors[2,6,10]. This study allowed observing a high prevalence of two MetS components, high WC, and low HDL levels in the younger group (18-39 years). This scenario predicts that future generations may reach a high prevalence of MetS earlier. The promotion of a healthier lifestyle such as a diet rich in fruits and vegetables and regular physical activity in young people could reduce MetS prevalence by delaying the accumulation of risk factors[32,35]. This finding signals that public policies for the prevention of cardiovascular diseases and diabetes, when there are no established conditions yet, and among women, can achieve better results in coping with cardiovascular diseases and diabetes.

Another relevant aspect of this study was the higher prevalence of MetS among women, corroborating findings from other studies[24,25]. Women had a higher prevalence in four of the five components, except for blood pressure, considered a more prevalent condition among men[36] globally. High blood pressure becomes more frequent after menopause, which can be partially attributed to estrogen's protective hormonal effect during the reproductive phase[36].

Besides the biological changes associated with a higher risk for NCDs, we observed a change in health behaviors among women from the results of recent studies. Incorporating unhealthy lifestyles, such as increased sedentary lifestyle[37] and

unhealthy food consumption[38], is increasingly frequent and is associated with a high prevalence of obesity among women[39]. Also, female social roles, which accumulate domestic responsibilities, and increased working hours, can have a strong influence on the risk of becoming ill[40], especially regarding NCDs, which may be related to the fact that women exceed the already high occurrence of MetS among men[41].

This study evidenced differences in the prevalence of MetS concerning schooling, and individuals with low education had worse metabolic conditions, which could reinforce the explanation that vulnerable people have lower access to quality information and conditions to maintain healthier lifestyle habits such as a diet rich in fruits and vegetables, restricted number of ultra-processed foods, and adequate exercise[42]. The most socially vulnerable people have more frequently shown chronic conditions[43], such as diabetes and hypertension, and their risk factors[44], especially in women[43], and the MetS components included in this study and the metabolic syndrome itself[42,45], corroborating our findings.

Also, the socially vulnerable environment is an essential determinant of these habits and conditions[46]. These findings reinforce the importance of considering these inequalities when promoting health care through public policies since unhealthy behaviors mainly influence the lipid profile and blood glucose of individuals[47].

Our findings may contribute to the consolidation of public policies to address NCDs and their risk factors in providing public health services, which implies meeting social vulnerability and strengthening the SUS and its dearest principles. It also shows the importance of PNS in the monitoring and surveillance of NCDs and their risk factors.

Limitations

A potential limitation of this study refers to using cutoff points for high WC that may not be suitable for Latin American[48] populations, even with its recommendation for international comparability[3]. In a sensitivity analysis, when comparing the prevalence of high WC and MetS using the cutoff points proposed by NCEP[4] with the cutoff points of the consensus used in this study, we observed, with the use of consensus, an increase of 21.8 % in the prevalence of abdominal obesity among women and 33.4% among men, with a total increase of 27.3%, leading to an increase of about 5% in the final prevalence of MetS. In other words, the use of consensus significantly increases the prevalence of high WC but does not impact the prevalence of MetS as much.

In this study, two MetS components were employed to replace the absence of glucose and triglyceride levels, namely, glycated hemoglobin and cholesterol, respectively. Regarding the option for total cholesterol, a sensitivity analysis, measuring MetS without this factor, showed a prevalence slightly lower than that found, of 32.4% (95% CI 31.2-33.7), and another using LDL cholesterol as a substitute for triglycerides showed a MetS prevalence of 38.0% (95% CI 36.7-39.4), very similar to that found. Thus, there were no significant differences in having used either cholesterol. Moreover, studies show that changing lifestyle habits would improve the three fractions (total cholesterol, LDL cholesterol, and triglycerides)[35]. On the other hand, glycated hemoglobin has the advantage of estimating the mean blood glucose concentration in the last 60 to 90 days, unlike fasting glucose or the glucose tolerance test, which are measured at specific times[15,49]. The advantage is the simplicity of the collection and the accuracy of the diagnosis. Both the World Health Organization and the American Diabetes Association (ADA) use this measure to diagnose and monitor MetS[15,49]. Also, the non-fasting collection option prevents losses and facilitates collection on any day and time[17,19].

Conclusion

In this study, MetS was a very prevalent condition in the Brazilian population, and high WC and low HDL cholesterol were the most prevalent component factors, with the aggravation of high property in young adults. Women, individuals with low schooling, and older individuals had an even higher prevalence of MetS. These findings reveal the need to consider laboratory data to obtain more reliable results from this condition, which can be a challenge at the national level. Consolidating and strengthening public policies that promote healthy lifestyles and combat risk factors is essential to address this challenge. It is also noteworthy that this is the first national study using laboratory data representative of the Brazilian population to estimate the prevalence of MetS as a basis for supporting prevention and health promotion programs.

Collaborations

LVA Oliveira supported the study's design, conducted the analysis and interpretation of data, spearheaded the writing of the first version, participated in critical reviews, and prepared the final version. BNS dos Santos participated in analyzing and interpreting data, writing the first version, and critical reviews of the paper. IE Machado, DC Malta, and G Velasquez-Melendez supported the study outline, design, data interpretation, and critical review of the paper. MS Felisbino-Mendes performed the study outline, design, supervised the analysis and interpretation of data, wrote the first version, and contributed to editing and preparing the final version. All authors approved the final version of the manuscript.

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