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Blood pressure in women in the First National Survey of Health and Nutrition of Indigenous Peoples in Brazil

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Abstract *Estimating average blood pressure levels and prevalence of arterial hypertension (AH) and associated factors is essential to monitoring health and planning actions to combat noncommunicable diseases (NCDs) in Indigenous peoples in Brazil. This is a cross-sectional study that investigated average blood pressure levels and prevalence of arterial hypertension in 4,680 Indigenous women (aged 18-49 years), using data from the 1st National Survey of Health and Nutrition of Indigenous Peoples (2008-2009) and associated factors, such as through gamma regression and multilevel logistics. The prevalence of hypertension was 10.7%, varying across macro-regions: North, Northeast, Midwest, and South/Southeast. Women who lived in villages without domestic waste collection and in households without stable income were more likely to have AH. Increasing BMI and age were positively associated with the chances of developing high blood pressure. In the model for DBP, unlike education, the variables stable household income, BMI, and age were positively associated. In the model for SBP, there was a negative association with education, in the medium and high strata of the household goods index and in households with no stable income, and a positive association with the housing indicator, BMI and age.*

Key words *Health of indigenous peoples, Health survey, Women's health, Arterial hypertension*

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Introduction

The health profile of Indigenous peoples in Brazil is only partially known, and it is defined by extreme heterogeneity produced by the sociocultural diversity of those peoples, as well as by exposure to distinctive social and environmental determinants in the different regions where they live, and by the limitations in quality and access to services of health surveillance and health care[1]. Nonetheless, nationally, as well as internationally, it is possible to recognize a general health standard for these peoples, marked by a high burden of morbidity and mortality by infectious diseases and poor nutrition and health care, especially during childhood, concomitantly with the emergence, among both children and adults, of grievances related to environmental contamination and degradation, to abuse of alcohol and other drugs, to violence and to noncommunicable grievances and diseases (NCDs), including arterial hypertension (AH))[2-7].

AH is one of the main causes of morbidity and mortality on a global scale. This grievance is responsible for 8.5 million deaths around the world by stroke, ischemic cardiac disease, as well as other vascular and kidney diseases. In 2019, the global prevalence of AH standardized by age among adults, aged 30 to 79 years, was 32% (95%CI: 30-34) for women and 34% (95%CI: 32-37) for men[8]. In Brazil, nearly 24% of the female population and 17% of the male population had a diagnosis of this condition in 2011[9]; however, these numbers have increased throughout the years, given that the estimates for 2023 are 26.4% and 29.3% for men and women, respectively[10].

Some studies have indicated that AH is an emerging health issue among Indigenous peoples in different parts of the world[5]. In the United States, for instance, after the 1980's, there has been a progressive and heterogeneous growth in the averages of systolic blood pressure (SBP) and diastolic (DBP), as well as in the prevalence of AH among different Indigenous groups, even surpassing, in some cases, the values found for the non-Indigenous population in the same area[11,12].

Studies which investigated pressure levels and prevalence of AH among Indigenous peoples in Brazil, indicate that, in a similar manner, there were low tensional levels and an absence of AH among Indigenous peoples in the 1970s[7], but more recent studies indicate an increase of these issues in several communities, with AH prevalence being higher than 60% in some places[13-18]. The changes observed in the profile of Indigenous health in recent decades have been attributed to historical contact processes with the surrounding society, increased by the opening of new demographic frontiers, and linked to socioeconomic and environmental changes, conflict and loss of traditional land, sociocultural and lifestyle changes, dependency of the regional market, food insecurity, an increase in the consumption of industrialized food, and barriers in access to health care[19-23].

Until the First National Health and Nutrition Survey of Indigenous Peoples (1st NHNSIP) in 2008-2009, financed by the World Bank and led by the Brazilian Association of Collective Health[24], there were no national estimates of the prevalence of different diseases and illnesses affecting Indigenous peoples, at the national and regional level. The estimation of pressure levels and prevalence of AH and associated factors among Indigenous people is a required condition for improving the characterization of the health profile of this population, for following up its tendencies in the next decades, as well as for the planning of healthcare actions and the production of strategies for the prevention and promotion of health[25,26].

The present study aimed to analyze the levels of SBP and DBP, as well as the prevalence of AH and associated factors in a probabilistic, representative sample of Indigenous adult females (aged 18 to 49 years) residing in Indigenous villages in Brazil in four macro-regions – North, Midwest, Northeast, and South/Southeast, using data collected by the 1st NHNSIP[24], and generating new information at a national and regional level regarding the cardiovascular health of Indigenous peoples in Brazil.

Methodology

This study is based on data collected between 2008 and 2009, time of the 1st NIHNIP, which had a representative complex probabilistic sample of adult Indigenous females in reproductive age (14 to 49 years of age) residing in Indigenous villages, from four macro-regions of the country – North, Northeast, Midwest, and South/Southeast. Additional details on the methodology of the 1st NIHNIP have already been published[24].

Blood pressure (BP) of adult women (aged 18 to 49 years) was measured according to *The Seventh Report of the Joint Committee* (JNC 7)[27], following protocols to ensure accuracy, such

as relative rest for 10 minutes, abstinence of tobacco or coffee for at least 30 minutes before the measurements, and reduction of external stimuli, such as people talking and playing; the participants were placed in a sitting position, the tensiometer was installed on the left wrist and kept at heart level. Whenever necessary and possible, the participants removed clothing items, bracelets, or other accessories that could interfere in the precision of the readings. In case of issues preventing measurements on the left wrist, measurements were taken on the right wrist. Such an event only occurred in 1.1% of the measurements, with no divergence between the regions.

Two BP measurements were taken: the first was obtained after the seven initial questions in the interview, and the second took place at the end of the interview, thus ensuring a minimum interval of ten minutes between measurements. The BP value of each participant was defined as the average between the two measurements. The average values were classified based on criteria for AH, as defined by the JNC 7[27]. Therefore, the values classified as normal for Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) were: SBP < 140 mmHg and DBP < 80 mmHg. Values of SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg were classified as AH. Considering the possibility of individuals with an existing AH diagnosis and using antihypertensive medication, who presented normal levels of de SBP and DBP at the time of the interview, we considered the reports of antihypertensive medication use as AH, regardless of the BP measurements. The proportion of cases with missing information regarding use of antihypertensive medication was 0.4% for the entire group of macroregions, with a higher proportion found in the North (1.4%), followed by the Midwest (0.3%) and South/Southeast (0.2%). This situation was not verified in the Northeast.

The main component analysis (MCA) was used to produce the following variables related to socioeconomic life conditions: (a) index of owned goods, based on the quantities of industrialized, durable goods present in each household (the first component explained 19% of the variance, self-value of 3.56); (b) housing conditions index, based on the quality of the floor, walls, roof, availability of electricity and cooking fuel (the first component explains 48.0% of the variance, self-value of 1.44); and (c) sanitation index, based on the availability of a place to defecate, having trash management, having water for human consumption and availability at home of filtered water for drinking (the first component explained 56.5% of the variance, self-value of 0.63). The households received scores based on the sum of the contribution of each item, multiplied by the amount of each item present in the household, and then households were classified according to the tertiles of the general distribution, considering the four macroregions together as one. In each case, the first tertile indicates a lower score for the index, which represents less industrialized, durable goods, less access to materials and living resources produced by the market, and poorer sanitation conditions[20].

The individual variables of the females who participated in this study include age group and years of education. Other variables analyzed in the study were self-explanatory and are presented in the tables.

Statistical analyses

Initially, we conducted the descriptive statistical analysis of SBP and DBP and of the prevalence of AH, stratified by macroregion and for the entire country. We then employed multilevel models with two levels, Village and Region, following a process of selection of variables with a hierarchized approach to investigate associations between these outcomes and the exposure variables of the individual, household, and village dimensions.

To analyze the factors associated with SBP and DBP, whose distributions presented positive asymmetry, multilevel Gamma regression with identity connection function was used. To analyze the factors associated with AH, multilevel logistic regression was applied. The phase of selection of variables to be maintained in the final adjusted model was conducted in a detailed manner, beginning with a crude analysis for the different variable dimensions – village, household, and women. Variables with a p-value below 0.20 were included in the multiple analyses, while the final model maintained those with a significance level (p-value) below 0.05.

Three multiple models were built for each outcome in the study, given that Model 1 exclusively included the variables related to the village (distal); Model 2 included the variables related to village and household (intermediate); and Model 3, which incorporated the variables related to the characteristics of the woman (proximal) into Model 2. It is important to remember that in the models involving SBP and DBP, women who used antihypertensive medication were exclud-

ed. The multilevel approach sought to conduct a broad analysis of the associations between cardiovascular outcomes and different demographic variables, as well as socioeconomic, eating, and nutritional variables, taking into consideration the living context in the villages and the households.

The study was approved by the National Research Ethics Committee (*Comissão Nacional de Ética em Pesquisa* – CONEP) and by the National Indigenous Foundation (*Fundação Nacional do Índio* – FUNAI). In each visited community, the team of researchers had meetings with leaders and other members of the community to present and explain the objectives and procedures of the study. At that time, we made it explicit that the participation of communities, households, and individuals was volunteer. The free and informed terms of consent were obtained through the signatures of leaders and/or other community representatives of the villages that chose to participate in the investigation.

Results

In the present study, 4,680 Indigenous women, aged 18 to 49 years, participated and were evaluated in terms of the cardiovascular outcomes of interest. The values of the median for SBP and DBP were 111.5mmHg and 71.0mmHg, respectively, in the group of Indigenous women in the target age group in Brazil. For SBP, as well as for DBP, it was observed that only the values obtained for women in the North macroregion (SBP:108.0mmHg; DBP: 67.5mmHg) were below the corresponding national Indigenous medians. The highest medians of SBP and DBP were those of the South/Southeast (SBP: 115.5mmHg; DBP:74.0 mmHg) and of the Midwest (SBP:115.0mmHg; DBP:74.5 mmHg), followed by the Northeast (SBP:111.5mmHg; DBP:72.0mmHg). The distributions of SBP and DBP according to macroregions are shown in Figure 1. There are significant differences in the distributions of SBP and DBP values, with higher medians in the Midwest and South/Southeast macroregions, which stand out as the regions with a higher variation between the values measured. Outliers were identified in all of the macroregions.

The prevalence of AH in adult Indigenous women, in reproductive age, in Brazil, was 10.7%. Heterogeneity can be noticed in prevalence according to macroregions, the North being the lowest (4.0%), and the Midwest and the South/Southeast being the highest, which proved to be similar and 4.5-fold higher than the prevalence of the North region (Table 1).

he analysis of the prevalence of AH by age group shows a consistent increase in the proportion of women with AH as age increases, considering the tendency observed in all of the macroregions, although with lower magnitude in the North region. The highest prevalence was found for the age group of 45 to 49 years of age, with macro-regional variation ranging from 11.3%, in the North, to 52.9%, in the South/Southeast. It is striking that the Midwest and South/Southeast macro-regions had a high prevalence (> 20%) even in the age bracket of 30 to 34 years of age (Table 1).

In the crude analysis, we verified the following associations with outcomes of the study, with significance level (p-value) lower than 0.20: the prevalence of AH was associated negatively with the practice of domestic fishing and hunting, education, stable income, and the presence of outside donations, and positively with BMI and age. The SBP and the DBP were negatively associated with collective cattle raising; with an index of owned goods, living conditions and sanitation; and with stable income in the household and education, and positively with BMI and age. Additionally, SBP was positively associated with the presence of outside donations (Table 2).

In the adjusted analysis, the variables which remained negatively associated with the prevalence of AH were domestic gathering of food, stable income, and education. Meanwhile, the positively associated variables were BMI and age. Notably, Indigenous women residing in villages where domestic gathering was not practiced and in households that had no stable income, had chances of having AH, 1.77 and 1.25-fold higher than those of women residing in villages where domestic gathering was practiced and in households with stable income, respectively. The increase in one unit in the values of BMI and age corresponded to an increase of 9% and 11% in the chances of having AH, respectively. By contrast, as the number of years of education increased, a significant gradient, was noticed in terms of a decrease in the chances of having AH, of 24%, 31%, and 68%, respectively, for strata 1 to 4 years, 5 to 9 years, and 10 or more years of study, in comparison to those who were unschooled (Table 3).

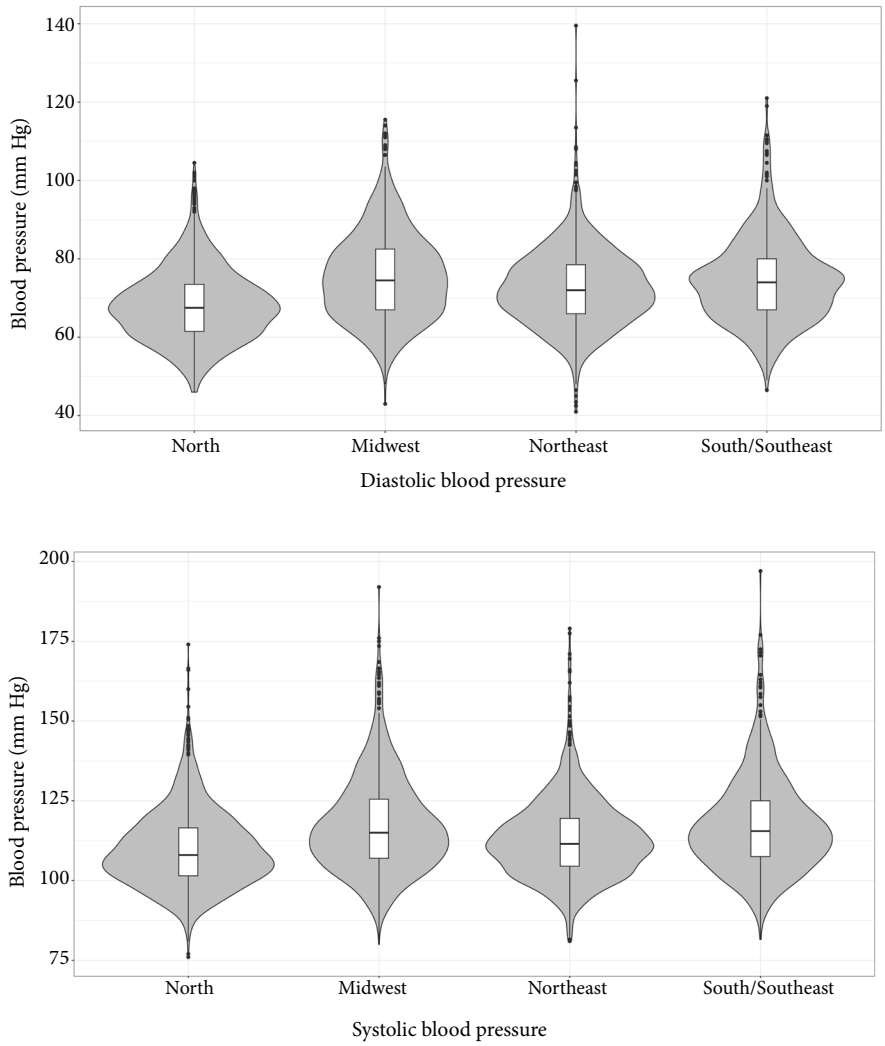

Figure 1. Distribution of diastolic and systolic blood pressure according to macroregion. 1st National Inquiry on Health and Nutrition of Indigenous Peoples, Brazil, 2008-2009.

Source: Authors.

Table 1. Prevalence of arterial hypertension according to age group and macroregion. First National Inquiry on Health and Nutrition of Indigenous Peoples, Brazil, 2008-2009.

	Macroregions									
	North		Midwest		Northeast		South/Southeast		Brazil	
Age	n	%	N	%	n	%	n	%	n	%
18-24	538	2.2	358	3.4	417	3.1	277	3.2	1590	2.9
25-29	346	2.9	195	10.8	272	5.5	144	6.9	957	5.9
30-34	289	4.5	168	20.8	223	6.3	116	22.4	796	11.1
35-39	207	4.8	113	33.6	149	15.4	100	28.0	569	17.4
40-44	147	4.1	84	38.1	109	28.4	84	41.7	424	24.5
45-49	133	11.3	58	46.6	102	39.2	51	52.9	344	31.7
Total	1660	4.0	976	16.9	1272	10.7	772	17.5	4680	10.7

Source: Authors.

Table 2. Prevalence of arterial hypertension, odds ratios, and crude β association coeficientes of AH, SBP and DBP with the characteristics of the village, household, and individual. First National Inquiry on Health and Nutrition of Indigenous Peoples, Brazil, 2008-2009.

Variables	n	%AH	AH		Diastolic blood pressure*		Systolic blood pressure*	
			OR (95%CI)	p-value	β (95%CI)	p-value	β (95%CI)	p-value
Village								
Collective agricultural production								
Local consumption	2761	10.3	1.00		0.00		0.00	
Commerce and local consumption	1875	11.3	1.19 (0.81; 1.75)	0.3660	0.49 (-1.82; 2.80)	0.6770	1.84 (-1.09; 4.77)	0.2190
No production	44	11.4	1.23 (0.28; 5.36)	0.7870	-4.62 (-11.71; 2.46)	0.2010	-5.91 (-15.06; 3.23)	0.2050
Collective cattle raising production								
Local consumption	2764	10.6			0.00		0.00	
Commerce and local consumption	1854	11.2		0.764	0.68 (-1.59; 2.96)	0.5560	0.52 (-2.39; 3.43)	0.7270
No production	62	0.0	**	0.634	-4.44 (-10.30; 1.41)	**0.1370**	-4.65 (-11.37; 2.08)	**0.1750**
Domestic hunting								
Yes	3441	9.9	1.00		0.00		0.00	
No	1239	13.0	1.24 (0.80; 1.93)	0.3390	-0.02 (-3.45; 3.42)	0.9930	0.70 (-3.61; 5.00)	0.7510
Domestic fishing								
Yes	4386	10.1	1.00		0.00		0.00	
No	294	19.4	1.65 (0.90; 3.01)	**0.1030**	2.42 (-1.35; 6.19)	0.2090	1.60 (-3.21; 6.42)	0.5130
Domestic gathering								
Yes	3925	9.1	1.00		0.00		0.00	
No	755	18.9	1.62 (1.02; 2.59)	**0.0427**	0.91 (-2.16; 3.99)	0.5610	0.38 (-3.56; 4.32)	0.8490
Government funds								
Yes	1263	14.2	1.00		0.00		0.00	
No	3417	9.5	0.86 (0.57; 1.30)	0.4840	0.76 (-1.94; 3.47)	0.5790	1.00 (-2.37; 4.37)	0.5610
Community development projects (Project VIGISUS)								
Yes	1473	12.6	1.00		0.00		0.00	
No	3207	9.9	0.88 (0.59; 1.30)	0.5130	-0.23 (-2.93; 2.46)	0.8650	-0.77 (-4.17; 2.62)	0.6550
School lunch for the Indigenous students								
Yes	3872	11.3	1.00		0.00		0.00	
No	808	7.9	0.92 (0.56; 1.52)	0.7460	-0.37 (-3.11; 2.37)	0.7910	-0.27 (-3.92; 3.37)	0.8830
Food Funding Program (PPA)								
Yes	1243	11.3	1.00		0.00		0.00	
No	3437	10.5	1.29 (0.87; 1.92)	0.2080	1.10 (-1.20; 3.41)	0.3480	1.49 (-1.48; 4.47)	0.3250
Support from a religious mission								
Yes	1174	14.1	1.00		0.00		0.00	
No	3506	9.6	0.85 (0.56; 1.30)	0.4540	0.63 (-2.08; 3.34)	0.6490	1.01 (-2.34; 4.36)	0.5560

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Table 2. Prevalence of arterial hypertension, odds ratios, and crude β association coeficientes of AH, SBP and DBP with the characteristics of the village, household, and individual. First National Inquiry on Health and Nutrition of Indigenous Peoples, Brazil, 2008-2009.

Variables	n	%AH	AH		Diastolic blood pressure*		Systolic blood pressure*	
			OR (95%CI)	p-value	β (95%CI)	p-value	β (95%CI)	p-value
Support from NGOs								
Yes	656	10.1	1.00		0.00		0.00	
No	4024	10.8	0.87 (0.54; 1.42)	0.5840	1.1 (-1.64; 3.84)	0.4320	1.27 (-2.30; 4.84)	0.4850
Household								
Index of owned household goods								
1st tertile	1502	9.3	1.00		0.00		0.00	
2nd tertile	1531	11.6	1.06 (0.82; 1.36)	0.6650	-0.59 (-1.34; 0.15)	**0.1195**	-1.33 (-2.31; -0.35)	**0.0079**
3rd tertile	1647	11.3	0.88 (0.67; 1.16)	0.2630	-1.01 (-1.84; -0.18)	**0.0175**	-1.94 (-3.03; -0.84)	**0.0005**
Stable household income								
Yes	2215	8.6	1.00		0.00		0.00	
No	2465	12.6	1.48 (1.21; 1.80)	**0.0001**	0.74 (0.18; 1.31)	**0.0100**	1.13 (0.39; 1.88)	**0.0029**
Living conditions index								
1st tertile	1526	9.7	1.00		0.00		0.00	
2nd tertile	1522	10.1	1.11 (0.83; 1.47)	0.4860	0.40 (-0.48; 1.28)	0.3750	0.75 (-0.42; 1.91)	0.2080
3rd tertile	1632	12.3	0.86 (0.64; 1.16)	0.3270	-0.68 (-1.69; 0.33)	**0.1870**	-1.01 (-2.33; 0.30)	**0.1320**
Sanitation Index								
1st tertile	2040	9.0	1.00		0.00		0.00	
2nd tertile	1262	11.1	0.93 (0.71; 1.23)	0.6290	-0.73 (-1.67; 0.20)	**0.1240**	-1.38 (-2.61; -0.16)	**0.0266**
3rd tertile	1378	12.9	0.97 (0.73; 1.30)	0.8600	-0.76 (-1.79; 0.27)	**0.1470**	-1.79 (-3.13; -0.46)	**0.0084**
Means of subsidence								
(1) Local production	2907	8.0	1.00		0.00		0.00	
(2) Outside donations	1773	15.2	1.16 (0.93; 1.46)	**0.1890**	0.57 (-0.20; 1.34)	**0.1460**	0.51 (-0.50; 1.52)	0.3200
Woman								
BMI		-	1.12 (1.10; 1.14)	**<0.0001**	0.48 (0.42; 0.55)	**<0.0001**	0.78 (0.69; 0.86)	**<0.0001**
Age		-	1.12 (1.11; 1.14)	**<0.0001**	0.26 (0.23; 0.30)	**<0.0001**	0.43 (0.39; 0.47)	**<0.0001**
Education (years of study)								
Unschooled	808	18.2	1.00		0.00		0.00	
1-4 years	1900	12.5	0.53 (0.41; 0.68)	**<0.0001**	-2.11 (-2.98; -1.25)	**<0.0001**	-3.87 (-5.00; -2.75)	**<0.0001**
5-9 years	1062	8.1	0.28 (0.21; 0.39)	**<0.0001**	-4.33 (-5.30; -3.36)	**<0.0001**	-7.09 (-8.35; -5.83)	**<0.0001**
>= 10 years	910	3.4	0.09 (0.06; 0.14)	**<0.0001**	-5.68 (-6.72; -4.63)	**<0.0001**	-9.28 (-10.64; -7.92)	**<0.0001**

* Excluding those who take medication. ** Not possible to obtain estimates since prevalence is zero for one of the categories. In bold: p-value < 0.20.

Source: Authors.

Table 3. Odds Ratios and adjusted β coefficient association of AH, SBP and DBP to characteristics of the village, household and individual. First National Health and Nutrition Survey of Indigenous Peoples, Brazil, 2008-2009.

Variables	AH OR (95%CI)		Diastolic blood pressure* coefficient (95%CI)		Systolic blood pressure* coefficient (95%CI)	
	M2	M3	M2	M3	M2	M3
Domestic trash management						
Sim	1.00	1.00				
Não	1.57 (0.99; 2.48)	1.77 (1.09; 2.86)				
Index of owned household goods						
1st tertile					1.00	
2nd tertile					-1.32 (-2.34; -0.30)	-1.31 (-2.27; -0.35)
3rd tertile					-1.66 (-2.85; -0.48)	-1.94 (-3.06; -0.81)
Stable income in the household						
Yes	1.00	1.00	0.00	0.00	0.00	0.00
No	1.47 (1.20; 1.79)	1.25 (1.00; 1.56)	0.74 (0.18; 1.31)	0.22 (-0.33; 0.78)	0.80 (0.02; 1.58)	-0.03 (-0.76; 0.70)
Living Conditions Index						
1st tertile					0.00	
2nd tertile					1.30 (0.10; 2.49)	0.95 (-0.17; 2.07)
3rd tertile					-0.20 (-1.58; 1.18)	0.19 (-1.11; 1.49)
BMI		1.09 (1.07; 1.11)		0.38 (0.31; 0.44)		0.62 (0.53; 0.70)
Age		1.11 (1.09; 1.12)		0.17 (0.14; 0.21)		0.29 (0.24; 0.34)
Education (years of study)						
Unschooled		1.00		0.00		
1-4 years		0.76 (0.58; 0.99)		-1.19 (-2.04; -0.33)		-2.19 (-3.29; -1.08)
5-9 years		0.69 (0.49; 0.98)		-2.31 (-3.32; -1.31)		-3.45 (-4.75; -2.14)
>=10 years		0.32 (0.20; 0.52)		-2.96 (-4.07; -1.84)		-4.37 (-5.83; -2.91)
AIC	M0 = 3000.28 M1 = 2998.58 M2 = 2986.34 M3 = 2516.63		M0 = 32586.94 M1 = 32586.94 M2 = 32582.33 M3 = 32194.55		M0 = 35046.34 M1 = 35046.34 M2 = 35031.64 M3 = 34426.12	
ICC M0 – macro	10.8%		7.5%		5.5%	
ICC M0 – Village	8.9%		10.7%		10.3%	

M0: Null model; M1: village (only home measurement of AH, no significant variables for diastolic and systolic blood pressures). M2: village+household M3: village+household+individual.

Source: Authors.

In the adjusted analysis, the variables that remained negatively associated with SBP were the index of owned goods, living conditions, stable household income, and education, while the positively associated variables were BMI and age. However, the living conditions index and stable income lost statistical significance in Model 3 (Table 3). An average reduction was noticed, of 1.31 mmHg and of 1.94 mmHg, respectively, in the second and third tertiles of the index of

owned goods, in comparison with the first tertile, which corresponds to less owned goods. Likewise, a decline was noticed in SBP, of 2.19 mmHg, 3.45 mmHg, and 4.37 mmHg, respectively, in strata 1 to 4, 5 to 9, and 10 or more years of study, when compared to those with no schooling. By contrast, there was an increase of 0.62mmHg and 0.29mmHg, as BMI and age were increased in one unit, respectively.

In this analysis, DBP remained negatively associated with education and positively associated with stable household income, BMI, and age; however, stable income lost statistical significance in Model 3 (Table 3). The DBP had reductions of 1.19 mmHg, 2.31 mmHg, and 2.96 mmHg, respectively, in strata 1 to 4, 5 to 9, and 10 or more years of education, when compared with the unschooled category. On the other hand, increases of 0.38mmHg and 0.17mmHg, were observed, with an increase of one unit in BMI and age, respectively.

Discussion

The results of this study are representative of the population of adult Indigenous women (aged 18 to 49 years) in Brazil and in four macroregions, and are an unprecedented initiative to estimate the magnitude of AH in this population, revealing the regional inequalities regarding BP levels and the prevalence of AH, as well as identifying factors associated with the increase in BP levels and in the prevalence of AH. This study therefore provides a new and broad view on NCDs, with focus on AH among Indigenous peoples in Brazil. Internationally, scientific literature has indicated health vulnerabilities of Indigenous peoples resulting from socioeconomic, demographic, sanitary, environmental, and territorial conditions, which are unfavorable[5,25], and has also indicated the emergence of NCDs in these populations, including AH among Indigenous women[11,13,17,28]. Such patterns are consonant with our results, insofar as they indicate that AH is an emerging health issue among Indigenous peoples in Brazil.

In a systematic review on BP levels and AH in Indigenous populations in North America, published in 2014, Foulds and Warburton[11] realized that, since 1980, there has been a progressive increase in the prevalence of AH through the decades, which had not been seen in the period pre-1980, and which have affected distinctive native populations, such as the First Nations/American Natives, and the Inuit, the natives of Alaska. The Inuit/Alaska Natives presented a high prevalence of AH, in the magnitude of 55.1% even before the 1980's. After 1980, those proportions remained stable, but more recently, the averages of SBP and DBP have shown continuous increases. These fluctuations in BP levels indicate notable changes in cardiovascular health of the Inuit/Alaska Natives over time. Considering this health scenario, which is heterogenous and in transition, affecting native communities at the global level, a pressing question regarding AH emerges. Although there are communities with a low or even nonexistent prevalence of hypertension, records indicate that some have a prevalences of above 50%[11,16,29,30].

Our study estimated a national average AH prevalence of 10.7% in adult Indigenous females of reproductive age, with considerable variations between macroregions. The North region had the lowest prevalence, while the South/Southeast and Midwest macroregions had the highest prevalence, 4.5-fold higher than the prevalence in the North. When comparing the prevalence of AH in Indigenous women, found in this study, and the general female population of Brazil above 18 years of age, the Indigenous women presented a prevalence that is equivalent to half of the 23.0% found for Brazilian women in general in the initial year of the study, 2008[31,32].

The magnitude of prevalence found in our study is similar to the results of 11% reported by a systematic review and meta-analysis about the metabolic health of Indigenous adults in Brazil[33]. However, such a similarity must be considered with caution, since the mentioned review estimated the prevalence for both genders together, for all ages, and regardless of residence in villages. By contrast, our estimates are restricted to adult Indigenous women of reproductive age who live in villages. Moreover, this review is based on studies conducted in a relatively small number of Indigenous communities in the country. Brazil has one of the most expressive social diversities on the planet, and shows considerable heterogeneity in the prevalence of AH between different communities and regions, with values ranging from 30% in the South, to discrete values of around 1% found for Indigenous communities in the North region. Older studies indicated the absence of AH among those communities, a phenomenon that is likely related to improvements in diagnosis and to the emergence of NCDs over time[33]. Other studies have reported the prevalence of AH among Indigenous people that were lower than that found in this study[16,34-37]. Other

studies have found a higher prevalence, as in the case of those conducted with the Mura people in the Amazon region (27.8%)[15], with the Krenak (27.6%)[38], the Kaingang from Santa Catarina (40.7%)[39], and the Tupinikin from Espírito Santo (20.8%) (for both genders)[40].

Therefore, our SBP and DBP averages and AH prevalence should be seen as estimates restricted to female Indigenous women of reproductive age, although they are representative of the diversity of Indigenous populations living in villages, considering that it was conducted with a probabilistic sample of adult Indigenous women of reproductive age and residing in villages in Brazil and in the four analyzed macroregions. This population cut-off results in estimates of a relatively low prevalence of AH when compared to other studies conducted with Indigenous populations and considering both genders, as well as studies considering higher age groups and populations that do not live in villages and on Indigenous lands[15,33,38]. Since the associations between AH and age, sex, and residency in urban areas are widely known, the inclusion of these segments in the study would result in considerably higher AH prevalence in comparison to what we found[26,34,36,39].

Our findings reveal different factors associated with BP levels and with AH among adult Indigenous women of reproductive age in Brazil. The absence of a stable family income, combined with the condition of residing in villages, where the consumption of food from hunting, fishing, and gathering is non-existent, appears as a context that increases the probability of AH. This relationship suggests a connection between adverse subsistence conditions and food insecurity, resulting in a scarcity of food of satisfactory quality and quantity, and consequently in the consumption of industrialized and ultra-processed foods, which cause weight gain, obesity, and deterioration of cardiovascular health, in the form of increased pressure levels and the prevalence of AH. At the same time, it is interesting to notice that education emerges as a protective factor against AH, emphasizing the importance of access to education in terms of favoring health promotion and the prevention of NCDs.

Other studies conducted with Indigenous peoples stood out for investigating the relationship between the way of life of those populations and BP, as in the case of the international study INTERSALT[41]. Conducted in the end of the 1980's, this study aimed to systematically investigate relationships between the ingestion of sodium (Na+) and potassium (K+) and BP levels, as well as other variables, in 52 different populations from 32 countries. The study included in its sample different Indigenous groups, such as the Yanomámi from the Amazon, who stood out in that scenario for presenting exceptionally low BP levels and an absence of AH diagnoses. Moreover, a striking positive association was identified between the ingestion of sodium and levels of BP, a result that diverged from patterns observed in other populations[16]. Those findings reveal the importance of considering cultural and environmental factors as related to BP, and proved the need for individualized approaches when investigating cardiovascular health in different population groups, as well as to understand more completely how it is determined.

In this context, it is worthwhile to highlight the negative repercussions for cardiovascular health related to substantial changes in eating patterns and lifestyle, which are associated with an alarming increase in the prevalence of obesity and overweight[42]. Results from this same previously published national inquiry showed evidence of a high prevalence of obesity and overweight among Indigenous women in our study[20]. Such an issue is extremely relevant, considering that we identified an increase in AH prevalence and high BP levels, which relate to increases in BMI, as observed in other studies about Indigenous groups[6,13,15,38]. In other words, the association between obesity and AH observed in the present study most likely reflects changes in eating patterns, physical activity patterns, and environmental conditions, which are part of the process of nutritional and epidemiological transition that these populations had to face when coming into contact with the surrounding society.

When we consider the limitations of this study, we should mention that the cross-sectional approach in this study does not allow for the attribution of causality to the investigated relationships. Moreover, it is important to highlight the fact that the 1st NHNSIP was focused on investigating maternal and infant health in the Indigenous population of Brazil, thereby excluding adult men, women over 50 years of age, and individuals residing outside of Indigenous villages and lands, thus restricting the results to women residing in Indigenous reservations officially recognized by the federal government and that were part of the Indigenous Health Subsystem (SASI-SUS).

Regarding the strengths of this study, we highlight that it was conducted with the objective of providing evidence to support healthcare for Indigenous peoples covered by the Indigenous

Healthcare Subsystem, especially in terms of mother and infant health, and in terms of nutritional and eating surveillance. Our findings are, therefore, applicable for the planning of health promotion and care actions within this segment, which is of particular interest, considering its health vulnerabilities. This study had a nationwide coverage and was based on a probabilistic sample of the population of women residing in villages, which is representative of four macroregions, with no loss of precision, and even included populations that had never been studied before. The estimates generated by this study are, therefore, robust and generalizable for Indigenous populations of the macroregions and for the country, and can be used as parameters for future comparisons of AH tendencies in these populations, and for the planning of health care and health promotion.

Future studies should consider the inclusion of other age groups, of the male sex, and of populations that do not reside in Indigenous villages and lands, in order to provide a more complete understanding of the burden of AH and the factors which influence the cardiovascular health of the Indigenous populations in Brazil. Carrying out investigations in specific communities reinforces the need to consider the cultural and geographic context in order to achieve a more precise and sensible understanding of the health determinants in those historically marginalized communities. The reproduction of studies such as this, in different contexts and scales, is essential in order to enable the monitoring of tendencies of NCDs among Indigenous peoples, and to guide health policies and strategies that seek to reduce inequalities and improve the health and wellbeing of these populations, respecting their cultural and socioeconomic specificities, as well as their constitutionally established rights to land and access to health.

Collaborations

AM Cardoso and BL Horta produced the concept and design of the study. All of the authors were involved in data collection. AA Nobre, AM Cardoso e FG Tavares conducted statistical analyses. FG Tavares, AM Cardoso and AA Nobre wrote the first draft. The final version submitted for publication was read and approved by all of the authors.

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