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Xingu Indigenous Territory: nutritional and metabolic profile of indigenous people evaluated between 2017 and 2019

Douglas A. Rodrigues (https://orcid.org/0000-0002-6810-5410) [1]
Vanessa Moreira Haquim (https://orcid.org/0000-0001-9655-8778) [1]
Lalucha Mazzucchetti (https://orcid.org/0000-0002-9649-5727) [2]
Pablo Natanael Lemos (https://orcid.org/0000-0003-0585-3187) [1]
Sofia Beatriz Machado de Mendonça (https://orcid.org/0000-0002-3801-9343) [1]

Abstract *The study evaluates the nutritional and metabolic profile of the adult population of the Xingu Indigenous Territory by gender and base hub. It was developed in 18 villages from 2017 to 2019. Anthropometry and clinical, physical examinations were conducted in loco in individuals over 18. A total of 1,598 Indigenous people were evaluated, with a mean age of 36.7 years. Of these, 50.6% were male, 53.2% lived in the Leonardo Base hub, 22.7% in Diauarum, 12.3% in Pavuru and 11.8% in Wawi. Women had a higher prevalence (p < 0.05) than men, respectively, of underweight (2.0% vs. 0.1%), normal weight (46.1% vs. 37.4%), central obesity (63.4% vs. 21 .8%), low HDL cholesterol (77.7% vs. 72.9%) and Metabolic Syndrome (29.0% vs. 23.5%). In comparison, men had a higher prevalence (p < 0.05) than women, respectively, of overweight (46.3% vs. 37.5%), high triglycerides (34.5% vs. 28.2%) and high blood pressure levels (13.1% vs. 8.6%). The Leonardo and Wawi base hubs had the worst nutritional and cardiometabolic results. Overall, subjects had a high frequency of noncommunicable diseases and cardiometabolic risk. Urgent measures need to be taken to control this situation.*
Key words *Indigenous population, Health of indigenous populations, Noncommunicable diseases, Metabolic syndrome, Nutritional assessment*

[1] Projeto Xingu, Universidade Federal de São Paulo. São Paulo SP Brasil.
[2] Pesquisadora independente. R. Prefeito Torquato Tasso 35, Centro. 88840-000 Urussanga SC Brasil. laluchamazzucchetti@gmail.com

Introduction

Data released by researchers at the World Health Organization (WHO)[1] in 2022 show that Noncommunicable Diseases (NCDs) were responsible for 74.0% of deaths worldwide. Despite their noncommunicable nature[2], a true epidemic of NCDs has been observed in recent decades, mainly cardiovascular diseases, cancer, chronic respiratory diseases, and diabetes[3-7].

Among Indigenous people in 23 countries, including Brazil, social and health conditions were worse than the non-Indigenous population[8]. The increase in NCDs has been highlighted in the epidemiological profile of several Indigenous communities around the world and prompted researchers to analyze cardiometabolic risk factors and changes in their lifestyle, although the high prevalence of deficiency and infectious diseases persist[8-18].

The relationship between Indigenous societies and the national society, considering different settings and historical moments, shaped behaviors and determined changes in how Indigenous peoples live and eat, mainly due to the exploitation and expropriation of their territories by agricultural, logging, and mining expansion fronts[19-25].

The impacts of these environmental and behavioral changes can be identified through the emergence of NCDs in Brazilian Indigenous people. Studies conducted in the country in recent decades show a rapid and progressive increase in the prevalence of obesity, dyslipidemia, systemic arterial hypertension (SAH), and metabolic syndrome (MS), revealing a high risk for cardiovascular diseases (CVD) and diabetes mellitus (DM) in both genders[9,13,16, 23-34]. Studies with people from the Xingu Indigenous Territory (TIX) show an increase in NCDs such as obesity, reduced high-density lipoproteins (HDLc), elevated triglycerides, and even the emergence of other previously non-existent diseases such as DM[13,23-25,32-34].

Other factors have contributed to changes in how Indigenous peoples live and eat, including the monetization and diversification of their economy and the emergence of new social roles. Welch et al. documented statistically significant associations between household income, health conditions, and anthropometric measurements indicative of obesity in Xavante adults of both genders[16,22].

Government programs for income transfer and distribution of staple food baskets, generally with an inadequate composition for local diets, also encourage the consumption of industrialized and ultra-processed foods to the detriment of traditional foods, contributing to the emergence of NCDs among Indigenous peoples[21-25].

In 2015, the United Nations (UN) proposed the establishment of "Sustainable Development Goals – SDGs" to its members, including Brazil. One target of the Health and Well-being goal is "to reduce by one third premature mortality from NCDs through prevention and treatment and promote mental health and well-being by 2030"[35]. In 2021, a new "Strategic Action Plan to Combat Chronic Diseases and Noncommunicable Diseases in Brazil, 2021-2030 (Dant Plan)" was drawn up per the global and national SDGs and is in force[36]. Also, in this context, in 2018, the Ministry of Health (MS) defined NCDs and studies on Indigenous populations' health as priorities on the national health research agenda[37].

Considering that NCDs are the leading causes of death in the world, that they reduce the quality of life and can lead to premature deaths, that they negatively impact the socioeconomic aspects of families and communities, that they are relevant given the SDGs agreed upon by the country and the programs to combat these diseases in force; and the priority in the national research agenda on this topic and the health of Indigenous populations, we deem it is appropriate to conduct this work, whose objective was to evaluate the nutritional and metabolic profile of the TIX adult population by gender and base hub.

This research is unprecedented regarding the number and ethnic diversity of Indigenous people assessed in the TIX, besides the analysis by base hub, which is a territorial subdivision belonging to the Special Indigenous Health District (DSEI). This stratification was selected for analysis because each base hub has significant particularities, mainly the differences related to access to the territory and health services, the history of contact of each ethnic group by region, and the cultural diversity expressed in these spaces that make up the TIX; the analysis by gender was based on biological issues. The results are expected to support policies that aim to reduce NCDs in the country, especially for Indigenous peoples.

Methods

This cross-sectional observational study used primary data collected directly from the adult and older adult population of the Xingu Indige-

Ciência & Saúde Coletiva, 29(12):1-14, 2024

nous Territory (TIX), Mato Grosso (MT), Brazil (11°14'41.4"S 53°12'26.3"W). According to the Socio-Environmental Institute (ISA), this space has a total of 2.8 million demarcated and approved hectares[20]. The TIX currently comprises four Indigenous Lands (TI): the Xingu Indigenous Park TI, Wawi TI, Batovi TI, and Pequizal do Naruvotu TI[20]. In 2017, the TIX was home to 93 villages and 16 ethnic groups, totaling 6,616 individuals, of which 3,025 were aged 18 or over[38].

This territory is divided into four regions: Alto, Médio, Baixo, and Leste Xingu. Each region has a base hub, a "territorial subdivision of the DSEI, serving as the base for the Multidisciplinary Indigenous Health Teams to organize technically and administratively the healthcare of the assigned Indigenous population"[39] (art. 2, III). The TIX base hubs are: *Diauarum* (Baixo Xingu), *Leonardo* (Alto Xingu), *Pavuru* (Médio Xingu), and *Wawi* (Leste Xingu). Each ethnic group has particularities related to the history of contact with the surrounding society, interactions with other Indigenous peoples, access to surrounding municipalities, and traditional rules and knowledge, agricultural technologies, mother tongue, among other specificities[40].

This work was conducted in 18 villages and included all ethnic groups from 2017 to 2019 during four annual trips. The villages were selected based on the most significant number of residents and ethnic diversity, with no probabilistic sampling process or even a search for a sample representative of the TIX. However, we aimed to continue with on-site assessments in other villages, but the COVID-19 pandemic hampered this process.

At the time of assessments, adults over 18 of both genders in the villages who agreed to participate in the research were evaluated. The exclusion criteria were being pregnant, not having weight or height measurements, and not having at least 80% of the clinical exams available. Data were collected from 1,612 Indigenous people, but 1,598 were included considering the exposed eligibility criteria, representing a sample of 52.8% against the total available for the age group (n = 3,025). Figure 1 shows the villages evaluated in the TIX.

The primary project for this study was developed with two components: one with an epidemiological focus and the other with an ethnographic nature, conducted with participant observation techniques, individual and collective interviews, home visits, discussion groups, and cooking workshops, together with the systematized researchers' experiences. Only epidemiological data were used for this manuscript.

The physical examinations, including anthropometry and clinical tests, were performed in the villages by professionals adequately trained for such tasks. The research team comprised doctors, nurses, nutritionists, dentists, medical and nursing students, Indigenous health and sanitation workers, nursing technicians, Indigenous teachers, and educators.

Sociodemographic information on the name, sex, and age of the Indigenous people was obtained through the demographic census provided by the DSEI Xingu. Anthropometric measurements (weight and height) were performed in duplicate and followed the procedures recommended by the WHO[41]. A portable electronic scale (KRATOS-CAS) with a maximum capacity of 150 kg and a scale of 50g was used to measure body weight (kg). All individuals wore light clothing and were barefoot during the assessment.

A portable stadiometer with a platform from AlturaExata, with a scale from 1 mm to 213 cm, was employed to measure height. The mobile part of the stadiometer was positioned at the highest point of the individual's head, with the arms extended along the body, the heels and knees together, and the body and head in contact with the measuring ruler.

The body mass index (BMI) was obtained using the formula of weight divided by height squared. WHO criteria[41] were adopted to assess nutritional status, which classifies BMI as underweight (BMI < 18.5 kg/m^2), eutrophy (BMI ≥ 18.5 and < 25.0 kg/m^2), overweight (BMI ≥ 25.0 and < 30.0 kg/m^2), and obesity (BMI ≥ 30.0 kg/m^2).

Abdominal circumference (AC) was measured with an inelastic anthropometric tape measure at the midpoint between the lower edge of the last rib and the upper edge of the iliac crest[41]. Central obesity (CO) was characterized by AC values greater than 94 cm and 80 cm for men and women, respectively[42,43].

The lipid profile [total cholesterol (TC), high-density lipoprotein (HDLc), low-density lipoprotein (LDL-c), and triglycerides (TG)] and fasting glucose (FG) were determined by the fingerstick method of capillary blood collection using the portable automated equipment Cholestech LDX (Alere, Waltham, MA – USA) through reflectance photometry. TC concentrations > 200 mg/dL or TG > 150 mg/dL or LDLc > 130 mg/dL

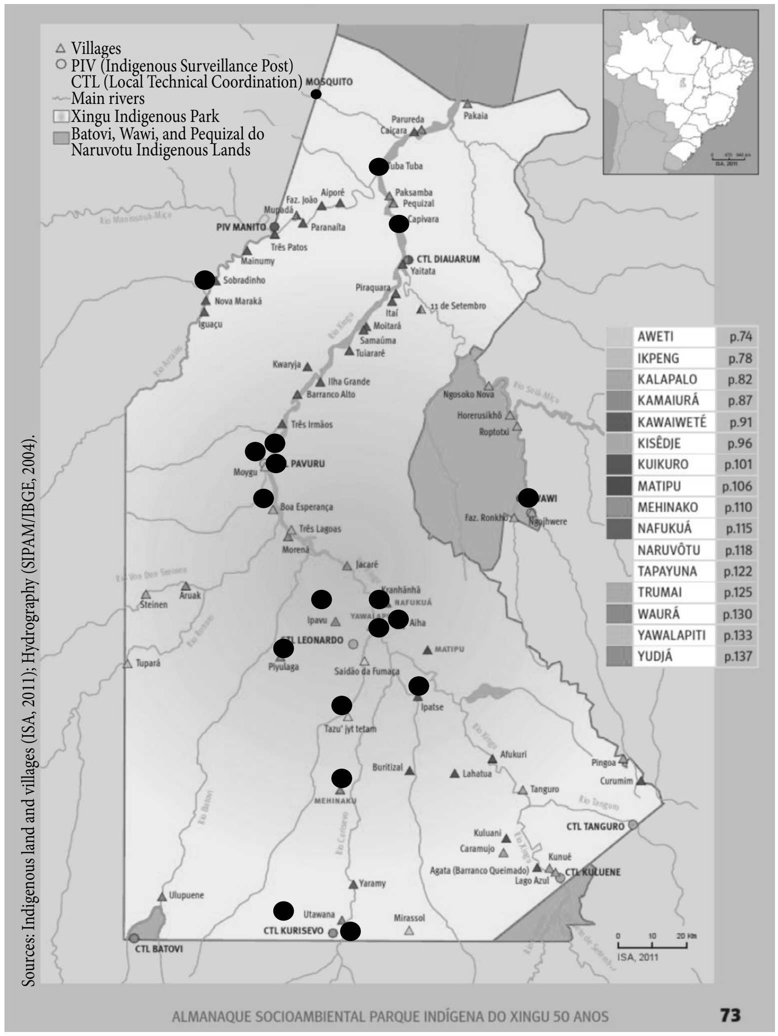

Figure 1. TIX map showing the location of the villages participating in the research, 2017-2019.

Source: Adapted from the Socio-Environmental Almanac of the Xingu Indigenous Territory: 50 years[53].

or HDLc < 40 mg/dL for men and < 50 mg/dL for women were considered altered[43,44].

In order to classify individuals according to their level of glucose tolerance, individuals with FBG <100 mg/dL were considered normal, individuals with altered FBG (pre-diabetics) were those with values between ≥ 100 and < 126 mg/dL, and diabetics with FBG ≥ 126 mg/dL[3,45].

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) values were measured using an automatic arm monitor (model HEM 741C-INT; OMRON, China). For the classification of blood pressure (BP) clinically, SBP < 140 mmHg and DBP < 90 mmHg were considered normal, and SBP ≥ 140 mmHg or DBP ≥ 90 mmHg were considered high blood pressure levels[46]. To evaluate MS criteria, SBP ≥ 130 mmHg or DBP ≥ 85 mmHg were considered high blood pressure levels[3].

MS was identified under the diagnostic criteria defined by Alberti *et al.*[3]. The syndrome's diagnosis occurred in the presence of at least three of the following components: increased abdominal circumference, high fasting glucose, high blood pressure levels, reduced high-density lipoproteins and high triglycerides; and the use of medication to treat the pathologies mentioned characterize its diagnosis.

Ciência & Saúde Coletiva, 29(12):1-14, 2024

The data description used absolute (n) and relative (%) frequencies for qualitative variables and measures of central tendency and dispersion for quantitative variables. Normality was identified by the Shapiro-Wilk test. Pearson's chi-square test of independence assessed the association; the post hoc residual analysis with Bonferroni adjustment and the Z test were used[47,48] in contingency tables greater than 2 x 2, where statistical significance was identified. Student's t-test was used to compare the means by gender, and Analysis of Variance (ANOVA) was employed to evaluate the base hub with the Bonferroni post hoc test. The significance level used in the research was 5% ($p < 0.05$). The prevalence per point and interval with 95% confidence were calculated for the nutritional status variables and altered metabolic diseases. The Excel program was adopted to prepare the database, and the SPSS 20.0 software (IBM®) was used for data analysis.

This study is nested in the project "New health problems: Assessment of the Nutritional and Metabolic Profile of Indigenous People in the Xingu Indigenous Territory", developed by the Xingu Project, an extension program of the Paulista School of Medicine of the Federal University of São Paulo, which has been developing healthcare, research and teaching activities in the Xingu Indigenous Territory (TIX) since 1965[40].

The planning phase was conducted through meetings with the participation of several leaders and social stakeholders from each community. Indigenous Health Workers and teachers from each community participated in the entire process of implementing the project and translating it into their native language, with the participants' consent. The preliminary results were consolidated, presented, and discussed with the community during the research. All diagnosed alterations were discussed with the medical team and each patient for appropriate therapeutic referral.

The results were sent to and discussed with the Xingu Special Indigenous Health District. This study was approved by the National Research Ethics Commission (CONEP) CAAE: 65147817.4.0000.5505 and UNIFESP Human Research Ethics Committee (CEP) (nº 0140.0088.02-2017 and 2.185.654).

Results

In this study, a total of 1,598 Indigenous people were evaluated; 850 lived in Leonardo, 363 in Diauarum, 197 in Pavuru, and 188 in Wawi. Fifteen ethnic groups were identified, the most frequent being Kaiabi, Kamaiurá, and Kisêdjê. Table 1 shows that the most frequent ethnic groups in Diauarum were Kaiabi and Yudja; in Leonardo, they were Kamaiurá and Kuikuro; in Pavuru, they were Ikpeng and Trumai; and in Wawi, they were Kisêdjê and Kamaiurá.

The evaluation of ethnic groups by gender identified 808 (50.6%) men and 790 (49.4%) women. Among females, the most frequent ethnic groups were Kaiabi and Kamaiurá; among males, they were Kaiabi and Kisêdjê. The base hub with the most significant ethnic diversity was Leonardo (11; 73.3%), and the one with the least was Diauarum (4; 26.7%). The Wawi base hub (57.7%) had the highest frequency of individuals evaluated compared to the population eligible for the research.

The mean age of the 1,598 individuals evaluated was 36.7 years (SD: 15.3 years and ranged from 18.0 to 87.1 years). There was no statistically significant difference in mean age between genders ($p = 0.3103$), female (Mean: 36.3 years; SD: 15.1 years) and male (Mean: 37.1 years; SD: 15.5 years), and between the base hubs ($p = 0.229$), Diauarum (Mean 36.1 years; SD: 16.3 years), Leonardo (Mean: 37.2 years; SD: 15.0 years), Pavuru (Mean: 35.4 years; SD: 14.8 years) and Wawi (Mean: 37.0 years; SD: 15.3 years). Figure 2 shows that the most frequent age group among those evaluated was 20 to 29 years (35.2%); the age groups were similar in the distribution by gender.

The prevalence of changes in nutritional status among those evaluated was 1.1% (95%CI 0.6–1.7%) underweight; 41.9% (95%CI 39.5–44.4%) overweight; 15.3% (95%CI 13.6–17.2%) obesity. Metabolic changes were 42.4% (95%CI 39.9–44.8%) central obesity; 22.8% (95%CI 20.8–25.0%) high total cholesterol; 31.4% (95%CI 29.1–33.8%) high triglycerides; 75.3% (95%CI 73.1–77.4%) low HDLc; 24.5% (95%CI 22.3–26.8%) high LDLc; 9.9% (95%CI 8.5–11.5%) prediabetes; 2.1% (95%CI 1.5–3.0%) DM; 10.9% (95%CI 9.4–12.5%) high blood pressure levels and 26.2% (95%CI 24.2–28.4%) MS.

Table 2 shows the prevalence rates of nutritional status and metabolic diseases by gender. Women had a higher prevalence ($p < 0.05$) than men of underweight, normal weight, central obesity, low HDLc, and MS. Men showed a higher prevalence ($p < 0.05$) than women of overweight, high triglycerides, and high blood pressure levels.

Table 3 shows the prevalence rates related to nutritional status and metabolic diseases by base hub, and only the variables of high total choles-

Table 1. Description of the number and percentage of Indigenous people assessed (N = 1.598) in the Xingu Indigenous Land by gender. ethnicity. and base hub. São Paulo. 2019.

Ethnicity	Base hub								Total	
	Diauarum		Leonardo		Pavuru		Wawi			
	N	%	N	%	N	%	N	%	N	%
Female										
Aweti	-	-	33	7.8	1	1.0	-	-	34	4.3
Ikpeng	2	1.1	-	-	69	71.1	1	1.1	72	9.1
Kaiabi	103	57.2	1	0.2	6	6.2	3	3.3	113	14.3
Kalapalo	-	-	60	14.2	-	-	-	-	60	7.6
Kamaiura	-	-	86	20.4	1	1.0	8	8.8	95	12.0
Kisedjê	1	0.6	-	-	1	1.0	69	75.8	71	9.0
Kuikuro	-	-	70	16.6	1	1.0	2	2.2	73	9.2
Matipu	-	-	4	0.9	-	-	-	-	4	0.5
Mehinako	-	-	43	10.2	-	-	1	1.1	44	5.6
Nakufua	-	-	23	5.4	-	-	-	-	23	2.9
Tapaiuna	-	-	-	-	-	-	2	2.2	2	0.2
Trumai	-	-	6	1.4	9	9.3	2	2.2	17	2.1
Wauja	-	-	60	14.2	6	6.2	-	-	66	8.3
Yawalapti	-	-	36	8.5	1	1.0	1	1.1	38	4.2
Yudja	74	41.1	-	-	2	2.1	2	2.2	78	9.9
Total	180	100	422	100	97	100	91	100	790	100
Male										
Aweti	-	-	38	8.9	-	-	-	-	38	4.7
Ikpeng	-	-	-	-	84	84.0	-	-	84	10.4
Kaiabi	103	56.3	-	-	5	5.0	2	2.1	110	13.6
Kalapalo	-	-	55	12.8	-	-	-	-	55	6.8
Kamaiura	-	-	84	19.6	2	2.0	1	1.0	87	10.8
Kisedjê	1	0.5	-	-	2	2.0	89	91.7	92	11.4
Kuikuro	-	-	78	18.2	-	-	-	-	78	9.6
Matipu	-	-	5	1.2	-	-	-	-	5	0.6
Mehinako	-	-	58	13.5	-	-	-	-	58	7.2
Nakufua	-	-	20	4.7	-	-	-	-	20	2.5
Tapaiuna	-	-	-	-	-	-	4	4.1	4	0.5
Trumai	-	-	1	0.2	5	5.0	-	-	59	7.3
Wauja	-	-	58	13.5	1	1.0	-	-	31	3.8
Yawalapti	-	-	31	7.2	-	-	-	-	31	3.8
Yudja	79	43.2	-	-	1	1.0	1	1.0	81	10.0
Total	183	100	428	100	100	100	97	100	808	100

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terol and LDLc did not show a statistically significant association ($p > 0.05$). The Leonardo hub had a higher frequency ($p < 0.05$) of overweight (Leonardo 45.3% vs. Pavuru 31.4%), obesity (19.8% vs. Diauarum 9.6% vs. Pavuru 5.6%), central obesity (48.7% vs. Diauarum 36.4% vs. Pavuru 27.9%), high triglycerides (31.4% vs. Pavuru 23.8%), prediabetes (12.8% vs. Diauarum 4.5%) and MS (28.8% vs. Pavuru 19.3%). At the Wawi base hub, a higher frequency of obesity (16.5% vs. Diauarum 9.6% vs. Pavuru 5.6%), high triglycerides (44.9% vs. Leonardo 31.4% vs. Diauarum 28.1% vs. Pavuru 23.8%), low HDLc (89.1% vs. Leonardo 71.7% vs. Diauarum 70.8%) was observed than the others. Pavuru showed a higher frequency of underweight (3.1% vs. Leonardo 0.2%), low HDLc (86.2% vs. Leonardo 71.7% vs. Diauarum 70.8%) and prediabetes (10.6% vs. Diauarum 4.5%). Diauarum had a higher frequency of high blood pressure levels (16.3% vs. Leonardo 9.5% vs. Wawi 8.0%), and it was the base hub with the lowest NCD frequencies.

Ciência & Saúde Coletiva, 29(12):1-14, 2024

Table 1. Description of the number and percentage of Indigenous people assessed (N = 1,598) in the Xingu Indigenous Land by gender, ethnicity, and base hub. São Paulo, 2019.

Ethnicity	Base hub								Total	
	Diauarum		Leonardo		Pavuru		Wawi			
	N	%	N	%	N	%	N	%	N	%
Total										
Aweti	-	-	71	8.3	1	0.5	-	-	72	4.5
Ikpeng	2	0.5	-	-	153	77.7	1	0.5	156	9.8
Kaiabi	206	56.7	1	0.1	11	5.6	5	2.7	223	13.9
Kalapalo	-	-	115	13.5	-	-	-	-	115	7.2
Kamaiura	-	-	170	20.0	3	1.5	9	4.8	182	11.4
Kisedjê	2	0.5	-	-	3	1.5	158	84.0	163	10.2
Kuikuro	-	-	148	17.4	1	0.5	2	1.1	151	9.4
Matipu	-	-	9	1.1	-	-	-	-	9	0.6
Mehinako	-	-	101	11.9	-		1	0.5	102	6.4
Nakufua	-	-	43	5.1	-	-	-	-	43	2.7
Tapaiuna	-	-	-	-	-	-	6	3.2	6	0.4
Trumai	-	-	7	0.8	14	7.1	2	1.1	23	1.4
Wauja	-	-	118	13.9	7	3.5	-	-	125	7.8
Yawalapti	-	-	67	7.9	1	0.5	1	0.5	69	4.3
Yudja	153	42.1	-	-	3	1.5	3	1.6	159	9.9
Total	363	100	850	100	197	100	188	100	1,598	100
Eligible population	727	100	1,548	100	424	100	326	100	3,025	100
% of assessed	-	49.9	-	54.9	-	46.5	-	57.7	-	52.8

Source: Authors.

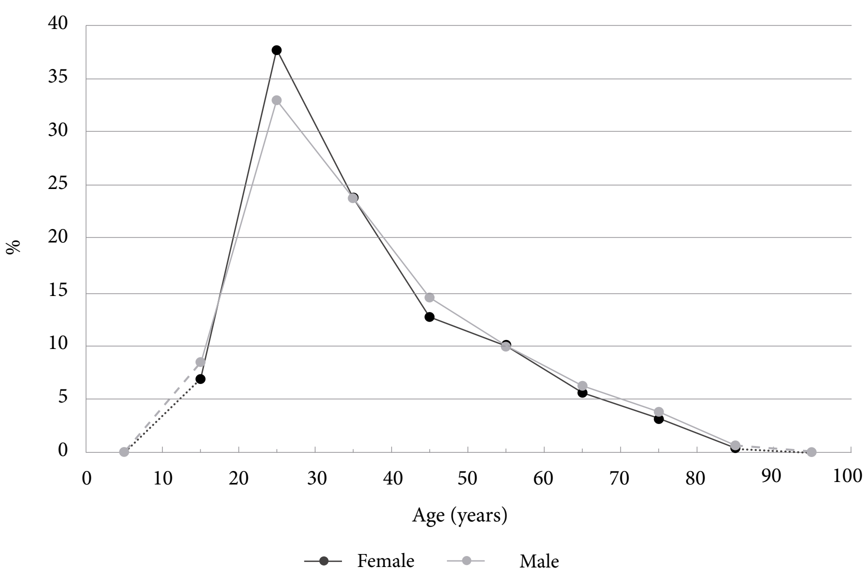

Figure 2. Percentage of Indigenous people by age and gender. São Paulo, 2021.

Source: Authors.

Table 2. Description of the number and percentage of Indigenous people assessed (N = 1,598) in the Xingu Indigenous Territory by gender and sociodemographic, anthropometric, and clinical variables. São Paulo, 2019.

Variables	Female		Male		P-value*	Total	
	N	%	N	%		N	%
Nutritional status							
Underweight	16a	2.0	1b	0.1	<0.0001	17	1.1
Eutrophy	364a	46.1	302b	37.4		666	41.7
Overweight	296a	37.5	374b	46.3		670	41.9
Obesity	114a	14.4	131a	16.2		245	15.3
Central obesity							
No	289	36.6	632	78.2	<0.0001	921	57.6
Yes	501	63.4	176	21.8		677	42.4
High total cholesterol							
No	593	75.2	638	79.2	0.057	1,231	77.2
Yes	196	24.8	168	20.8		364	22.8
High triglycerides							
No	546	71.8	523	65.5	0.007	1,069	68.6
Yes	214	28.2	275	34.5		489	31.4
Low HDLc							
No	176	22.3	218	27.1	0.026	394	24.7
Yes	613	77.7	586	72.9		1,199	75.3
High LDLc							
No	526	73.8	590	77.1	0.134	1,116	75.5
Yes	187	26.2	175	22.9		362	24.5
Blood glucose metabolism disorders							
Normal	708	89.6	698	86.4	0.058	1,406	88.0
Prediabetes	64	8.1	94	11.6		158	9.9
Diabetes Mellitus	18	2.3	16	2.0		34	2.1
High blood pressure levels							
No	721	91.4	702	86.9	0.004	1,423	89.1
Yes	68	8.6	106	13.1		174	10.9
Metabolic Syndrome							
No	561	71.0	618	76.49	0.013	1,179	73.8
Yes	229	29.0	190	23.5		419	26.2

N: number; %: percentage; *: relative to Pearson's chi-square test; a/b/c: different letters in the base hubs indicate statistically significant difference ($p < 0.05$).

Source: Authors.

Discussion

Studies with different ethnic groups of the TIX have been conducted to understand health conditions over the years. The first one, identified in 1964[49], aimed to evaluate the prevalence of atherosclerosis in 53 Indigenous people from the Tupi, Gê, Arawak, and Caraibas (sic) ethnic groups and showed that the levels of lipid fractions were lower than any other reported for Indigenous adults and much lower than non-Indigenous people. All lipid fractions were significantly higher in women, with no evidence of atherosclerosis. The Indigenous people did not show malnutrition, and men had good muscle development.

In 1981, Baruzzi and Franco[50] assessed 392 Indigenous people from the TIX. They found that the highest average weight and height were among the Suya, Txukahamaye, and Kren-akarore peoples (eastern Xingu), and the lowest means were among the Kaiabi peoples (lower Xingu). Men had little subcutaneous fat and good muscle development. Hypertension was rare and did not increase with age. These results were related to constant physical activity, preservation of a traditional diet, and low stress levels.

Table 3. Description of the number and percentage of Indigenous people assessed (N = 1,598) in the Xingu Indigenous Land, according to the base hub and sociodemographic, anthropometric, and clinical variables. São Paulo, 2021.

Variables	Base Hub								P-value*	Total	
	Diauarum		Leonardo		Pavuru		Wawi				
	N	%	N	%	N	%	N	%		N	%
Nutritional status											
Underweight	4[ab]	1.1	2[b]	0.2	6[a]	3.1	5[a]	2.7	< 0.0001	17	1.1
Eutrophy	175[a]	48.2	295[b]	34.7	118[c]	59.9	78[ab]	41.5		666	41.7
Overweight	149[ab]	41.0	385[b]	45.3	62[a]	31.4	74[ab]	39.3		670	41.9
Obesity	35[ab]	9.6	168[c]	19.8	11[b]	5.6	31[ac]	16.5		245	15.3
Central obesity											
No	231[a]	63.6	436[b]	51.3	142[a]	72.1	112[ab]	59.6	< 0.0001	921	57.6
Yes	132[a]	36.4	414[b]	48.7	55[a]	27.9	76[ab]	40.4		677	42.4
High total cholesterol											
No	270[a]	74.4	651[a]	76.6	160[a]	81.2	150[a]	81.1	0.157	1.231	77.2
Yes	93[a]	25.6	199[a]	23.4	37[a]	18.8	35[a]	18.9		364	22.8
High triglycerides											
No	261[a]	71.9	575[a]	68.6	131[ab]	76.2	102[b]	55.1	< 0.0001	1.069	68.6
Yes	102[ab]	28.1	263[b]	31.4	41[a]	23.8	83[c]	44.9		489	31.4
Low HDLc											
No	106[a]	29.2	241[a]	28.3	27[b]	13.8	20[b]	10.9	< 0.0001	394	24.7
Yes	257[a]	70.8	609[a]	71.7	169[b]	86.2	164[b]	89.1		1.199	75.3
High LDLc											
No	255[a]	75.7	598[a]	74.7	125[a]	73.5	138[a]	80.7	0.375	1.116	75.5
Yes	82[a]	24.3	202[a]	25.3	45[a]	26.5	33[a]	19.3		362	24.5
Blood glucose metabolism disorders											
Normal	345[a]	95.0	717[b]	84.4	173[b]	87.8	171[ab]	91.0	< 0.0001	1.406	87.9
Pre-diabetes	16[a]	4.5	109[b]	12.8	21[b]	10.6	12[ab]	6.4		158	9.9
Diabetes Mellitus	2[a]	0.5	24[a]	2.8	3[a]	1.6	5[a]	2.6		34	2.2
High blood pressure levels											
No	304[a]	83.7	76[b]	90.5	178[ab]	90.6	173[b]	92.0	0.003	1.423	89.1
Yes	59[a]	16.3	81[b]	9.5	19[ab]	9.4	15[b]	8.0		174	10.9
Metabolic Syndrome											
No	280[ab]	77.1	605[b]	71.2	159[a]	80.7	135[ab]	71.8	0.016	1.179	73.8
Yes	83[ab]	22.9	245[b]	28.8	38[a]	19.3	53[ab]	28.2		419	26.2

N: number; %: percentage; *: relative to Pearson's chi-square test; a/b/c: different letters in the base hubs indicate statistically significant difference ($p < 0.05$).

Source: Authors.

In 1989, an international multicenter study called INTERSALT[51] included a sample of ten ethnic groups from the TIX (n = 198) and did not identify any overweight cases. Women showed a mean BMI of 22.6 kg/m^2 and men 24.2 kg/m^2. Regarding hypertension, they found a frequency of 1.0%, with no increase in blood pressure with age.

In 2007, among the 201 Indigenous people of the Aruak group (Mehinaku, Waurá, and Yawalapiti) (upper Xingu), prevalence rates of 51.8% overweight, 15.0% obesity, 52.1% central obesity, 77.1% dyslipidemia, 6.7% changes in blood pressure levels, 4.9% altered fasting glucose, and no DM[23] were observed.

In 2009, among the 251 Indigenous people from the Karib group (Kalapalo, Kuikuro, Matipu, Nahukuá) (upper Xingu), the prevalence of overweight was 39.3%, obesity 6.8%, central obesity 41.8%, high total cholesterol 20.8%, low HDLc 48.0%, high LDLc 20.4%, high triglycerides 23.4%, changes in blood pressure levels 2.6%, altered fasting glucose 5.5%, without DM and MS 15.5%[24].

In 2009, 86 Indigenous people among the Kisêdjê (Suyá) people (eastern Xingu) were evaluated, and 33.7% were overweight, 12.8% were obese, 38.4% had central obesity, 3.5% had altered blood pressure levels, 63.9% had dyslipidemia, 4.0% had altered fasting glucose levels, without DM, and 21.9% had MS[32].

In the following decade, a new study was conducted with the Khisêdjê people, and we identified unprecedented incidence measures in the TIX. Among the 78 Indigenous people evaluated simultaneously in 1999/2000 and 2010/2011, we observed the cumulative incidence of 30.4% of overweight, 32.0% of central obesity, 29.1% of high total cholesterol, 25.0% of low HDLc, 10.4% of high LDLc, 47.4% of high triglycerides, 38.9% of hypertension, 2.9% of type 2 DM, and 37.5% of MS was observed. Unlike what was found by Baruzzi and Franco[50] and Pazzanese *et al.*[49], age was identified as a risk factor for the incidence of hypertension, DM, and high LDLc, regardless of gender[25]. Still, regarding the Khisêdjê, two other studies evaluated the Indigenous people's physical conditions and had satisfactory cardiometabolic results[13,52].

In 2013, among the Kawaiwete (lower Xingu) (n=62), 35.5% were overweight, 4.8% were obese, 58.1% had central obesity, 22.5% had high total cholesterol, 67.7% had low HDLc, 29.0% had high LDLc, 17.7% had high triglycerides, 25.8% had altered fasting glucose, 24.2% had high blood pressure, and 25.8% had MS[33].

Like the present research, the studies mentioned above published between 2007 and 2017[13,23-25,32,33,52], with different Indigenous ethnic groups from Xingu, identified an increased prevalence of NCDs and, consequently, a deteriorated cardiometabolic profile, when considering the studies published between 1964 and 1986[49-51].

Comparing studies conducted with other Indigenous peoples requires great care due to the different criteria and samples. However, a systematic review and meta-analysis published in 2022 evaluated the impact of urbanization on the cardiometabolic health of Indigenous Brazilians and, considering its scope, could serve as a reference parameter. The research included 46 studies, with a total of 20,574 Indigenous people from at least 33 ethnicities and found for the total population and for the Midwest (MW), where the TIX is located, respectively, 57.0% and 64.0% of excess weight (overweight + obesity); 18.0% and 23.0% of obesity; 58.0% and 58.0% of central obesity; 31.0% (MW without information) of high triglycerides; 53.0% (MW without information) of low HDLc; 40.0% (MW without information) of dyslipidemia; 23.0% and 24.0% of prediabetes (altered fasting glucose); 5.0% and 8.0% of DM; and 11.0% and 19.0% of high blood pressure levels. The prevalence of obesity among Indigenous people living in urbanized areas was 3.5 times that identified among those living in native lands (28.0% vs. 8.0%, respectively). The authors also found that, between 1997 and 2019, the crude cardiovascular mortality rate of Indigenous people living in the Southeast (more urbanized) was 2.5 times that observed among residents of the North (less urbanized) (1,942 vs. 758 cases for every 100,000 inhabitants, respectively), with the same pattern identified in the standardized rates. Finally, the authors conclude that changes in the traditional way of life of Indigenous people, especially those related to urbanization, are associated with a higher prevalence and risk of adverse cardiovascular events[14]. These results corroborate those found in this TIX research and reinforce the need to analyze the specificities of each region and ethnic group.

The analyses by gender of the TIX show a troubling cardiometabolic profile, and it is not possible to single out one of them as less affected. Regarding the analyses by base hub, the differences in the frequencies of NCDs stand out. The Leonardo and Wawi base hubs showed worse metabolic indicators than Pavuru and Diauarum. Diauarum had the lowest frequencies of indicators and NCDs. These differences may be related to factors such as more frequent access to cities, non-traditional foods, reduced physical activity patterns, and socioeconomic and environmental changes that TIX communities have been experiencing in recent decades[16,21,34]. However, further studies are needed to identify associations between factors implicated in the increase in NCDs by region and ethnicity.

A study published in 2021 with Indigenous people from the Kisêdjê ethnic group highlights that, besides identifying NCDs, it is essential to associate them with the meaning of these diseases for each population. Implementing collective strategies based on participatory or collaborative methodologies, ensuring dialogue and interconnection between concepts, practices, and knowledge, can mobilize processes to reverse many health problems. This requires the involvement and implication of all subjects in producing health, prevention, and the possibility of changing the course of these new diseases[34].

The studies above show a continuous growth trend in health problems related to chronic and noncommunicable conditions in the TIX over the years. Urban growth and growing surrounding roads, the deteriorated food insecurity during the COVID-19 pandemic, and changes in lifestyle and eating habits may signal an even more severe outlook in the coming years. Monitoring this health situation is essential.

One limitation of this study is that data do not allow in-depth discussion of the determinants and factors influencing the increase in NCDs. The qualitative data collected but not analyzed in this study may help to understand these determinants a posteriori. The second issue refers to the collection of data from 52.8% of the Indigenous people of the TIX, which could be minimized by evaluating the 95%CI of the outcomes of interest, which showed for the population values very close to those identified at the time.

As a strength, this is the most extensive study with Indigenous people from the TIX. The analysis by base hub identified relevant differences in the profile of NCDs in the same Indigenous territory. The results are similar to the realities of other territories and contribute to a greater understanding of the epidemiological transformations and vulnerability Brazilian Indigenous peoples experience.

In macropolitics, in 2023, the creation of a Ministry for Indigenous Peoples and the restructuring of the National Foundation for Indigenous Peoples (FUNAI) were significant achievements to resume protection of Indigenous territories after several years of attacks on Indigenous rights achieved and guaranteed by the Federal Constitution. Since these issues require an intersectoral approach, all institutions involved in the care of the people living in the TIX must structure territorial protection actions, including actions for the management and valorization of traditional foods.

Regarding the health sector, besides studies such as this one, which seek a better understanding and visibility of NCDs in this territory, proposals related to the training of multidisciplinary teams on how to tackle these issues in the territory and constant dialogue with communities must be continued in the TIX. Organizing workshops to promote traditional food and the appropriate use of non-traditional foods are also some successful strategies for the communities in this territory. We should underscore that the health surveillance model becomes essential in this territory to address this complex issue, and the information produced in this study will assist in planning and evaluating the services of the Xingu DSEI, identifying priorities and strategies more relevant to the reality.

Finally, we would like to answer the question "How long will Indigenous people, in intermittent contact with non-Indigenous people, be able to maintain their traditional characteristics of food, health, and life?" posed in 1981[50] by two pioneering authors in Indigenous health care, Roberto Baruzzi and Laércio Franco – in memoriam. Unfortunately, this situation has changed significantly and resulted in significant losses over approximately four decades. Public policies that recognize the right of Indigenous people to their lands and protect their traditional way of life need to be implemented urgently so that this health situation identified can be controlled and the harm to the native peoples of this land can be minimized.

Collaborations

SBM Mendonça and DA Rodrigues: study design and planning; data retrieval; critical review and approval of the final version. VM Haquim and PN Lemos: study design and planning; data retrieval and interpretation; drafting, critical review, and approval of the final version. Mazzucchetti: data analysis and interpretation; drafting, critical review, and approval of the final version.

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