Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Sociodemographic, Clinical, and Behavioral Factors Associated with Obesity among Paraguayan Adults: A Nationally Representative Cross-Sectional Study

Felicia Cañete

feliciacanete@gmail.com

National University of Asunción

Ethel Santacruz

Ministry of Public Health and Social Welfare

Luís Gatti

Ministry of Public Health and Social Welfare

Andrés Ávalos

Ministry of Public Health and Social Welfare

Noelia Cañete

Ministry of Public Health and Social Welfare

Alberto Barceló

University of Miami

Ángel José Ortellado

Ministry of Public Health and Social Welfare

Research Article

Keywords: Obesity, Risk factors, Noncommunicable diseases, Hypertension, Diabetes mellitus, Social determinants of health, STEPS survey, Paraguay

Posted Date: November 12th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10694355/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Although obesity has become a major global public health challenge, nationally representative evidence on its multifactorial determinants remains scarce in Paraguay. Obesity is closely linked to major noncommunicable diseases, including diabetes mellitus, hypertension, and cardiovascular diseases. This study aimed to analyze the sociodemographic, clinical, and behavioral factors associated with obesity among Paraguayan adults using nationally representative data.

Methods

An observational cross-sectional study was conducted using secondary data from the 2022 Paraguay WHO STEPS survey. A total of 5,098 adults aged 18–69 years were included through a stratified multistage cluster sampling design to obtain nationally representative estimates. Obesity was defined as a body mass index (BMI) ≥ 30 kg/m². Sociodemographic, clinical, and behavioral variables were analyzed using multivariable logistic regression models accounting for the complex survey design to compute adjusted odds ratios (aOR) and 95% confidence intervals (95% CI).

Results

The overall national prevalence of obesity was 33.0%, with a higher prevalence among women than men (37.8% vs. 28.2%). Obesity increased progressively with age, reaching 48.0% among individuals aged 40–49 years. Higher prevalence was also observed among married or cohabiting individuals, urban residents, and those in higher income brackets. In the final adjusted multivariable model, hypertension showed the strongest independent association with obesity (aOR = 2.5, 95% CI: 2.1–3.0), followed by age ≥ 40 years (aOR = 1.6, 95% CI: 1.3–1.9), urban residence (aOR = 1.3, 95% CI: 1.0–1.5), and being married or cohabiting (aOR = 1.2, 95% CI: 1.0–1.5). Lower income was associated with lower odds of obesity (aOR = 0.7, 95% CI: 0.6–0.8). No independent associations were observed for tobacco smoking, fruit and vegetable consumption, or physical activity.

Conclusions

Obesity affects one in three Paraguayan adults and is more strongly associated with sociodemographic and clinical characteristics than with individual behavioral factors in this population. These findings highlight the importance of addressing obesity through comprehensive public health strategies targeting social and environmental determinants rather than relying solely on individual behavioral advice. Given the cross-sectional design, causal inferences cannot be established.

Background

Obesity has become one of the most important global public health challenges because of its rapidly increasing prevalence and its contribution to morbidity, premature mortality, and healthcare costs. It is a major risk factor for chronic noncommunicable diseases, including type 2 diabetes mellitus, hypertension, and cardiovascular disease [1,2].

In recent decades, the sustained increase in obesity has been particularly notable in low- and middle-income countries, where nutritional transition, lifestyle changes, and urbanization have modified dietary patterns and physical activity behaviors [3,4].

In Latin America, obesity has reached alarming levels, affecting more than one-third of the adult population in several countries [5]. Paraguay is no exception to this trend, has experienced a steady increase in the prevalence of overweight and obesity in recent years, within the context of socioeconomic and demographic changes [6].

Several studies have shown that obesity is associated not only with individual factors such as age, sex, and educational level, but also with structural conditions including income, urban environment, and access to healthy foods [7,8]. Although these factors have been consistently reported worldwide, their relative contribution varies according to the socioeconomic, demographic, and epidemiological context of each country [2,9]. Furthermore, there is a strong bidirectional relationship between obesity and chronic diseases, particularly hypertension and diabetes, which increases disease burden and healthcare system costs [2,9].

In Paraguay, nationally representative evidence on factors associated with obesity remains scarce. Most available information is limited to prevalence estimates, whereas comprehensive analyses simultaneously evaluating sociodemographic, clinical, and behavioral determinants using nationally representative data are still lacking. Identifying these factors is essential for designing evidence-based public health policies and interventions aimed at preventing and controlling obesity.

The aim of this study was to analyze the sociodemographic, clinical, and behavioral factors associated with obesity among adults in Paraguay using secondary data from the 2022 Paraguay STEPS survey.

Materials and Methods

Study design and data source

This study was a secondary analysis of data from the 2022 Paraguay National Survey of Risk Factors for Noncommunicable Diseases (2022 Paraguay STEPS survey), an observational cross-sectional survey conducted by the Ministry of Public Health and Social Welfare of Paraguay following the World Health Organization (WHO) STEPwise Approach to NCD Risk Factor Surveillance (WHO STEPS). Data collection was conducted between July and October 2022.

The survey sample size was calculated according to the WHO STEPS methodology, considering the expected prevalence of the main risk factors, desired precision, sampling error, design effect, and anticipated non-response.

The survey used a stratified multistage cluster probabilistic sampling design to obtain nationally representative estimates for the adult population of Paraguay, including urban and rural areas. Eligible participants were adults aged 18–69 years residing in private households. Individuals living in collective institutions, temporary visitors, and participants with missing weight or height measurements were excluded from the present analysis.

The final analytical sample comprised 5,098 participants, including 2,210 men and 2,888 women.

Sociodemographic, anthropometric, clinical, and behavioral variables were included in the analysis.

Sociodemographic variables included sex, age, area of residence (urban/rural), interview language (Guaraní or Spanish), educational level, marital status, employment status, and annual income (Paraguayan guaraníes).

Anthropometric measurements were performed following the standardized procedures of the WHO STEPwise Approach to NCD Risk Factor Surveillance (STEPS), using calibrated equipment and trained personnel. Body weight was measured using calibrated digital scales, with participants barefoot and wearing light clothing, and recorded in kilograms (kg). Height was measured using standardized portable stadiometers, with participants barefoot, standing upright, with the head positioned in the Frankfurt plane and heels together, and recorded in centimeters (cm). Waist circumference was measured using a non-extensible measuring tape placed at the midpoint between the lower margin of the last palpable rib and the iliac crest, with participants standing and at the end of a normal expiration, and recorded in centimeters (cm).

Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m²), according to WHO STEPS criteria. BMI was classified as underweight (< 18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), and obesity (≥ 30.0 kg/m²). For logistic regression analyses, obesity was analyzed as a dichotomous outcome (BMI ≥ 30.0 kg/m²).

Behavioral variables were obtained using the standardized WHO STEPS questionnaire and included fruit and vegetable consumption, smoking, and physical activity. Fruit and vegetable consumption was assessed based on the reported number of servings consumed per week. Smoking was evaluated through questions on current daily smoking status and the number of cigarettes smoked per day. Physical activity was classified according to the WHO STEPS protocol and the International Physical Activity Questionnaire (IPAQ) criteria as low, moderate, or high, based on MET-minutes/week derived from the reported frequency, duration, and intensity of physical activities.

Diabetes mellitus was defined as a self-reported previous diagnosis by a healthcare professional and/or fasting blood glucose ≥ 126 mg/dL.

Hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg measured during the survey, and/or self-reported use of antihypertensive medication. Blood pressure measurements were performed according to the WHO STEPS protocol using calibrated equipment and standardized procedures. Three consecutive blood pressure measurements were obtained with participants seated and at rest, and the average of the last two measurements was used for analysis.

Statistical Analysis

Data were analyzed using the Complex Samples module of IBM SPSS Statistics version XX (IBM Corp., Armonk, NY, USA), accounting for the complex survey design through the incorporation of sampling weights, strata, and primary sampling units (clusters).

Descriptive statistics included means with 95% confidence intervals (95% CI) for continuous variables and proportions for categorical variables.

Associations between categorical variables were assessed using the Rao–Scott adjusted chi-square test.

Multivariable logistic regression models were used to estimate odds ratios (OR) and corresponding 95% confidence intervals (95% CI) for factors associated with obesity.

- Model 1: adjusted for sociodemographic, clinical, and behavioral variables.
- Model 2: adjusted for sociodemographic variables only.
- Model 3: final adjusted model including variables that were statistically significant and epidemiologically relevant in the previous two models.

For the final adjusted model, Adjusted Odds Ratio (aOR) was considered.

A two-sided p-value < 0.05 was considered statistically significant.

Potential sources of bias included the self-reported nature of behavioral variables, which may be subject to recall and social desirability bias. Anthropometric and blood pressure measurements were obtained following standardized WHO STEPS procedures performed by trained personnel, minimizing measurement bias. Selection bias was minimized through the nationally representative multistage probabilistic sampling design.

Results

A total of 5,098 participants were included in the analysis. The mean age was 38.3 years (95% CI: 37.7–38.8), with no relevant differences between men and women. Men had higher mean body weight (84.1 vs. 73.9 kg) and height (172.5 vs. 160.0 cm), whereas mean body mass index (BMI) was similar between sexes (28.3 vs. 28.7 kg/m²; overall mean: 28.5 kg/m²).

Participants completed approximately 10 years of schooling on average, with similar educational attainment in men and women. Annual income was higher among men than women (45,003,000 vs. 38,522,000 million G$). Women reported greater fruit and vegetable consumption, whereas men had higher levels of physical activity and larger waist circumference. Among smokers, women reported smoking a greater number of cigarettes per day (Table 1).

Table 1
Continuous Variables, Paraguay 2022.

Characteristics	Male			Female			Both		
	n	Mean	CI-95%%	n	Mean	CI-95%%	n	Mean	CI-95%%
Age	2,210	38.2	37.4–39.0	2,888	38.3	37.6–38.9	5,098	38.3	37.7–38.8
Weight	2,012	84.1	80.7–87.6	2,617	73.9	70.9–77.0	4,629	79.1	76.8–81.4
Hight	2,012	172.5	171.2–173.7	2,617	160.0	157.4–162.7	4,629	166.3	164.8–167.8
BMI	2,012	28.3	27.2–29.4	2,617	28.7	28.3–29.0	4,629	28.5	27.8–29.1
Years of education	2,207	9.9	9.6–10.2	2,888	9.7	9.4–9.9	5,095	9.8	9.6–10.0
Annual income*	433	45,003	41,765–48,241	159	38,522	36,304–40,741	592	41,863	39,610–44,115
Daily cigarettes	2,208	42.9	19.2–66.6	2,887	102.4	38.9–165.9	5,095	55.7	32.1–79.3
Portions of fruits	2,209	7.2	6.8–7.56	2,885	8.0	7.7–8.4	5,094	7.6	7.3–7.9
Portions vegetables	1,901	4.7	4.5–5.0	2,352	5.1	4.9–5.3	4,253	4.9	4.7–5.1
Waist circumference	2,004	95.2	94.3–96.0	2,610	90.1	89.3–91.0	4,614	92.7	92.1–93.3
Physical activity (MET)	2,006	4,053	3,707-4,398	2,663	2,295	2,057 – 2,534	4,669	3,180	2,949-3,412
* x1000 (millions)									

The study population was predominantly aged 20–39 years (approximately 59%). Most participants resided in urban areas (74.8%), and Spanish was the predominant interview language (91.7%). Secondary education was the most frequent educational level (49.3%), and approximately half of the participants were married or cohabiting (49.5%).

Employment status varied by sex. Men were more frequently engaged in formal employment and self-employment, whereas women more commonly reported unpaid work or household activities. The distribution across income quintiles was relatively homogeneous (Table 2).

Table 2
Demographics characteristics by gender, Paraguay 2022.

Characteristic	Male		Female		Both	
	n = 2,210		n = 2,888		n = 5,098	
Age group	%	CI-95%	%	CI-95%	%	CI-95%
< 20 years	5.0	3.7–6.7	4.7	3.7–5.9	4.8	4.0-5.8
20–29	29.7	27.3–32.3	29.3	27.1–31.7	29.5	27.9–31.2
30–39	24.0	21.9–26.1	29.3	27.1–31.7	29.5	27.9–31.2
40–49	16.8	15.0-18.7	17.5	15.9–19.2	17.1	15.9–18.4
50–59	15.1	13.5–16.9	15.2	13.6–16.9	15.2	13.9–16.5
60+	9.4	8.2–10.8	9.5	8.5–10.6	9.5	8.6–10.4
Residency						
Urban	74.3	69.7–78.4	75.3	71.1–79.1	74.8	70.6–78.6
Rural	25.7	21.6–30.3	24.7	20.9–28.9	25.2	21.4–29.4
Interview language						
Guaraní	9.5	7.9–11.3	7.1	6.0-8.4	8.3	7.3–9.4
Spanish	90.5	88.7–92.1	92.9	91.6–94.0	91.7	90.6–92.7
Level of education						
None	2.9	2.2–3.8	3.8	3.0-4.8	3.4	2.8-4.0
Primary	27.8	25.2–30.5	30.4	27.9–33.0	29.1	27.0-31.2
Secondary	51.9	49.3–54.4	46.7	44.3–49.2	49.3	47.5–51.2
University	17.5	15.1–20.1	19.1	16.9–21.5	18.3	16.4–20.3
Civil status						
Single	46.7	44.2–49.2	38.7	36.4–41.1	42.7	40.9–44.5
Married, in union	47.8	45.4–50.1	51.2	48.7–53.7	49.5	47.7–51.3
Divorced, widowed	5.6	4.6–6.7	10.1	8.8–11.5	7.8	7.0-8.7
Employment status						
Employed	45.5	42.5–48.5	29.2	27.0-31.6	37.4	35.5–39.4
Self-employed	44.1	41.4–46.9	30.2	28.1–32.3	37.2	35.5–39.0
Student, volunteer	3.7	2.7–4.9	5.4	3.9–7.3	4.5	3.6–5.6
* x1000 (millions)						

Characteristic	Male		Female		Both	
	n = 2,210		n = 2,888		n = 5,098	
Retired, homemaker	1.9	1.4–2.7	31.6	29.3–34.0	16.7	15.4–18.1
Disable, unknown	4.8	3.8–6.1	3.6	2.8–4.7	4.2	3.5–5.1
Income*/ year (quintiles, Gs)						
< 15,600,000	14.7	12.6–17.0	21.3	19.0-23.9	17.9	16.1–19.8
15,600,000–25,344,000	14.7	12.6–17.0	21.3	19.0-23.9	17.9	16.1–19.8
25,344,001–34,800,000	20.4	18.0-23.2	21.7	19.7–23.9	21.1	19.3–22.9
34,800,001–58,800,000	22.9	20.4–25.5	19.6	17.5–22.0	21.3	19.6–23.1
> 58,800,000	20.6	18.2–23.3	17.4	15.3–19.7	19.1	17.2–21.1
* x1000 (millions)						

The prevalence of diabetes was higher among women than men (12.0% vs. 9.1%; p = 0.021), whereas hypertension was more frequent among men (37.2% vs. 28.9%; p < 0.001).

Insufficient fruit consumption (< 14 portions/week) was highly prevalent in both sexes but was more frequent among men (83.0% vs. 77.8%; p < 0.001). No significant sex differences were observed for vegetable consumption or smoking prevalence.

Women had a higher prevalence of high-risk waist circumference, whereas men showed higher levels of physical activity. Regarding nutritional status, obesity was more frequent among women (37.8% vs. 28.2%), while overweight predominated among men (40.4% vs. 32.3%) (p < 0.001) (Table 3).

Table 3
Chronic diseases and risk factors by gender, Paraguay 2022.

Characteristic	Male		Female		Both	
	n = 2,210		n = 2,888		n = 5,098	
	%	CI-95%	%	CI-95%	%	CI-95%
Diabetes						
Yes	9.1	7.4–11.1	12.0	10.6–13.6	10.6	9.4–11.8
No	90.9	88.9–92.6	88.0	86.4–89.4	89.4	88.2–90.6
p					0.021	
Hypertension						
Yes	37.2	34.5–39.9	28.9	27.0–30.9	33.0	31.3–34.8
No	62.8	60.1–65.5	71.1	69.1–73.0	67.0	65.2–68.7
p					< 0.001	
Daily smoker						
Yes	60.0	54.0–65.7	54.3	43.1–65.0	58.8	53.7–63.7
No	40.0	34.3–46.0	45.7	35.0–56.9	41.2	36.3–46.3
p					0.381	
Fruit consumption (week)						
< 14 portions	83.0	81.0–84.8	77.8	75.8–79.7	80.4	78.9–81.8
14 + portions	17.0	15.2–19.0	22.2	20.3–24.2	19.6	18.2–21.1
p					< 0.001	
Vegetable consumption (week)						
< 21 portions	93.1	91.5–94.5	91.9	90.6–93.0	92.5	91.5–93.4
21 + portions	6.9	5.5–8.5	8.1	7.0–9.4	7.5	6.6–8.5
p					0.208	
Waist circumference						
Low risk	47.8	44.9–50.8	25.4	23.3–27.7	36.8	34.9–38.8
Moderate risk	23.8	21.4–26.3	21.6	19.6–23.9	22.7	21.2–24.3
High risk	28.4	25.9–31.1	52.9	50.2–55.6	40.5	38.5–42.4
p					< 0.001	
Physical activity:						

Characteristic	Male		Female		Both	
	n = 2,210		n = 2,888		n = 5,098	
Low (< 600 MET-min/week)	17.0	14.7–19.6	30.5	28.0–33.2	23.5	17.0
Moderate (600-1,499 MET-min/week)	20.4	17.9–23.2	28.0	25.6–30.5	24.0	20.4
High (≥ 1,500 MET-min/week)	62.6	59.3–65.7	41.5	38.5–44.6	52.5	62.6
p					< 0.001	
Body Mass Index						
Underweight (< 20 Kg/m^2)	1.4	0.9–2.2	2.2	1.5–3.0	1.8	1.4–2.3
Normal (20–24 Kg/$m^{2)}$	30.0	27.3–32.8	27.7	25.3–30.3	28.9	27.0–30.8
Overweight (25–29 Kg/m^2)	40.4	38.0–42.9	32.3	30.0–34.8	36.4	34.6–38.2
Obese (≥ 30 Kg/m^2)	28.2	25.7–30.8	37.8	35.4–40.2	33.0	31.2–34.8
p					< 0.001	

Obesity prevalence increased progressively with age, from 14.4% among individuals younger than 20 years to 48.0% among those aged 40–49 years, remaining high in the older age groups. Women had a higher prevalence of obesity than men. Obesity was also slightly more frequent among urban than rural residents and among married/cohabiting and divorced/widowed participants than among single individuals. Differences in obesity prevalence were observed across educational levels, although no consistent pattern was evident. Higher obesity prevalence was observed among retired individuals and homemakers, and obesity tended to be more frequent in the upper income quintiles, reaching its highest prevalence in the highest-income group (Table 4).

Table 4
Classification of BMI by demographic characteristics, Paraguay 2022.

Characteristic	**Underweight**		**Normal**		**Overweight**		**Obese**	
Age group	%	CI-95%	%	CI-95%	%	CI-95%	%	CI-95%
< 20 years	7.0	4.0–12.2	58.1	47.3–68.1	20.5	13.8–29.5	14.4	8.7–22.7
20–29	2.8	1.8–4.5	42.3	38.5–46.1	36.3	32.9–39.7	18.7	15.7–22.0
30–39	0.9	0.4–1.7	26.5	23.0–30.3	35.3	31.6–39.3	37.3	33.9–40.9
40–49	0.7	0.3–1.7	15.2	12.7–18.2	36.1	31.9–40.4	48.0	43.9–52.1
50–59	1.0	0.5–1.9	16.7	13.9–19.9	42.1	37.7–46.7	40.2	36.2–44.4
60+	1.2	0.6–2.3	20.7	16.8–25.3	39.5	35.4–43.7	38.6	34.6–42.9
All	1.8	1.4–2.3	28.9	27.0–30.8	36.4	34.6–38.2	33.0	31.2–34.8
Gender								
Male	1.4	0.9–2.2	30.0	27.3–32.8	40.4	38.0–42.9	28.2	25.7–30.8
Female	2.2	1.5–3.0	27.7	25.3–30.3	32.3	30.0–34.8	37.8	35.4–40.2
Residence								
Urban	1.7	1.2–2.4	27.9	25.6–30.4	36.4	34.2–38.6	34.0	31.8–36.2
Rural	2.0	1.3–3.0	31.5	28.8–34.3	36.4	33.7–39.1	30.1	27.4–32.9
Survey language								
Guaraní	0.6	0.1–4.4	30.1	24.6–36.3	38.1	32.4–44.0	31.2	25.6–37.3
Spanish	1.9	1.4–2.5	28.7	26.8–30.8	36.3	34.4–38.1	33.1	31.3–35.0
Educational level								
None	6.3	2.4–15.8	26.0	18.4–35.3	34.5	27.2–42.6	33.3	26.0–41.4
Primary	1.5	0.9–2.6	24.2	21.3–27.4	37.8	35.0–40.6	36.5	33.7–39.3
* x1000 (millions)								

Characteristic	Underweight		Normal		Overweight		Obese	
Secondary	1.9	1.4–2.8	34.4	31.8–37.2	34.3	31.7–37.0	29.3	26.9–31.8
University	0.8	0.3–2.2	21.8	18.0–26.1	40.2	35.7–44.9	37.2	32.5–42.0
Civil status								
Single	2.9	2.1–4.1	37.9	34.8–41.0	33.9	31.2–36.7	25.3	23.0–27.8
Married, in union	0.9	0.6–1.5	23.2	20.9–25.6	38.4	35.8–41.0	37.5	35.1–40.1
Divorced, widowed	0.6	0.2–1.9	15.4	11.8–19.8	37.8	31.8–44.1	46.3	39.9–52.7
Employment status								
Employed	0.7	0.4–1.3	29.8	26.9–32.8	39.1	35.8–42.6	30.4	27.4–33.5
Self-employed	1.1	0.7–1.8	27.2	24.5–30.1	36.8	34.0–39.6	34.9	32.3–37.6
Student, volunteer	8.2	4.5–14.7	49.2	39.8–58.7	25.8	18.1–35.4	16.8	10.6–25.5
Retired, homemaker	2.1	1.2–3.6	23.2	19.7–27.1	32.7	29.3–36.2	42.1	38.4–45.9
Disable, unknown	8.5	4.0–17.1	35.9	27.6–45.1	34.3	26.3–43.2	21.3	14.7–29.8
Income*/ year (quintiles, Gs)								
< 15,600,000	1.0	0.6–1.9	34.6	30.0–39.5	36.6	32.6–40.9	27.8	23.7–32.3
15,600,000–25,344,000	2.5	1.5–4.3	31.9	28.2–35.9	36.2	32.6–40.1	29.3	25.7–33.2
25,344,001–34,800,000	1.3	0.7–2.4	27.2	23.4–31.3	38.2	33.6–43.1	33.3	29.3–37.6
34,800,001–58,800,000	1.6	0.9–3.2	28.5	24.7–32.6	37.0	33.1–41.0	32.9	29.2–36.8
> 58,800,000	1.2	0.5–2.8	19.7	16.4–23.5	36.4	32.3–40.7	42.7	37.9–47.6
* x1000 (millions)								

Obesity was significantly more frequent among individuals with diabetes than among those without diabetes (51.5% vs. 30.9%; $p < 0.001$) and among participants with hypertension than among those without hypertension (47.7% vs. 25.6%; $p < 0.001$). No significant associations were observed between obesity and smoking or fruit and vegetable consumption. Conversely, obesity was more frequent among participants with elevated waist

circumference and showed a weak association with low physical activity, although the latter did not reach statistical significance (Table 5).

Table 5
Classification of BMI by chronic diseases and risk factors, Paraguay 2022.

Characteristic	Underweight		Normal		Overweigh		Obese	
	n = 77		n = 1,200		n = 1,592		n = 1,694	
	%	CI-95%	%	CI-95%	%	CI-95%	%	CI-95%
Diabetes								
Yes	1.0	0.4–2.4	15.2	11.6–19.6	32.3	27.0–38.1	51.5	45.9–57.1
No	1.9	1.4–2.5	30.4	28.4–32.4	36.9	35.0–38.7	30.9	29.1–32.8
p							< 0.001	
Hypertension								
Yes	0.8	0.4–1.5	17.7	15.4–20.1	33.8	31.3–36.5	47.7	44.9–50.5
No	2.3	1.7–3.0	34.5	32.0–37.0	37.7	35.3–40.1	25.6	23.7–27.7
p							< 0.001	
Daily smoker								
Yes	2.1	1.1–3.9	39.3	31.5–47.6	31.2	24.7–38.4	27.5	21.2–34.7
No	2.2	0.9–5.6	35.0	27.8–42.9	33.2	25.8–41.6	29.5	22.1–38.2
p							0.864	
Fruit consumption (week)								
< 14 portions	1.8	1.4–2.5	29.5	27.3–31.9	36.0	34.0–38.0	32.6	30.7–34.6
14 + portions	1.3	0.7–2.4	26.0	22.7–29.6	38.2	34.2–42.4	34.5	31.0–38.2
p							0.254	
Vegetable consumption (week)								
< 21 portions	1.8	1.3–2.3	29.2	27.3–31.3	36.3	34.5–38.1	32.7	30.8–34.6
21 + portions	1.3	0.3–5.2	23.8	18.3–30.4	37.8	31.4–44.7	37.1	31.2–43.4
p							0.379	

Characteristic	Underweight		Normal		Overweigh		Obese	
	n = 77		n = 1,200		n = 1,592		n = 1,694	
Waist circumference								
Low risk	3.8	2.8–5.1	64.1	60.6–67.4	30.2	27.1–33.6	1.8	1.2–2.8
Moderate/high risk	0.5	0.2–0.9	8.1	6.9–9.4	40.2	38.0–42.5	51.2	49.0–53.5
p							< 0.001	
Physical activity								
Low (< 600 MET-min/week)	2.3	1.4–3.7	27.0	23.1–31.2	35.2	31.4–39.1	35.6	31.8–39.6
Moderate/high (≥ 600 MET-min/week)	1.3	0.9–1.8	30.6	28.4–32.9	36.7	34.6–38.9	31.4	29.3–33.6
P								0.048

In the multivariable regression analysis, diabetes was associated with an increased risk of obesity (OR = 2.4; 95% CI: 1.8–3.0), consistently in both men and women. Hypertension showed the strongest overall association with obesity (overall OR = 2.6), with an even stronger association among women (OR = 3.2; 95% CI: 2.6–3.9). No significant associations were observed for smoking or fruit and vegetable consumption. Low physical activity showed a trend toward an increased risk of obesity but did not reach statistical significance (Table 6).

Table 6
Obesity risk (OR, CI-95%%) by the presence chronic diseases and risk factors by gender, Paraguay 2022.

Factor		Gender								
		Male			Female			Both		
	%	OR	CI-95%		%	OR	CI-95%	%	OR	CI-95%
Diabetes	Yes	12.1	1.9	1.3–2.9	18.0	2.6	2.0–3.5	15.5	2.4	1.8–3.0
	No	6.7	Ref	-	7.7	Ref	-	7.1	Ref	-
	p		0.002			< 0.001			< 0.001	
Hypertension	Yes	52.5	2.4	1.9–3.1	44.9	3.2	2.6–3.9	48.2	2.6	2.3–3.1
	No	30.9	Ref	-	20.2	Ref	-	26.0	Ref	-
	p		< 0.001			< 0.001			< 0.001	
Daily smoker	Yes	57.7	0.8	0.4–1.6	57.7	1.2	0.5–2.8	57.7	0.9	0.5–1.5
	No	62.0	Ref	-	53.1	Ref	-	60.1	Ref	-
	p		0.577			0.664			0.705	
Fruit consumption (14 portions/ week)	Yes	81.8	0.9	0.6–1.2	78.9	1.0	0.8–1.3	80.2	0.9	0.7–1.1
	No	16.2	Ref	-	21.2	Ref	-	18.5	Ref	-
	p		0.399			0.965			0.398	
Vegetable consumption (21 portions / week)	Yes	92.4	0.7	0.4–1.2	91.9	0.9	0.7–1.3	92.1	0.8	0.6–1.1
	No	5.7	Ref	-	7.7	Ref	-	6.6	Ref	-
	p		0.187			0.748			0.187	
Low physical activity (< 600 MET-min/week)	Yes	27.5	0.98	0.68–1.42	40.6	1.22	0.97–1.54	35.6	1.21	0.99–1.48
	No	27.8	Ref	—	35.9	Ref	—	31.4	Ref	—

Factor	Gender								
	Male			Female			Both		
	%	OR	CI-95%	%	OR	CI-95%	%	OR	CI-95%
	p		0.933			0.089			0.059

Age ≥ 40 years was associated with a higher risk of obesity (OR = 2.2; 95% CI: 1.9–2.5). Being married or cohabiting was also associated with a higher risk of obesity (OR = 1.6). Lower income was associated with a lower risk of obesity (OR = 0.7; 95% CI: 0.6–0.8). Urban residence was associated with a higher risk of obesity in the overall analysis, although this association was not consistent across sex-stratified analyses. No significant associations were observed for survey language or employment status (Table 7).

Table 7
Obesity risk (OR, CI-95%%) by demographic characteristics and gender, Paraguay 2022.

Factor		Gender								
		Male			Female			Both		
	%	OR	CI-95%		%	OR	CI-95%	%	OR	CI-95%
Age	< 40	40.9	Ref	-	41.8	Ref	-	41.3	Ref	-
	≥40	59.1	1.7	1.3–2.1	58.2	2.7	2.3–3.3	58.7	2.2	1.9–2.5
	p		< 0.001			< 0.001			< 0.001	
Residency	Urban	73.8	1.6	1.2–2.0	74.4	0.946	0.8–1.1	74.1	1.194	1.0–1.4
	Rural	26.2	Ref	-	25.6	Ref	-	25.9	Ref	-
	p		< 0.001			0.582			0.035	
Guaraní	Yes	9.4	0.906	0.3–1.4	6.8	1.0	0.7–1.4	8.1	0.9	0.7–1.2
language	No	90.6	Ref	-	93.2	Ref	-	91.9	Ref	-
	p		0.650			0.990			0.538	
Education	0–6	31.6	0.7	0.6–1.0	35.0	1.8	1.4–2.2	33.3	1.2	1.6–1.4
	> 6	68.4	Ref	-	65.0	Ref	-	66.7	Ref	-
	p		0.023			< 0.001			0.008	
Married/union	Yes	24.2	1.711	1.3–2.3	25.4	1.5	1.2–1.9	24.8	1.6	1.4–1.9
	No	75.8	Ref	-	74.6	Ref	-	75.2	Ref	-
	p		< 0.001			< 0.001			< 0.001	
Employed	Yes	89.5	1.5	0.9–2.5	59.1	1.0	0.8–1.3	74.3	0.9	0.8–1.1
	No	10.5	Ref	-	40.9	Ref	-	25.7	Ref	-
	p		0.087			0.775			0.480	
Annual income*	< 30,000	44.8	Ref	-	51.3	Ref	-	48.0	Ref	-

* x1000 (millions)

Factor		Gender								
		Male			Female			Both		
	%	OR	CI-95%	%	OR	CI-95%	%	OR	CI-95%	
	≥ 30,000	55.2	0.5	0.3–0.6	48.7	1.0	0.8–1.2	52.0	0.7	0.6–0.8
	p		< 0.001			0.818			< 0.001	
* x1000 (millions)										

In the fully adjusted model (Model 3), hypertension remained the factor most strongly associated with obesity (aOR = 2.5; 95% CI: 2.1–3.0), followed by age ≥ 40 years (aOR = 1.6; 95% CI: 1.3–1.9). Urban residence was independently associated with a higher risk of obesity (aOR = 1.3; 95% CI: 1.0–1.5), as was being married or living in union (aOR = 1.2; 95% CI: 1.0–1.5). Participants with an annual income below 30,000,000 guaraníes were less likely to have obesity than those with higher incomes (aOR = 0.7; 95% CI: 0.6–0.8). No independent associations were observed for Guaraní interview language, educational level, or employment status (Table 8).

Table 8
Adjusted risk of obesity (OR, CI-95%%) using three model of logistic regression, Paraguay 2022.

Factor		Model 1			Model 2			Model 3		
		aOR	CI-95%	p	aOR	CI-95%	p	aOR	CI-95%	p
Gender	M/F	0.65	0.34–1.23	0.183	0.6	0.5–0.8	< 0.001	0.6	0.5–0.7	< 0.001
Age (years)	40+/<40	1.39	0.69–2.78	0.355	2.0	1.7–2.4	< 0.001	1.6	1.3–1.9	< 0.001
Urban residency	Yes/No	1.84	0.92–3.65	0.083	1.2	1.0–1.4	0.106	1.3	1.0–1.5	0.019
Guaraní interview	Yes/No	0.53	0.20–1.42	0.207	0.9	0.6–1.2	0.357	0.9	0.6–1.1	0.304
Education	0–6/7+	0.76	0.34–1.73	0.512	1.1	1.0–1.3	0.403	1.0	0.8–1.2	0.997
Married/in union	Yes/No	2.30	1.00–5.27	0.049	1.2	1.0–1.5	0.033	1.2	1.0–1.5	0.042
Employed	Yes/No	2.13	0.99–4.62	0.055	1.0	0.8–1.3	0.757	1.1	0.9–1.3	0.486
Income*	< 30,000/ ≥30,000	0.46	0.23–0.92	0.028	0.7	0.6–0.8	< 0.001	0.7	0.6–0.8	< 0.001
Diabetes	Yes/No	1.13	0.44–2.86	0.805	—	—	—	—	—	—
Hypertension	Yes/No	1.56	0.79–3.08	0.196	—	—	—	2.5	2.1–3.0	< 0.001
Daily smoker	Yes/No	0.88	0.46–1.68	0.700	—	—	—	—	—	—
Fruits (< 14 portions/week)	Yes/No	1.61	0.71–3.65	0.256	—	—	—	—	—	—
Vegetables < 21 portions/week	Yes/No	1.08	0.38–3.07	0.888	—	—	—	—	—	—
Low physical activity	Yes/No	0.95	0.38–2.35	0.912						
* x1000 (millions)										
STROBE Checklist Compliance										
A completed STROBE checklist for cross-sectional studies has been prepared and is available as supplementary material.										

Discussion

The present study, based on nationally representative data from the 2022 Paraguay STEPS survey, found that approximately one in three Paraguayan adults was living with obesity, confirming obesity as a major public health challenge in the country. Beyond documenting a high national prevalence, this study identified important sociodemographic, clinical, and contextual factors associated with obesity, underscoring its multifactorial nature. These findings are consistent with recent global estimates showing that obesity has more than doubled among adults over the past three decades and now affects more than one billion people worldwide, with the fastest increases occurring in many low- and middle-income countries undergoing nutritional and epidemiological transition (1, 10).

In Latin America, this transition has been driven by rapid urbanization, changes in food systems, and increasingly obesogenic environments, resulting in a complex interplay of biological, social, economic, and environmental determinants of obesity (11). Accordingly, the pattern observed in Paraguay is consistent with the obesity transition described in several middle-income countries, where obesity initially predominates among women, adults, and socioeconomically advantaged groups (12).

Age ≥ 40 years emerged as one of the strongest determinants of obesity in this study, a finding consistent with reports from both high-income and low- and middle-income countries, including populations from Latin America (14, 15). Several biological mechanisms have been proposed to explain the higher prevalence of obesity with advancing age, including a progressive decline in lean body mass, reduced resting energy expenditure, and hormonal alterations that favor adipose tissue accumulation (15). In addition, cumulative exposure to obesogenic environments across the life course may contribute to weight gain and later obesity risk (16). These findings highlight the importance of adopting a life-course approach to obesity prevention and cardiometabolic risk reduction, with interventions beginning early in adulthood before excess weight and related risks become established (17).

Women showed a higher prevalence of obesity than men, consistent with findings from epidemiological studies conducted in both high-income and low- and middle-income countries, including Latin America (14, 18). Although biological factors such as pregnancy, menopause, and sex hormone-related differences in body fat distribution contribute to these disparities, they do not fully explain the higher burden of obesity among women (18). Social determinants, including gendered social roles, a greater burden of unpaid domestic and caregiving work, lower opportunities for leisure-time physical activity, and unequal access to healthy environments, also play a substantial role in shaping obesity risk among women (18, 19). These findings support the incorporation of a gender-sensitive perspective into obesity prevention policies, recognizing that effective interventions should address not only individual behaviors but also the social and structural conditions that shape health outcomes (18, 19).

The independent association between urban residence and obesity observed in the present study is consistent with growing evidence highlighting the role of obesogenic urban environments in shaping dietary behaviors and physical activity patterns (11, 13). Rapid urbanization has been accompanied by increased availability and marketing of ultra-processed foods, greater reliance on motorized transportation, more sedentary occupations, and reduced opportunities for routine physical activity, all of which contribute to positive energy balance and weight gain (11, 13). Similar patterns have been described across Latin America, where urbanization,

socioeconomic inequalities, and characteristics of the built environment have emerged as major drivers of the obesity epidemic (11). These findings reinforce the need for multisectoral action beyond the health sector, incorporating urban planning, food policies, active transportation, and healthier community environments as essential components of obesity prevention (21).

The positive association between being married or living with a partner and obesity observed in this study is consistent with recent evidence from a systematic review and meta-analysis demonstrating that married individuals have a higher likelihood of obesity than those who are single, divorced, or widowed (22). Several behavioral and social mechanisms have been proposed to explain this association, including changes in dietary habits, increased frequency of shared meals, larger portion sizes, reduced motivation to maintain a healthy body weight after partnership formation, and lower levels of leisure-time physical activity (22, 23). These findings suggest that family- and couple-based interventions may represent an important component of comprehensive obesity prevention strategies, as evidence indicates that lifestyle interventions involving couples achieve greater weight reduction than individual-based approaches (24).

Higher socioeconomic status was independently associated with obesity in this study, both in descriptive analyses and multivariable models. This finding is consistent with evidence from several low- and middle-income countries, where obesity has historically been more prevalent among socioeconomically advantaged groups during the early stages of the obesity transition (12). The higher prevalence of obesity among socioeconomically advantaged individuals observed in this study is consistent with the obesity transition framework proposed by Jaacks et al., in which obesity initially predominates among higher socioeconomic groups before progressively shifting toward more disadvantaged populations as countries undergo economic and nutritional transition (12). In Latin America, rapid economic development, urbanization, and changes in food systems have been associated with shifts in dietary patterns and lifestyles that favor obesity (11, 13). These findings highlight the importance of considering the country's stage of the obesity transition and socioeconomic inequalities when designing obesity prevention strategies, as the social distribution of obesity and the populations at greatest risk may differ according to the stage of the transition (12, 20).

Among the clinical factors evaluated, hypertension was independently associated with obesity in the final multivariable model, consistent with the well-established epidemiological relationship between both conditions.

Together, obesity and hypertension are major contributors to cardiovascular disease and premature mortality, reinforcing the importance of integrating obesity prevention and hypertension control into comprehensive public health strategies aimed at reducing the cardiovascular burden of noncommunicable diseases (25, 26).

The nationally representative design of the STEPS survey provides robust evidence on the distribution of obesity and its associated factors among Paraguayan adults, supporting the generalizability of these findings to the national population aged 18–69 years. Nevertheless, the cross-sectional design precludes causal inference, and the self-reported assessment of behavioral variables may have introduced recall and social desirability bias.

Limitations and strengths

The cross-sectional design does not allow establishing temporal or causal relationships between the factors examined and obesity. Some variables, particularly behavioral characteristics such as fruit and vegetable consumption, smoking, and physical activity, relied on self-reported information and may therefore be affected by recall bias and social desirability bias. Additionally, diabetes status was partially based on self-reported previous diagnosis, which may underestimate the true prevalence because undiagnosed diabetes is more common among populations with limited access to healthcare.

Despite these limitations, this study has several important strengths. It is, to our knowledge, one of the first nationally representative studies to comprehensively examine sociodemographic, clinical, and behavioral factors associated with obesity among Paraguayan adults using standardized WHO STEPS methodology. It uses a large, nationally representative sample with rigorous data collection following international standards. Finally, the inclusion of multiple domains of determinants within the same multivariable framework provides a comprehensive assessment of obesity that is directly relevant for informing national public health policies and multisectoral prevention strategies in the Paraguayan context.

Generalizability

The findings of this study are generalizable to the adult population of Paraguay aged 18–69 years, given the nationally representative sampling design. The use of sampling weights and complex survey analysis further enhances the external validity of the estimates. However, these findings should not be extrapolated to individuals younger than 18 years, adults older than 69 years, or populations outside Paraguay, where demographic characteristics, healthcare systems, and social determinants of obesity may differ.

Conclusions

The findings of this study support a social determinant of health approach to obesity in Paraguay, highlighting that obesity results from a complex interplay of sociodemographic, clinical, and structural factors. The observed associations with age, sex, urban residence, marital status, socioeconomic status, and hypertension suggest that obesity cannot be addressed through interventions focused solely on individual behaviors. Comprehensive and multisectoral strategies are needed to address the broader social and environmental determinants of health, while creating supportive environments that facilitate healthy lifestyles across the population.

Abbreviations

BMI
Body Mass Index
CI
Confidence Interval
DVENT
Dirección de Vigilancia de Enfermedades No Transmisibles
ENFR
Encuesta Nacional de Factores de Riesgo de Enfermedades No Transmisibles
NCD

Noncommunicable Disease

Declarations

Ethics approval and consent to participate

This study was based on a secondary analysis of anonymized data from the 2022 Paraguay STEPS survey conducted by the Ministry of Public Health and Social Welfare of Paraguay through the Directorate of Surveillance of Noncommunicable Diseases (DVENT) within the framework of the Essential Public Health Functions. Written informed consent was obtained from all participants during the original survey. Because the present study used fully anonymized secondary data and involved no contact with participants or access to personal identifiers, additional ethical review and approval were waived.

Consent for publication

Not applicable. This manuscript does not contain any individual person's data, images, or videos in any form.

Funding

This research received funding from the Data4Health Initiative, part of Bloomberg Philanthropies. The funders were not involved in the study design, data collection, analysis or interpretation, nor in the drafting of the manuscript or the decision to publish it. The Article Processing Charge (APC) was funded by the authors.

Author Contribution

F.C. designed the study and methodology, A.A., E.S data analysis, A.A., L.G., writing—original draft preparation, L.G., E.S. writing—review and editing, F.C., A.O., A.B. critical revisions to the manuscript, F.C., N.C.; project administration. All authors have read and agreed to the published version of the manuscript.

Acknowledgements

The authors thank the Ministry of Public Health and Social Welfare of Paraguay, particularly the Directorate of Surveillance of Noncommunicable Diseases (DVENT), for conducting the 2022 National STEPS Survey and providing access to the data.

Authors' information

Not applicable

Data Availability

The STEPS survey's data that support the findings of this study are available from the Surveillance Direction of Noncommunicable Diseases of the Ministry of Public Health and Social Welfare from Paraguay, but restrictions

apply to the availability of these data, which were used under licence for the current study and so are not publicly available. The data are, however, available upon request and with the permission of the institution via formal letter to the director.

References

1. World Health Organization. Obesity and overweight [Internet]. Geneva: World Health Organization. 2025 [cited 2026 Jul 21]. Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
2. GBD 2021 Risk Factors Collaborators. Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. Lancet. 2024;403(10440):2162–203. 10.1016/S0140-6736(24)00933-4.
3. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutr Rev. 2012;70(1):3–21. 10.1111/j.1753-4887.2011.00456.x.
4. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014;384(9945):766–81. 10.1016/S0140-6736(14)60460-8.
5. Pan American Health Organization. Obesity in the Americas. Washington (DC): PAHO; 2021.
6. Ministerio de Salud Pública y Bienestar Social. Dirección General de Vigilancia de la Salud. Dirección de Vigilancia de Enfermedades No Transmisibles. Segunda Encuesta Nacional de Factores de Riesgo de Enfermedades No Transmisibles, Paraguay 2022. 2a ed. Asunción: MSPyBS. 2025. ISBN: 978-99925-11-65-7.
7. Monteiro CA, Moura EC, Conde WL, Popkin BM. Socioeconomic status and obesity in adult populations of developing countries: a review. Bull World Health Organ. 2004;82(12):940–6.
8. Drewnowski A. Obesity, diets, and social inequalities. Nutr Rev. 2009;67(Suppl 1):S36–9. 10.1111/j.1753-4887.2009.00157.x.
9. Hruby A, Hu FB. The epidemiology of obesity: a big picture. PharmacoEconomics. 2015;33(7):673–89. 10.1007/s40273-014-0243-x.
10. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in underweight and obesity from 1990 to 2022: a pooled analysis of 3663 population-representative studies with 222 million children, adolescents, and adults. Lancet. 2024;403(10431):1027–50. 10.1016/S0140-6736(23)02750-2.
11. Ferreira SRG, Macotela Y, Velloso LA, et al. Determinants of obesity in Latin America. Nat Metab. 2024;6:409–32. 10.1038/s42255-024-00977-1.
12. Jaacks LM, Vandevijvere S, Pan A, et al. The obesity transition: stages of the global epidemic. Lancet Diabetes Endocrinol. 2019;7(3):231–40. 10.1016/S2213-8587(19)30026-9.
13. Popkin BM, Ng SW. The nutrition transition to a stage of high obesity and noncommunicable disease prevalence dominated by ultra-processed foods is not inevitable. Obes Rev. 2022;23(1):e13366. 10.1111/obr.13366.
14. Pan American Health Organization. Obesity in the Americas: regional report 2022. Washington (DC): PAHO; 2022.

15. Chooi YC, Ding C, Magkos F. The epidemiology of obesity. Metabolism. 2019;92:6–10. 10.1016/j.metabol.2018.09.005.
16. Hesketh KD, Zheng M, Campbell KJ. Early life factors that affect obesity and the need for complex solutions. Nat Rev Endocrinol. 2025;21:31–44. 10.1038/s41574-024-01035-2.
17. Perak AM, Ning H, Khan SS, Bundy JD, Allen NB, Lewis CE, et al. Associations of late adolescent or young adult cardiovascular health with premature cardiovascular disease and mortality. J Am Coll Cardiol. 2020;76(23):2695–707. 10.1016/j.jacc.2020.10.002.
18. Kim H, Kim SE, Sung MK. Sex and gender differences in obesity: biological, sociocultural, and clinical perspectives. World J Mens Health. 2025;43(4):758–72. 10.5534/wjmh.250126.
19. Cockerham WC. Theoretical approaches to research on the social determinants of obesity. Am J Prev Med. 2022;63(2):281–8. 10.1016/j.amepre.2022.01.030.
20. Autret K, Bekelman TA. Socioeconomic status and obesity. J Endocr Soc. 2024;8(11):bvae176. 10.1210/jendso/bvae176.
21. World Health Organization. WHO acceleration plan to stop obesity. Geneva: World Health Organization. 2023. ISBN: 978-92-4-007563-4.
22. Nikolic Turnic T, Jakovljevic V, Strizhkova Z, Polukhin N, Ryaboy D, Kartashova M, et al. The association between marital status and obesity: a systematic review and meta-analysis. Diseases. 2024;12(7):146. 10.3390/diseases12070146.
23. Lee J, Shin MH, Cho SY, Choi JH, Kang D, Lee JS. Marital status and the prevalence of obesity in a Korean population. Obes Res Clin Pract. 2020;14(3):217–24. 10.1016/j.orcp.2020.04.003. . PMID:32418738.
24. Arvanitidou EI, Tsofliou F, Wood J, Tsatsani I. The effectiveness of couples' lifestyle interventions on weight change: a systematic review and meta-analysis of randomised controlled trials. Nutr Health. 2025;31(1):65–80. 10.1177/02601060241291123.
25. Powell-Wiley TM, Poirier P, Burke LE, Després JP, Gordon-Larsen P, Lavie CJ, et al. Obesity and cardiovascular disease: a scientific statement from the American Heart Association. Circulation. 2021;143(21):e984–1010. 10.1161/CIR.0000000000000973.
26. Blüher M. An overview of obesity-related complications: the epidemiological evidence linking body weight and other markers of obesity to adverse health outcomes. Diabetes Obes Metab. 2025;27(Suppl 2):3–19. 10.1111/dom.16263.