Int J Cardiovasc Sci. 2022; 35(2), 230-242

ORIGINAL ARTICLE

Overview of Cardiovascular Disease Risk Factors in Adults in São Paulo, Brazil: Prevalence and Associated Factors in 2008 and 2015

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Abstract

Background: Cardiovascular diseases (CVDs) are the main cause of morbidity and mortality in Brazil.

Objective: To provide population-based data on prevalence and factors associated with CVD risk factors.

Methods: Individuals aged ≥20 years from two editions of the cross-sectional Health Survey of São Paulo focusing on Nutrition (ISA-Nutrition), performed in Sao Paulo city in 2008 (n=590) and 2015 (n=610), were evaluated for: obesity, central obesity, waist/height ratio, high blood pressure (HBP), dyslipidemia, diabetes, and number of CVD risk factors ≥3. Prevalence was estimated according to complex survey procedures. Factors associated with cardiovascular risk factors were assessed using logistic regression, with statistical significance of $p<0.05$.

Results: Obesity and older age were associated with higher odds of all cardiovascular risk factors investigated, except for dyslipidemia. HBP was positively associated with being Black/Brown and negatively associated with being physicaly active in leisure time. Women were more likely to have increased adiposity indicators and three or more cardiovascular risk factors than men. Those with higher education had lower chances of having diabetes, HBP and dyslipidemia, and those with higher income had higher chances of having three or more risk factors. Former smokers had higher odds of diabetes, obesity, and high waist/height ratio, and smokers had higher odds of high non-HDL cholesterol levels. From 2008 to 2015, there was an increase ($p<0.001$) in the prevalence of diabetes (6.9% to 17.3%), HBP (31.9% to 41.8%), dyslipidemia (51.3% to 67.6%), and number of CVD risk factors ≥3 (18.9% to 34.1%).

Conclusion: This study shows increasing prevalence of CVD risk factors in adult population in Sao Paulo and may support the definition of target groups and priority actions on CVD prevention and treatment.

Keywords: Cardiovascular Diseases/epidemiology; Risk Factors; Urban Health Services; Prevalence; Mortality; Morbidity

Introduction

Cardiovascular diseases (CVDs) are the main cause of morbidity and mortality worldwide, including in Brazil, where approximately 395,700 deaths (30% of total deaths) registered in 2018 were due to CVDs.[1] Considering the negative impact on individual's health, health systems, and the economy, monitoring CVD risk factors become imperative for both CVD prevention and control.[2] Moreover, many risk factors for CVDs are also risk factors for other non-communicable diseases (e.g., cancer), and are associated with worse outcomes and increased risk of death in patients with infectious diseases (e.g., SARS-CoV-2, responsible for the COVID-19 pandemic).[3,4]

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DOI: https://doi.org/10.36660/ijcs.20210076

Manuscript received on March 19, 2021; reviewed on July 19, 2021; accepted on September 01, 2021.

Several factors can be related to the genesis and prognosis of CVDs.[3,5,6] Some of them are not modifiable, such as aging, hereditary factors, and sex, while others are related to behavioral factors, such as unhealthy diet, physical inactivity, stress, tobacco use, and harmful use of alcohol. Also, some factors are related to underlying social determinants, such as globalization, urbanization, poverty, air pollution, and access to health services. To some extent, all of them are related to intermediate risk factors that can be evaluated and adequately monitored in primary health care, (e.g. elevated blood glucose levels, high blood pressure, dyslipidemia, overweight and obesity), and indicate an increased risk of developing heart failure, stroke, heart attack, or other complications.[3]

In the last decades, São Paulo, the largest city of Brazil, has witnessed substantial changes in the lifestyle of its inhabitants and socio-demographic profile, many of them associated with an increase in cardiovascular risk factors.[7] This study aimed to evaluate intermediate CVD risk factors, by analysis of population-based data from Sao Paulo, which may support primary and secondary prevention through evidence-based planning of health policies.

Methods

Population and study design

The study assessed data from two cohorts of the cross-sectional Health Survey of São Paulo focusing on Nutrition (ISA-Nutrition study), a sub-sample of the Health Survey of São Paulo (ISA-Capital), carried out in 2008 and 2015. ISA-Capital is a population-based survey aiming to evaluate population health status and use of health services, using a probabilistic sample of individuals aged 12 years or more living in households in the urban area of São Paulo city. Sociodemographic data, and information on morbidity, use of health services, and lifestyle were obtained using a structured questionnaire administered by trained interviewers in the households, to 3,271 individuals (2,086 aged ≥20 years) in 2008, and 4,024 (3,165 aged ≥20 years) in 2015. The samples of both surveys were independent of each other. Details of both editions were previously described.[8-10]

The ISA-Nutrition aimed at evaluating lifestyle-related CVD risk factors in the population of São Paulo.[10] Anthropometric data, blood pressure measurements, and blood samples were obtained by trained nurses during a second visit to the participant's household. Dietary intake was assessed by two 24-hour recalls. The 2008's and 2015's editions comprised 750 individuals (590 aged ≥20 years) and 901 individuals (610 aged ≥20 years), respectively. For this analysis, only individuals aged at least 20 years were evaluated (n=1200).

Anthropometric and cardiometabolic risk factors

Detailed protocols for laboratory, blood pressure and anthropometric measurements were published elsewhere.[10] Body weight, height, and waist circumference were measured in triplicate, and the average of three measures was calculated for analyses. Central obesity was defined as waist circumference ≥88 cm for women and ≥102 cm for men.[11] Waist-to-height ratio was considered elevated when ≥0.52 for adult men, ≥0.54 for adult women, and ≥0.55 for older adults.[12] According to body mass index (BMI=weight (kg)/height (m)^2), participants were categorized as: normal weight, overweight (adults: 25≥BMI>30 kg/m^2; older adults: 28<BMI<30 kg/m^2),[11,13] or obese (BMI≥30 kg/m^2).[13] High blood pressure was defined as elevated systolic (≥140 mmHg) or diastolic (≥90 mmHg) blood pressure, or use of antihypertensive drugs.[14]

Diabetes was defined as fasting plasma glucose ≥126 mg/dL, use of oral hypoglycemic drugs or insulin therapy.[12] Variables related to dyslipidemia were isolated hypercholesterolemia (low-density lipoprotein cholesterol [LDL-C] ≥160 mg/dL), isolated hypertriglyceridemia (triglycerides ≥160 mg/dL), mixed hyperlipidemia (LDL-C ≥160 mg/dL and triglycerides ≥160 mg/dL), low-HDL (high-density lipoprotein cholesterol [HDL-C] ≤40 mg/dL for men or HDL-C ≤50 mg/dL for women), high non-HDL cholesterol (≥160 mg/dL), and dyslipidemia (elevated LDL-C, elevated triglycerides, low HDL-C, or drug treatment for dyslipidemia).[6]

Participants were categorized according to the number of CVD risk factors present (less than 3 or equal to or more than 3), that is, diabetes, or high fasting plasma glucose (≥100 mg/dL), or insulin resistance (homeostatic assessment of insulin resistance [HOMA-IR = fasting glucose (mg/dL) x fasting insulin (μU/L)/405) ≥2.71];[12] high blood pressure; dyslipidemia; and obesity.

Statistical Analysis

The variables analyzed were: sex (male/female); age (adults: 20-59 years/older adults: ≥60 years); self-reported skin color (white/black/brown/other); *per capita* household income (<1 minimum wage / ≥1 minimum wage, according to the survey year); educational attainment (≤9 years: completed elementary school / >9 years of study: high school or more); smoking status (smoker/former smoker/do not smoke); physical activity at leisure time (obtained from the International Physical Activity Questionnaire, IPAQ long version, adapted to the Brazilian population:[15] follow/do not follow WHO recommendations).[16]

Categorical variables were described as frequencies and 95% confidence intervals, weighted according to the survey sample design. Differences were verified using the Rao-Scott chi-square test. Adjusted odds ratios and 95% confidence intervals were estimated for characteristics associated with CVD risk factors using logistic regression models. Models were well-calibrated according to the Hosmer-Lemeshow goodness-of-fit test for deciles of risk. Fitted models for the responses were used to estimate the adjusted prevalence of risk factors whose prevalence increased from 2008 to 2015. Sample weight and complex survey data analyses for population representativeness were performed using Stata-13 (https://www.stata.com) with statistical significance of $p<0.05$.

This study was conducted according to the guidelines established in the Declaration of Helsinki. The surveys were approved by the Ethics Committee on Research of the School of Public Health, University of São Paulo. All participants provided informed written consent before data collection in each stage of the study.

Results

Table 1 shows the prevalence of CVD risk factors in the population of São Paulo in 2008 and 2015, stratified by age group and sex. Older adults had a higher prevalence of diabetes, high blood pressure, central obesity, higher waist/height ratio, and CVD risk factors≥3 than adults in both survey years (2008 and 2015), and a higher prevalence of isolated hypercholesterolemia, mixed hyperlipidemia, high non-HDL cholesterol, and obesity in ISA-2008. Compared to adult men, older men had more diabetes, high blood pressure, high waist/height ratio, and central obesity in both survey years, higher prevalence of obesity in ISA-2008, and of CVD risk factors≥3 in ISA-2015. Older women also had a higher prevalence of high non-HDL than adult women in both ISA studies, higher dyslipidemia in ISA-2015, and higher isolated hypercholesterolemia and CVD risk factors≥3 in ISA-2008.

Among adults, the prevalence of central obesity in both surveys and low-HDL in 2008 were higher in women than men. Among older adults, older women showed a higher prevalence of dyslipidemia in both periods, and higher prevalence of diabetes, isolated hypercholesterolemia, obesity and CVD risk factors ≥ 3 compared with older men in ISA-2015. Older men showed a higher prevalence of isolated hypertriglyceridemia than older women in ISA-2008.

Comparing the prevalence of CVD risk factors in the population between 2008 and 2015, there was an increase in the prevalence of individuals with diabetes, high blood pressure, dyslipidemia, low-HDL and CVD risk factor≥3, and a decrease in the prevalence of mixed hyperlipidemia and high non-HDL cholesterol. Examining the differences according to sex and age groups, there was an increased prevalence of individuals with three or more CVD risk factors in all groups, and an increased prevalence of dyslipidemia and low-HDL in all groups, except in adult women. The prevalence of diabetes increased only in older adults (men and women), while high blood pressure increased in both age groups. However, a significant difference in high blood pressure was observed between sexes only in the older group. Also, in this group, the prevalence of mixed hyperlipidemia (for men and women) and non-HDL cholesterol (total individuals) was lower in 2015 than in 2008.

Logistic regression models indicated that women had higher chances of presenting elevated adiposity indicators (i.e. high BMI, elevated waist circumference, and high waist/height ratio) and three or more CVD risk factors than men (Table 2). Older age was associated with higher odds of all risk factors analyzed, except dyslipidemia. Excess body weight was associated with higher odds of presenting all risk factors analyzed. Individuals who self-identified as black or brown had higher chances of presenting high blood pressure. Those with higher education levels had lower odds of diabetes, high blood pressure and dyslipidemia. Individuals with higher income had higher chances of having three or more cardiovascular risk factors. Former smokers were more likely to have diabetes, obesity, and a high waist/height ratio; while smokers had higher odds of high non-HDL cholesterol levels. Individuals who were physically active in leisure time had lower chances of having high blood pressure.

Among the cardiovascular risk factors evaluated by logistic regression models in 2008 and 2015, there was a significant increase in the prevalence of four factors:

Table 1 – Prevalence of intermediate cardiovascular risk factors, according to sex and age groups in the city of São Paulo. ISA-Nutrition 2008 and 2015

CVDR	ISA-Nutrition 2008 (n=590)*														p-values for difference in ISA 2008†				
	ISA 2008		Adults (20-59 years)						Older adults (60 years or more)										
	(total population)		Total		Male		Female		Total		Male		Female						
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	p1	p2	p3	p4	p5
Diabetes	**6.53**	(4.6, 9.2)	4.47	(2.6, 7.6)	3.10	(1.2, 7.6)	5.74	(3.1, 10.5)	**15.1**	(11.2, 20.2)	**10.8**	(6.4, 17.8)	**17.9**	(12.4, 25.3)	**p<0.001**	0.241	0.106	0.025	**0.002**
High blood pressure	**27.9**	(22.9, 33.5)	**21.3**	(16.6, 26.9)	23.3	(15.1, 34.2)	19.5	(13.3, 27.5)	**57.3**	(48.7, 65.4)	**55.6**	(43.9, 66.7)	**58.4**	(48.5, 67.6)	**p<0.001**	0.555	0.660	**<0.001**	**<0.001**
Dyslipidemia	**49.2**	(44, 54.5)	**47.9**	(41.5, 54.5)	**42.6**	(32.3, 53.5)	52.8	(44.7, 60.8)	**54.8**	(47.6, 61.9)	**43.7**	(34.4, 53.4)	**62.0**	(53.5, 69.8)	0.208	0.144	**0.001**	0.892	0.137
Isolated hypercholesterolemia	2.87	(1.6, 5.1)	1.86	(0.7, 4.7)	0.89	(0.1, 6.3)	2.74	(1.1, 6.5)	7.30	(4, 13)	3.14	(1.2, 8.2)	9.99	(5, 19)	**0.020**	0.212	0.056	0.195	**0.028**
Isolated hypertriglyceridemia	2.81	(1.2, 6.3)	2.7	(0.9, 7.5)	4.99	(1.5, 15.3)	0.61	(0.1, 4.3)	3.28	(1.7, 6.2)	7.68	(3.9, 14.7)	0.44	(0.1, 3.2)	0.753	0.076	**0.008**	0.534	0.824
Mixed hyperlipidemia	**3.16**	(1.9, 5.3)	2.31	(1.1, 4.9)	3.18	(1.1, 8.7)	1.51	(0.5, 4.9)	**6.90**	(4.3, 10.8)	**9.21**	(4.5, 17.8)	**5.40**	(3.1, 9.1)	**0.016**	0.354	0.209	0.071	0.057
Low-HDL	**38.0**	(32.9, 43.3)	**39.6**	(33.5, 46)	**31.6**	(23, 41.6)	46.9	(39.2, 54.8)	**30.8**	(24.4, 37.9)	**19.8**	(12.5, 29.9)	**37.8**	(29.7, 46.7)	0.067	**0.014**	**0.003**	0.077	0.110
High non-HDL cholesterol	**30.0**	(24.3, 36.3)	27.5	(21.1, 35)	31.9	(21.4, 44.6)	23.5	(17.3, 31.1)	**40.8**	(35.3, 46.4)	32.5	(24.3, 41.9)	46.1	(37.9, 54.5)	**0.005**	0.174	0.056	0.939	**<0.001**
Obesity	23.0	(18.7, 27.8)	20.0	(15.1, 25.9)	17.2	(9.5, 29)	22.5	(16.3, 30.3)	36.9	(32, 42.1)	35.3	(26.6, 45.1)	37.9	(30.6, 45.8)	**p<0.001**	0.429	0.697	**0.012**	**0.006**
Central obesity	46.4	(41.2, 51.6)	41.6	(35.9, 47.4)	23.5	(14.9, 35)	58.3	(50.7, 65.5)	69.4	(62.7, 75.2)	43.1	(32.8, 54.1)	86.0	(79, 90.9)	**p<0.001**	**<0.001**	**p<0.001**	**0.009**	**<0.001**
High waist/height ratio	63.6	(57.9, 69.0)	59.3	(52.8, 65.6)	56.2	(43.6, 68.0)	62.3	(54.9, 69.2)	84.6	(79.3, 88.7)	79.8	(71.3, 86.2)	87.6	(80.8, 92.3)	**p<0.001**	0.434	0.074	**0.002**	**p<0.001**
CVD risk factors ≥ 3‡	**17.9**	(14.3, 22.2)	**15.3**	(11.3, 20.2)	**13.5**	(8.2, 21.4)	**16.9**	(11.4, 24.2)	**30.4**	(23.9, 37.8)	**23.7**	(15.7, 34.1)	**34.9**	(26.1, 44.7)	**p<0.001**	0.480	0.088	0.060	**0.006**

CVDR	ISA-Nutrition 2015 (n=610)*																p-values for difference in ISA 2015†				
	ISA 2015		Adults (20-59 years)						Older adults (60 years or more)												
	(total population)		Total		Male		Female		Total		Male		Female								
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	p1	p2	p3	p4	p5
Diabetes	**17.0**	(14, 20.3)	9.8	(6.9, 13.7)	10.2	(6.3, 16.1)	9.34	(5.3, 15.8)	**31.1**	(25.4, 37.6)	**25.5**	(19.2, 33)	**37.3**	(29, 46.3)	**p<0.001**	0.814	**0.020**	**0.001**	**p<0.001**
High blood pressure	**45.5**	(40.7, 50.4)	**31.3**	(26, 37.1)	33.1	(25.8, 41.3)	29.3	(22, 37.7)	**73.9**	(67.6, 79.3)	**69.4**	(60.1, 77.3)	**78.7**	(70.4, 85.1)	**p<0.001**	0.498	0.107	**p<0.001**	**p<0.001**
Dyslipidemia	**68.3**	(62.9, 73.3)	**67.2**	(60.1, 73.6)	**70.8**	(62.4, 78)	63.2	(53.3, 72.2)	**70.5**	(63.9, 76.3)	**64.3**	(54.9, 72.6)	**77.2**	(67.5, 84.7)	0.445	0.173	**0.049**	0.284	**0.026**
Isolated hypercholesterolemia	2.02	(1.1, 3.8)	1.89	(0.9, 4)	1.21	(0.3, 4.9)	2.63	(1, 6.6)	2.29	(0.8, 6.7)	0.67	(0.1, 4.8)	4.06	(1.4, 11.5)	0.775	0.372	**0.049**	0.632	0.548
Isolated hypertriglyceridemia	2.25	(1.3, 4)	1.64	(0.7, 3.8)	1.41	(0.3, 5.5)	1.89	(0.6, 5.7)	3.47	(1.6, 7.4)	3.91	(1.6, 9.4)	2.99	(0.7, 11.9)	0.203	0.749	0.761	0.225	0.618
Mixed hyperlipidemia	**1.81**	(0.9, 3.5)	2.43	(1.2, 5)	4.13	(1.9, 8.7)	0.54	(0.1, 3.9)	**0.56**	(0.1, 2.2)	**0.58**	(0.1, 4.1)	**0.54**	(0.1, 3.6)	0.066	0.059	0.958	0.073	0.994
Low-HDL	**60.2**	(54.7, 65.5)	**61.2**	(54.1, 67.8)	**66.1**	(57.7, 73.6)	55.7	(45.8, 65.2)	**58.3**	(50.8, 65.4)	**57.3**	(48.1, 66)	**59.4**	(48.9, 69.1)	0.553	0.076	0.739	0.160	0.596
High non-HDL cholesterol	**26.7**	(22.9, 31)	25.6	(20.8, 31.1)	29.5	(21.9, 38.3)	21.4	(16.4, 27.5)	**28.9**	(23.4, 35.2)	24.6	(17.9, 32.8)	33.7	(26.2, 42)	0.394	0.100	0.077	0.361	**0.011**
Obesity	26.2	(22.7, 30.1)	24.3	(20.2, 28.8)	19.7	(14.5, 26.2)	29.3	(22.7, 36.9)	30.1	(24.1, 36.9)	23.5	(15.8, 33.4)	37.1	(28.6, 46.5)	0.113	0.056	**0.043**	0.471	0.193
Central obesity	49.5	(44.9, 54.1)	42.6	(36.8, 48.6)	25.8	(19.4, 33.3)	61.1	(53, 68.6)	63.0	(55, 70.3)	46.1	(37.1, 55.4)	80.8	(71.5, 87.7)	**p<0.001**	**p<0.001**	**p<0.001**	**0.001**	**0.002**
High waist/height ratio	66.2	(61.3, 70.8)	59.9	(53.9, 65.6)	56.5	(47.4, 65.2)	63.6	(56.8, 69.8)	78.5	(71.4, 84.3)	74.2	(65.2, 81.5)	83.1	(73.7, 89.6)	**p<0.001**	0.187	0.088	**0.007**	**0.001**
CVD risk factors ≥ 3‡	**35.4**	(31.2, 39.9)	**27.4**	(22.6, 32.7)	**26.9**	(20.3, 34.6)	**27.9**	(21.7, 35.2)	**51.4**	(44.1, 58.6)	**43.4**	(34.6, 52.6)	**60.0**	(49.7, 69.4)	**p<0.001**	0.831	**0.013**	**0.007**	**p<0.001**

CVDR, cardiovascular disease risk factors; 95%CI, 95% confidence interval; HDL-C, high-density lipoprotein cholesterol.
**The numbers presented are absolute frequency. The percentages and 95%CL are weighted according to the survey sample design.*
†p-values shown across categories in each ISA-Nutrition edition from Rao-Scott Chi-Square tests.
‡Cardiovascular disease risk factors were categorized as having three or more of the following conditions: diabetes (fasting plasma glucose ≥ 126 mg/dL or drug treatment for diabetes) or high fasting plasma glucose (≥ 100 mg/dL), or insulin resistance (HOMA_IR ≥ 2.71),[12] high blood pressure (systolic blood pressure ≥ 140 or diastolic blood pressure ≥ 90 or use of antihypertensive drugs),[6] dyslipidemia (LDL-C ≥ 160 mg/dL, or HDL-C ≤ 40 mg/dl for male or HDL-C ≤ 50 mg/dl for female, or triglycerides ≥ 150 mg/dL, or drug treatment for dyslipidemia)[6], and obesity (BMI ≥ 30 kg/m²).[11,13]
p1 = adults vs older adults
p2 = adult men vs. adult women
p3 = older men vs. older women
p4 = adult men vs. older men
p5 = adult women vs. older women.
Note: Significant differences between ISA-Nutrition 2008 and 2015 (p<0.05) are in bold, considering the survey sample design

Table 2 – Odds ratios (95% confidence interval) of characteristics associated with cardiovascular disease risk factors in the population of São Paulo; ISA-Nutrition 2008 and 2015

	Frequency				Multiple Logistic Regression Models								
	ISA-2008 (n=590)		ISA-2015 (n=610)		Diabetes			High blood pressure			Dyslipidemia		
	%	95% CI	%	95% CI	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Sex (vs. Male)													
Female	59.7	(56.0, 63.3)	47.3	(42.1, 52.6)	1.42	(0.97, 2.07)	0.075	0.94	(0.71, 1.26)	0.693	1.29	(0.98, 1.69)	0.068
Age group (vs. Adults < 60 years)													
Older adults (≥ 60 years)	22.8	(19.1, 27.1)	33.5	(29.5, 37.8)	3.60	(2.35, 5.52)	**p<0.001**	5.93	(4.35, 8.08)	**p<0.001**	1.16	(0.87, 1.55)	0.302
Self-reported skin color (vs. White)													
Black	6.2	(4.1, 9.5)	9.5	(7.1, 12.7)	1.15	(0.63, 2.1)	0.657	2.01	(1.23, 3.3)	**0.005**	1.07	(0.67, 1.71)	0.791
Brown	28.6	(22.6, 35.5)	29.4	(24.9, 34.3)	0.69	(0.44, 1.08)	0.108	1.58	(1.15, 2.19)	**0.005**	0.82	(0.6, 1.1)	0.183
Other	2.5	(1.1, 5.6)	6.0	(4.1, 8.7)	1.10	(0.49, 2.43)	0.822	0.59	(0.29, 1.18)	0.134	1.16	(0.58, 2.31)	0.677
Body Weight Status (vs. normal weight)													
Overweight	28.5	(24.0, 33.5)	28.4	(24.4, 32.8)	1.10	(0.65, 1.87)	0.721	1.52	(1.05, 2.19)	**0.026**	2.08	(1.47, 2.94)	**p<0.001**
Obesity	24.7	(20.7, 29.1)	26.2	(22.7, 30.1)	2.07	(1.38, 3.11)	**p<0.001**	2.35	(1.67, 3.29)	**p<0.001**	1.90	(1.38, 2.6)	**p<0.001**
Per capita household income (vs. < 1 Minimum wage)													
≥ One minimum wage	66.4	(58.8, 73.2)	53.4	(47.5, 59.3)	1.01	(0.69, 1.47)	0.980	1.06	(0.79, 1.43)	0.700	1.08	(0.82, 1.43)	0.578
Education of householder (vs. < High School)													
≥ High School	51.8	(44.5, 59.0)	51.6	(45.4, 57.8)	0.59	(0.39, 0.89)	**0.013**	0.71	(0.52, 0.97)	**0.031**	0.63	(0.47, 0.85)	**0.002**
Smoking status (vs. Do not smoke)													
Former smoker	21.5	(17.4, 26.2)	20.7	(17.2, 24.8)	1.73	(1.14, 2.61)	**0.010**	1.05	(0.74, 1.47)	0.798	1.03	(0.75, 1.42)	0.851
Smoker	23.9	(19.1, 29.4)	17.6	(14.5, 21.3)	1.19	(0.69, 2.06)	0.538	1.13	(0.77, 1.67)	0.534	1.24	(0.86, 1.79)	0.244
Physical Activity at Leisure time (vs. physically inactive)													
Physically active	26.4	(22.8, 30.3)	20.8	(17.0, 25.2)	1.11	(0.7, 1.74)	0.657	0.64	(0.46, 0.9)	**0.009**	1.17	(0.85, 1.59)	0.333
ISA year (vs. 2008)													
2015	-	-	-	-	2.87	(1.95, 4.24)	**p<0.001**	1.9	(1.42, 2.54)	**p<0.001**	2.26	(1.72, 2.97)	**p<0.001**

	High non-HDL cholesterol			Obesity			Central Obesity			High Waist/Height ratio			CVDRc ≥3*		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Sex (vs. Male)															
Female	1.03	(0.78, 1.37)	0.820	1.63	(1.22, 2.19)	**0.001**	5.08	(3.8, 6.8)	**p<0.001**	1.45	(1.08, 1.94)	**0.013**	1.37	(1.02, 1.83)	**0.035**
Age group (vs. Adults < 60 years)															
Older adults (≥ 60 years)	1.72	(1.28, 2.32)	**p<0.001**	1.51	(1.12, 2.03)	**0.006**	2.30	(1.71, 3.1)	**p<0.001**	2.22	(1.63, 3.03)	**p<0.001**	2.51	(1.86, 3.38)	**p<0.001**
Self-reported skin color (vs. White)															
Black	0.81	(0.49, 1.34)	0.410	1.14	(0.7, 1.85)	0.593	1.00	(0.61, 1.64)	0.995	0.77	(0.47, 1.25)	0.287	1.60	(1.00, 2.57)	0.052
Brown	1.14	(0.83, 1.55)	0.415	0.99	(0.72, 1.38)	0.975	0.93	(0.67, 1.28)	0.649	0.99	(0.71, 1.37)	0.944	1.19	(0.86, 1.64)	0.303
Other	0.86	(0.43, 1.75)	0.680	0.54	(0.24, 1.2)	0.128	0.87	(0.44, 1.7)	0.681	0.83	(0.42, 1.66)	0.603	0.73	(0.37, 1.47)	0.384
Body Weight Status (vs. normal weight)															
Overweight	2.01	(1.41, 2.86)	**p<0.001**	-	-	-	-	-	-	-	-	-	-	-	-
Obesity	1.70	(1.23, 2.35)	**0.001**	-	-	-	-	-	-	-	-	-	-	-	-
Household income per capita (vs. < 1 MW)															
≥ One minimum wage	1.27	(0.95, 1.69)	0.111	1.22	(0.9, 1.64)	0.198	1.25	(0.93, 1.68)	0.141	1.34	(0.99, 1.81)	0.060	1.42	(1.05, 1.92)	**0.022**
Education of householder (vs. < high school)															
≥ High School	0.83	(0.61, 1.12)	0.221	1.03	(0.76, 1.41)	0.835	1.08	(0.79, 1.47)	0.637	0.95	(0.69, 1.3)	0.726	0.82	(0.60, 1.11)	0.201
Smoking status (vs. non-smoker)															

Int J Cardiovasc Sci. 2022; 35(2), 230-242
Original Article

Former smoker	1.2	(0.86, 1.66)	0.281	1.45	(1.04, 2.00)	**0.027**	1.39	(0.99, 1.95)	0.060	1.49	(1.03, 2.15)	**0.034**	1.35	(0.97, 1.88)	0.076
Smoker	1.51	(1.04, 2.19)	**0.028**	0.68	(0.44, 1.04)	0.078	0.77	(0.53, 1.14)	0.195	0.80	(0.55, 1.16)	0.246	0.92	(0.61, 1.38)	0.673
Physical Activity at Leisure time (vs. physically inactive)															
Physically active	1.07	(0.78, 1.48)	0.667	0.94	(0.67, 1.33)	0.743	0.88	(0.63, 1.23)	0.445	0.91	(0.65, 1.28)	0.591	0.70	(0.49, 1.00)	0.052
ISA year (vs. 2008)															
2015	0.89	(0.67, 1.18)	0.425	1.09	(0.81, 1.45)	0.571	1.01	(0.76, 1.35)	0.929	0.86	(0.64, 1.16)	0.322	2.68	(2.00, 3.60)	**p<0.001**

95%C.L., 95% Confidence Limits; CVDRc, cardiovascular disease risk factors count; MW, minimum wage
** Cardiovascular disease risk factors were categorized as having three or more of the following conditions: diabetes (fasting plasma glucose ≥ 126 mg/dL or drug treatment for diabetes) or high fasting plasma glucose (≥ 100 mg/dL), or insulin resistance (HOMA_IR ≥ 2.71),[12] high blood pressure (systolic blood pressure ≥ 140 or diastolic blood pressure ≥ 90 or use of antihypertensive drugs),[6] dyslipidemia (LDL-C ≥ 160 mg/dL, or HDL-C ≤ 40 mg/dl for male or HDL-C ≤ 50 mg/dl for female, or triglycerides ≥ 150 mg/dL, or drug treatment for dyslipidemia)[6], and obesity (BMI ≥ 30 kg/m²)[11,13]*

diabetes, high blood pressure, dyslipidemia, and number of CVD risk factors ≥ 3 (Figure 1). The prevalence of individuals with diabetes increased 2.5 fold, with high blood pressure and dyslipidemia increased 1.3 fold, and those with CVD risk factors ≥3 increased 1.8 fold. Dyslipidemia was the most prevalent CVD risk factor in 2015 (67.6%). Among individuals aged 20 years and older in São Paulo in 2015, approximately one in six had diabetes, two in five had high blood pressure, two in three had dyslipidemia, and two in six had three or more CVD risk factors.

Discussion

The present study evaluated the prevalence of intermediate cardiovascular risk factors in people aged 20 years and older of São Paulo city. During the period between 2008 and 2015, there was an important increase in the prevalence of diabetes mellitus, high blood pressure, dyslipidemia, as well as individuals with three or more risk factors for CVD simultaneously. Population characteristics associated with CVD risk factors included adiposity (overweight and obesity), sex, age group, skin color, smoking status, physical activity level, income, and education.

In the last decades, chronic non-communicable diseases have become a priority in the global health agenda. According to the World Health Organization Sustainable Development Goal (SDG) target 3.4, the member countries are committed to pursuing a reduction of 33% in the probability of dying from NCD, in comparison with data registered in 2015, especially considering cardiovascular diseases, diabetes, chronic respiratory diseases, and cancers.[17] In Brazil, the mortality from these causes has been declining at rates that will probably allow reaching the target proposed.[17] However, the country presents a heterogeneous scenario across its vast territory, therefore, it is important to understand factors associated with CVD and implement effective actions in its prevention and treatment.[18]

The south and southeast regions of Brazil, which include the city of São Paulo, have the highest adjusted coefficients of mortality from CVD, ischemic heart disease and cerebrovascular diseases compared with other regions of the country, with patterns similar to that observed in developed countries.[19] Nevertheless, both regions have also presented the highest reduction in the mortality rates in the last decades.[20] This reduction may have occurred in large part due to the successful

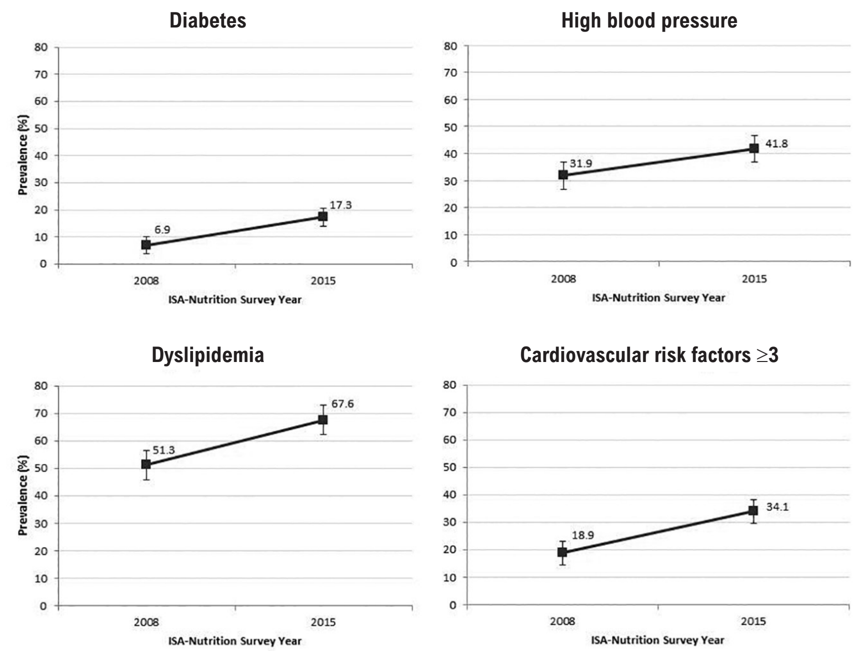

Figure 1 – Adjusted prevalence of risk factors for cardiovascular disease with increasing trends (p <0.05) from 2008 to 2015 in São Paulo city, using multiple logistic models (Table 2) and considering sample complex design. ISA-Nutrition 2008 and 2015; vertical bars indicate the 95% confidence limits

implementation of tobacco control policies and expansion of access to primary health care. In São Paulo, there was a reduction of 34% in the prevalence of smokers – from 20.9% to 13.7% – between 2008 and 2015,[21,22] for example.

Despite the positive results observed in mortality due to CVD, the prevalence of intermediate factors of CVD does not follow the same decreasing trend. From 2006 to 2019, Brazil experienced an increase in the prevalence of self-reported diabetes, hypertension, and obesity in the population aged 18 years and older.[23] The results presented in this study also showed a significant increase in the prevalence of diabetes, high blood pressure, and dyslipidemia in the population aged 20 years and older in São Paulo municipality from 2008 to 2015. Despite the absence of significant difference in the prevalence of obesity between 2008 and 2015, the increase in the prevalence of obesity among adults, in the long run, showed a statistically significant difference between 2003 and 2015.[24] The decrease in mortality rates from CVD may be a result of improved health care; however, the concomitant increase in the risk factors for CVD causes a negative impact on life expectancy and quality of life, and disability-adjusted life years (DALYs),[18] in addition to increased medical costs. This hypothesis could be illustrated by the fact that women, who are usually more prone to use health services[25] and have a longer life expectancy compared with men,[26] had higher prevalence of several CVD risk factors in our study. Additionally, a recent study showed an increase (GBD 2017) or stability (Corrected SIM) in the mortality rates due to CVD in Brazil from 2015 to 2017, which could be explained by the increasing prevalence of these intermediate factors in combination with the economic crisis, marked by an increase in poverty, and cuts in health and social policies.[20] This data should be revised in future studies to evaluate if this trend is confirmed in the long term.

In addition, the different methods used to assess the risk factors and outcomes may result in different prevalence rates across studies. The prevalence of hypertension in the study of Malta et al.,[27] using data from the National Health Survey, was 21.4% (95% CI 20.8 - 22.0) using the self-reported criteria, while the measurement of hypertension yielded a prevalence of 22.8% (95% CI 22.1 - 23.4) and the measurement of arterial hypertension and/or reporting of medication use resulted in a prevalence of 32.3% (95% CI 31.7 - 33.0). In the study ISA-Capital 2008, the sensitivity of self-reported diabetes was 85.8% (95%CI 70.7–93.8) in older adults and only 42.1% (95%CI 22.4–64.6) in adults.[28] Therefore, an advantage of the present study refers to the adoption of direct measurement of risk factors, e.g., anthropometry was assessed by the determination of adiposity measures, while blood pressure and blood samples were used to define high blood pressure, dyslipidemia and diabetes, in combination with information on medication use (confirmed and registered by a nurse in the household visit). This procedure probably resulted in higher values of prevalence compared with other studies based on self-reported information.

Among the characteristics associated with intermediate risk factors for CVD, two should be highlighted: age and adiposity. Aging is associated with progressive loss of tissue and organ function over time, and accumulation of oxidative damage to macromolecules (lipids, DNA, and proteins) by reactive oxygen species, resulting in several acute and chronic pathological processes, such as CVD.[29] As we age, another important aspect to be addressed is inflammaging — a state of chronic low-grade systemic inflammation —, which is associated with immunosenescence, metabolic inflammation, and increased insulin resistance and consequently, increased risk of type 2 diabetes.[30] In fact, in the present study, older age was associated with higher chances of having diabetes, elevated blood pressure, non-HDL cholesterol and adiposity, and presenting three or more CVD risk factors. In terms of public health, Brazil, including São Paulo municipality, has been experiencing a sharp demographic transition,[31] marked by population aging and consequent increase in social and economic burden. Such increase in health care demands may represent a real challenge, which requires public policy planning in health and economy.

Another important challenge for the Brazilian health system is the alarming prevalence of excess adiposity, which leads to an inflammatory condition that is directly involved in the etiology of cardiovascular diseases and type 2 diabetes. It should be noted that one in four people aged 20 years and older in the city of São Paulo is obese and half of the population has high waist circumference. In accordance with previous studies,[11,32] excess body weight (overweight and/or obesity) was positively associated with all characteristics associated with CVD risk factors, besides being a risk factor itself. High adiposity, especially obesity, is an important health problem worldwide and, during the last decades, little progress has been made, considering that no country has shown decreasing trends in population obesity.[33]

Besides sex, age and adiposity, other conditions were associated with intermediate risk factors for CVD in this study, such as skin color and high blood pressure. Other studies have also shown that black and brown ethinicity is an important risk factor for high blood pressure.[34,35] Although hereditary predisposition may be involved,[36] socioeconomic conditions and lifestyle may play more important roles in this association.[14,37-39] This evidence highlights the importance of the social determinants of health in the context of CVDs,[40] such as education, which was inversely associated not only with high blood pressure, but also with diabetes and dyslipidemia in the present study, and is the most consistent social determinant related to CVD outcomes. Lower levels of educational attainment has been associated with higher prevalence of many cardiovascular risk factors, higher incidence of cardiovascular events, and higher cardiovascular mortality, independent of sociodemographic factors.[40,41]

The risk factors for CVD usually occur together, due to a substantial overlap between disease etiology and mechanisms.[42] It has been estimated that, for every 4.5 kg of weight gain, there is a 20% increase in the risk of hypertension.[43] In the present study, subjects with overweight and obesity were 1.5 and 2.4 fold, respectively, more likely to have high blood pressure. Besides, weight reduction promotes a decrease in blood pressure both in normotensive and hypertensive individuals.[14] The prevalence of subjects with three or more risk factors for CVD increased from 18% to 35% in the city of São Paulo, which may result in increased mortality, functional decline, and lower quality of life in a substantial proportion of the population, leading to an increasing demand of health care services during the following decades.[44]

Additionaly, the risk factors investigated are also related to the worse health outcomes and increased risk of mortality due to infectious diseases, like the new coronavirus disease (COVID-19).[4] Recent studies have shown that obesity, hypertension, diabetes, and cardiovascular disease greatly affect the prognosis of the COVID-19.[45,46] Also, social strategies adopted to fight the COVID-19 pandemic (e.g. lockdown and self-isolation) can even worsen the occurrence of obesity and other metabolic diseases due to physical inactivity and anxiety.[47,48] Therefore, evaluating and adequately controlling these risk factors is a good strategy in public health, since it can be easily made in primary care and have a low cost compared with the management of CVD consequences.[3]

The main limitation of this study is its cross-sectional design, which limits the evaluation of some associations, such as the higher likelihood of former smokers having obesity and diabetes. Although there is evidence regarding the relationship between smoking cessation and weight gain,[49] the results should be interpreted considering the study design, due to the possibility of reverse causality. Additionally, other aspects potentially associated with CVD were not investigated in the present research. Alcoholic beverage intake (yes/no) and diet quality (using the revised version of the Brazilian Healthy Eating Index) were evaluated, but excluded from the models due to the absence of effect or statistical significance. Future research should explore these and other associations in detail using methods specific to CVD risk factors in the Brazilian population.

Despite these limitations, the present study has strengths, such as the use of direct measurements to estimate the evaluated parameters, with methodological rigor, to obtain high-quality information. In addition, important confounders were taken into account in the analysis, such as income, education, and physical activity. Finally, this study evaluated the population in the urban area of the biggest city in Brazil, with more than 12 million habitants[50] and a high degree of genetic admixture.[51]

Conclusion

The prevalence of intermediate CVD risk factors in a population sample from Sao Paulo varied according to non-modifiable (age, sex, skin color) and modifiable characteristics (physical activity, smoking status, income, education). From 2008 to 2015, there was an important increase in the prevalence of diabetes, high blood pressure, dyslipidemia, and invidiuals with three or more CVD risk factors, whereas adiposity parameters (e.g. obesity) had no significant increase, despite their high prevalence. The results may support the selection of target groups and priority actions on CVD prevention and treatment, considering the current health scenario of the high prevalence of CVD, associated with population aging, which exposes epidemiological and mechanistic relationships with cardiometabolic risk factors (abnormal adiposity, dysglycemia, dyslipidemia, and high blood pressure).

Acknowledgements

We acknowledge the contribution of all people involved in ISA-Capital, especially Maria Cecilia Goi Porto Alves, Marilisa Berti de Azevedo Barros, Maria Mercedes Loureiro Escuder, the GAC group (Grupo de Avaliação do Consumo Alimentar – Group of Assessment of Dietary Intake) and the participants of the study.

Author contributions

Conception and design of the research: Pereira JL, Castro MA, Rogero MM, Sarti FM, Fisberg RM. Acquisition of data: Cesar, CLG, Goldbaum M, Fisberg RM. Statistical analysis: Pereira JL, Castro MA, Leite JMRS. Obtaining financing: Fisberg RM, Cesar, CLG, Goldbaum M, Pereira JL. Writing of the manuscript: Pereira JL. Critical revision of the manuscript for intellectual content: Castro MA, Leite JMRS, Rogero MM, Sarti FM, Fisberg RM.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

This work was supported by the São Paulo Municipal Health Department (grant number #2013-0.235.936-0), Research Support Foundation of the State of São Paulo (grant numbers #2012/22113-9, #2017/05125-7, and #2019/23985-9), and National Council for Scientific and Technological Development (grant number #472873/2012-1).

Study Association

This study is not associated with any thesis or dissertation work.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the *Faculdade de Saúde Pública da Universidade de São Paulo* under the protocol number 30848914.7.0000.5421. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

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