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HEALTH SCIENCES POSTGRADUATE PROGRAMME

SOCIOECONOMIC DETERMINANTS OF CARDIOMETABOLIC RISK FACTORS IN LATIN AMERICAN AND CARIBBEAN CHILDREN AND ADOLESCENTS

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Curitiba, Parana State, Brazil

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I offer my thanks to God for this blessed experience that has made me a better and more service-oriented person!

Sometimes your life is as a logistic model which must be calibrated,

thus, you finished compared your reality with what you expected to be was.

Don’t be afraid to the tests if the results are not your expected,

adjusted to your model to your life for you…

Ella R

ABSTRACT

Introduction: The occurrence of cardiometabolic disorders is linked to the heightened prevalence of diverse risk factors. While associations between Socioeconomic Status (SES) and cardiometabolic disorders are well-studied in high-income countries, cardiometabolic risk factors in Latin America and the Caribbean (LAC) young populations have received little attention. This thesis analyzed socioeconomic status and its determinants and the relationship to cardiometabolic factors, mainly those that are components of metabolic syndrome (MetS) in children and adolescents from LAC countries.

Methods: We carried out two studies: The first study a cross-sectional analytical study into the Brazilian ERICA study (Estudo de Risco Cardiometabolic measurements). A logistic regression model was used to analyze the MetS components and SES in Brazil. Potential confounders were considered based on evidence from previous literature and the available data in the ERICA study. The second study was a systematic review of observational studies published up to October 2023 that examined the relationships between socioeconomic status and its indicators and cardiometabolic risk factors in children and adolescents from LAC. The meta-analysis was performed to associate the metabolic syndrome components and SES high compared with middle and low SES.

Results: Out of 25,822 Brazilian adolescents classified by SES, the mean age was 14.6 (SD 3.7) years old, and the proportion of girls was higher in the lower strata (67.7%). The prevalence of MetS was 2.6% (95% CI=2.2-2.9). Compared to the lower SES the OR of triglycerides altered were greater in the higher SES stratum (OR 2.76, 95% CI= 1.10–6.92) and protected ORs of c-HDL (OR 0.43, 95% CI=0.30–0.63). For the second study, we systematically reviewed sixty-four references from 58 eligible studies in 10 LAC countries, encompassing a total of 591,471 participants aged 5 to 19. SES definitions were assessed in forty-three references. We showed significant differences with higher SES compared to middle-lower SES on the association size effects of obesity and overweight (OR 1.92, 95% CI 1.58-2.35). The observed heterogeneity could be attributed to factors such as age and country.

Conclusion: the association between overweight, obesity and middle and higher SES tends to be more pronounced among children and adolescents from LAC. Furthermore, triglyceride levels altered were higher in Brazilian adolescents from a higher SES, as well as higher weight. The socioeconomic gradient of cardiometabolic health appears to be dynamic in children from low and middle-income countries, highlighting the importance of analyzing cardiovascular disease risk factors individually and not as a composite.

KEY WORDS:
"Socioeconomic Factors"[Mesh]; socioeconomic status, "Cardiometabolic Risk Factors"[Mesh]; "Metabolic Syndrome"[Mesh]; child; "Adolescent"[Mesh]; "Latin America"[Mesh]; Latin America and the Caribbean.

PLAIN LANGUAGE SUMMARY

Cardiovascular disorders are on the rise, and their causes include a mix of clinical, political, economic, social, cultural, and environmental factors. The impact of economic and social status on cardiometabolic health varies among people in lower- and middle-income countries, and it's also influenced by the stage of changes in diet and lifestyle. The research has described and studied how socioeconomic status is going to affect the cardiovascular and metabolism when people grow up in developed countries, but we've investigated it less for kids and teenagers from Latin America and the Caribbeans (LAC). That's why this thesis analyzes what we know about how kids and teenagers in LAC are affected by their family's socioeconomic background when it comes to heart and metabolism.

In a study of a large group of adolescents from Brazil, we looked at their health and found some interesting patterns. We observed that adolescents from higher socioeconomic backgrounds tended to be overweight and obese. Additionally, total cholesterol levels were higher in higher socioeconomic levels. However, we also noted that in some cases, young people from lower socioeconomic backgrounds had lower levels of HDL cholesterol, which is generally considered beneficial. We also summarized the research from ten LAC countries involving a significant number of participants, including children and adolescents. This summary confirms the issue of cardiovascular and metabolic health in youngsters. In LAC, many young people, regardless of their socioeconomic status, face health issues such as weight gain problems. It's important to investigate how each component of the metabolic syndrome develops in cardiovascular diseases in children and adolescents, instead of just looking at the metabolic syndrome. This will aid in better addressing these health challenges.

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Abbreviations

ABEP	Brazilian Association of Research Companies (Associação brasileira de empresas de pesquisa)
BMI	Body Mass Index
CVD	Cardiovascular diseases
CI	Confidence intervals
DM	Diabetes Mellitus
HDL-c	High density lipoprotein cholesterol
HOMA-IR	The homeostasis model assessment of insulin resistance
HTN	Hypertension
IDF	International Diabetes Federation
LAC	Latin America and the Caribbean
LDL-c	Low density lipoprotein cholesterol
LMIC	Low and middle income countries
MetS	Metabolic Syndrome
NOS	New Castle Ottawa Scale
OR	Odds Ratio
PR	Prevalence ratios
SES	Socioeconomic status
TG	Triglycerides
VLDL-c	Very low-density lipoprotein cholesterol
WC	Waist circumference
WHO	World Health Organisation

TABLE CONTENT

I. INTRODUCTION

Cardiovascular and metabolic disorders are the leading causes of mortality and morbidity worldwide (1). Nearly 80% of deaths from cardiovascular disease (CVDs) and diabetes occur in low- and middle-income countries, and despite the inequitable distribution of these diseases, prevention could be possible through well-understood, feasible and cost-effective interventions. The increasing prevalence of risk factors and nowadays the component of Metabolic Syndrome (MetS) is alarming in most societies (1, 2). Several studies have suggested that the high levels of cardiovascular disorders are due to a higher prevalence of risk factors which can be clinic, politic, economic, social, cultural and environmental (3, 4). Recently epidemiological studies have established the relationship between other environmental risk factors and CVDs in adult stages of the life (5-7).

One of the most important aspects is the socioeconomic gradient of health and disease is that it is not uniform across low- and middle-income countries populations and importantly, may depend on the stage of nutritional transition in which a population stands (8, 9). Previous studies have evaluated the associations between Socioeconomic Status (SES) with cardiovascular and metabolic diseases in adults, and they consistently showed and increased prevalence of individual cardiometabolic risk factors in low SES groups (10, 11). Furthermore, social, and economic components as level of education, income, occupation and in housing conditions such as construction type and materials, and access to public utilities (sewer, electricity, potable water, and garbage collection) are related to the prevalence of overweight and obesity in lower SES in adults (12-14).

In more economically prosperous societies, the components of the MetS (cluster of metabolic factors that increase the risk for cardiometabolic diseases) are more prevalent among those with lower SES in the early stages of life. For example, North American and European studies consistently report that early life socioeconomic disadvantage is associated

with childhood overweight and obesity (15), insulin resistance (16), and other cardiovascular risk factors. Identifying and addressing potential risk and protective factors will be the most important challenge of the nations to perform effective preventive health programs, especially in younger periods of life, when biological and psychological changes interact with social determinants and generate lifestyle behaviors (17-19).

Despite evidence from economically developed populations, little is known about how the social, economic and lifestyles of children and adolescents from Latin American and Caribbean countries impact their cardiometabolic risk factors. Latin American countries are rapidly moving through the nutrition transition and thus experiencing increasingly higher rates of obesity and MetS (15, 17-20). Therefore, this research aims to analyze these possible associations in LAC adolescents and children.

II. LITERATURE REVIEW

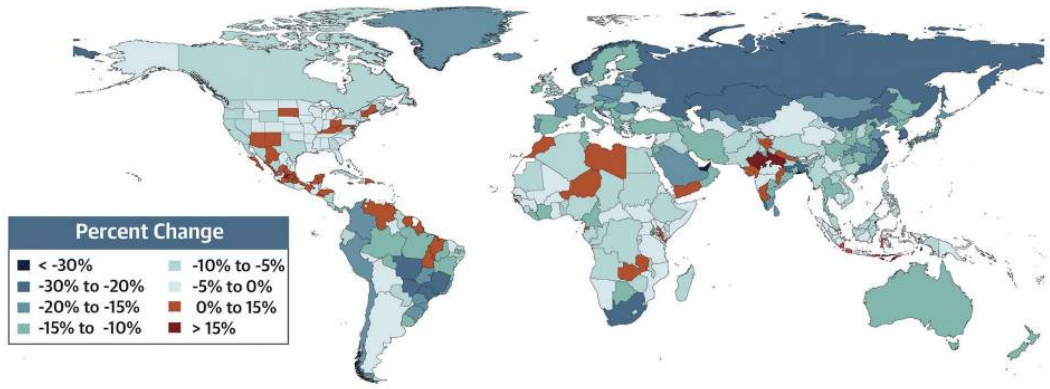
1. Cardiometabolic syndrome as an increasing issue in nations

Cardiovascular diseases (CVD), primarily ischemic heart disease and stroke, are still responsible for more than 17.9 million global deaths of noncommunicable diseases (20, 21). Within this worldwide statistic, over 1.1 billion people have high blood pressure, 425 million adults have diabetes, and approximately 40% of adults are overweight or obese (5, 22). Furthermore, over 75% of CVD deaths occur in low- and middle-income countries, and 85% of these deaths are attributable to heart attacks and strokes (2, 23). This type of disease is preventable through the identification of risk factors and numerous organizations have been working to reduce the global burden of cardiovascular diseases starting with the identification of cardiovascular and metabolic risk factors (2).

A recent multinational collaborative research study, aiming to assess the global burden of disease for every country, has revealed that even modest and gradual reductions in age- and sex-specific death rates from CVD have significant implications across various locations (4) (**Figure 1**). It is crucial to emphasize that the growth of the population and the aging demographic are primary factors contributing to the overall increase in total CVD cases. Management interventions including to prevent some of the cardiometabolic risk factors within universal health coverage packages have proven effective and are available in many countries (18). However, the problem continues to grow, and in a changing and evolving world, new hypotheses have emerged, including prevention through environmental changes, and addressing behavioral cardiometabolic risk factors such as tobacco use, an unhealthy diet, obesity, physical inactivity, and harmful alcohol consumption. Furthermore, studies have revealed that lifestyle choices are influenced by social gradients and global transitions and can be addressed early in life (17-19, 24). The significance of healthy early

childhood development and the opportunity to reduce health-harming behaviors are crucial (17). CVD numbers are expected to increase, and the COVID-19 pandemic lockdown and emerging infectious diseases may exacerbate this issue (25, 26). Therefore, substantial investments and the strengthening of health systems are necessary to combat these diseases.

Figure 1. Percent change in age-standardized CVD death rate from 2010 to 2019



Source: Gregory A. Roth, et al. The Global Burden of Cardiovascular Diseases and Risks

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1.1 Metabolic Syndrome and cardiometabolic components

Metabolic Syndrome (MetS) is defined as a group of cardiovascular risk factors, including abdominal obesity, high blood pressure, elevated blood sugar levels, high triglyceride, and low HDL-c levels. The term 'syndrome X' was first described by Dr. Reaven in 1988, encompassing a cluster of risk factors but later renamed MetS, it is recognized as a complex risk factor for type 2 diabetes and atherosclerotic cardiovascular disease, primarily due to its strong association with insulin resistance. Additionally, it is closely correlated with other further clinical disorders, including non-alcoholic fatty liver disease, a prothrombotic or proinflammatory state, and reproductive issues. MetS components and cardiometabolic components are often used interchangeably to refer to the various individual health parameters or risk factors that are associated with metabolic syndrome or cardiometabolic

health. These conditions are interconnected and share common underlying mediators, mechanisms, and pathways (27). These components have been assessed, indicating different measurement options at various life stages. For example, abdominal obesity has been described as waist circumference, body fat, or body mass index with its corresponding z-score, which can be measurements of abdominal fat and identify overweight or obesity. Another component that has shown different measurements is the increase in glucose levels, where not only these altered blood levels but also HOMA as an indicator of insulin resistance have been considered by several consensuses regarding this component for MetS. Most of these cardiometabolic components have been an expanded waist circumference (WC) resulting from overnutrition, a sedentary lifestyle, and the sequential accumulation of abdominal fat (27-29).

1.1.1 MetS definitions and global burden of disease

Currently, there exist various definitions of MetS. This outcome is a combination of different unfavorable conditions with a shared pathophysiology involving abdominal obesity and insulin resistance, rather than a single distinct disease (17, 30). Recent controversy has arisen over these definitions in adults and their utility, with differences being relatively minor, as indicated in Table 1 (31).

MetS is associated with an increased risk of CVD, and its prevalence rises with age (32-35). The frequency and outcomes of MetS depend on the criteria used, leading to variations of the population (eg. age, country, race, etc) (35, 36). For example, when employing the criteria from the International Diabetes Federation (IDF) and the National Cholesterol Education Program, the estimated prevalence of metabolic syndrome in the United States exceeds 30%. In contrast, using the Adult Treatment Panel criteria, the estimated prevalence is around 22% (37).

Furthermore, the incidence of MetS often parallels the rates of obesity and type 2 diabetes. The incidence of type 2 diabetes (T2DM) is notably higher in specific ethnic groups, such as American Indians (15%) but lower among Chinese Americans (4.3%). South Asian Americans exhibit a high prevalence of metabolic syndrome and a greater incidence of abdominal obesity (38). According to a global obesity survey conducted in 2015 across 195 countries, 604 million adults and 108 million children were found to be obese. Since 1980, obesity rates have doubled in 73 countries and have risen in most other nations (39-41).

It is essential to establish a standardized criterion for evaluating MetS based on the characteristics of the population. Although various MetS criteria have been modified, in 2009, The Harmonizing the MetS criteria represented a significant step toward standardization (42). The criteria defined by the National Cholesterol Education Program-Adult Treatment Panel III (ATP III) and adjusted by the American Heart Association and the National Heart, Lung, and Blood Institute (ATP III/AHA/NHLBI) (28), as well as those established by the IDF, continue to be the most widely used worldwide for adults (42).

Regarding other criteria, prior evidence has compared MetS definitions and the risk of incident CVD in the elderly. Except for the European Group for the Study of Insulin Resistance (EGIR), all definitions of metabolic syndrome were significantly associated with an increased risk of incident cardiovascular (coronary or cerebrovascular) events (35, 43, 44).

Table 1. Metabolic syndrome definitions in adults

Criteria	WHO 1998	EGIR 1999	NCEP-ATP III 2001	AHA 2005	IDF 2006	Harmonized definition 2009
Metabolic syndrome	Glucose intolerance, IGT or T2D and/or IR + 2 or more criteria	3 or more criteria	3 or more criteria	3 or more criteria	Abdominal obesity +2 other factors	3 or more criteria
Waist to wip ratio and/ or	Male > 0.90 Women > 0.85					
BMI	>30 kg/m^2					
Waist circumference		Male > 94 Women > 80	Male > 102cm Women > 88	Male > 102cm Women > 88	**Europe:** Male ≥ 94cm Women ≥ 80cm **South Asians/Chinese:** Male ≥ 90cm Women ≥ 80cm **Japanese:** Male ≥ 85cm Women ≥ 80cm **Latin America:** Use South Asian recommendations until more. specific data are available	Population and country specific definitions
Triglycerides mmol/l (mg/dL)	≥1.7 (150)	≥1.7 (150)	≥1.7	≥1.7	≥1.7 or med for HTG	≥1.7 or med for HTG
HDL-c mmol/l (mg/dL)	HTG and/or Male <35 mg/dL Women <39 mg/dL	Male <39 mg/dL Women <39 mg/dL	Male <1.0 Women <1.3	Male <1.0 Women <1.3	Male <1.0 Women <1.3 or med for rHDL-c	Male <1.0 Women <1.3 or med for rHDL-c
Blood Pressure (mmHg)	≥140/90	≥140/90	≥130/85	≥130/85	≥130/85	≥130/85
Fasting glucose mmol/l (mg/dL)	IGR or T2D		≥06.1 (110)	≥5.6 (100) or diagnosed T2D	≥5.6 (100) or diagnosed T2D	≥5.6 (100) or diagnosed T2D
Insulin resistance	, IR ≥ 20mg/min	Plasma insulin ≥75th percentile				
Other criteria	µ alb, acr ≥20mg/g					

ARC Albumin:Creatinine Ratio; ATP, Adult Treatment Panel; EGIR European group for the study of Insulin Resistance; HTG, Hight Triglycerides; IDF, International Diabetes Federation; IGR, impaired fasting glucose; IGT, impaired glucose tolerance; IR, Insulin Resistance; NCEPT, National Cholesterol Education Program; med, medications; T2D, Type 2 Diabetes; WHO, World Health Organization;

1.1.2 Metabolic Syndrome in children and adolescents

Currently, there is no consensus on the definition of MetS in children and adolescents (45, 46). Various research groups, such as ATP III, IDF, and NHANES, have adapted

existing MetS definitions designed for adults based on studies conducted to understand how these parameters function in this age group (see **Table 2**) (47). Nevertheless, comparing studies that employ different diagnostic criteria has proven to be challenging. This lack of consistency leaves clinicians without clear parameters for assessing the long-term clinical implications of MetS in children or for monitoring the effectiveness of lifestyle interventions.

Table 2 Definitions of metabolic syndrome in children and adolescents

Criteria	Modified ATP III	IDF (10 to 16 years)	NHANES III
Metabolic syndrome	3 or more criteria	2 or more criteria	All criteria
Waist circumference		≥90th percentile* ***>16 to 17 years*** Boys ≥90 cm Girls ≥80 cm	≥90th percentile
Triglyceride	≥90th percentile	≥150 mg/dL(1.7 mmol/L)	≥110 mg/dL(1.24 mmol/L)
HDL-c	< 5th percentile	<40 mg/dL(1.03 mmol/L)	≤40 mg/dL (1.03 mmol/L)
BP	Either SBP or DBP criteria	Either SBP or DBP criteria	≥90th percentile
Systolic	>95th percentile	>130 mmHg	
Diastolic	>95th percentile	≥85 mmHg	
Glucose	Impaired glucose tolerance	≥100 mg/dL (5.6 mmol/L	Fasting ≥110 mg/dL (6.1 mmol/L)

ATP, Adult Treatment Panel; BP, Blood Pressure; DBP, diastolic Blood Pressure; IDF, International Diabetes Federation; SBP, Systolic Blood Pressure.
** Ethnic-specific waist circumference (see Fernandez JR, Redden DT, Pietrobelli A, et al. Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. J Pediatr 2004; 145:439).*

The IDF definition of MetS in children aged 10 to 16 is similar to the criteria used for adults by IDF. However, the definition for adolescents incorporates ethnic-specific waist circumference percentiles and a single age-cut-off level for high-density lipoprotein (HDL-c) instead of a sex-specific cut-off (48-51). For children aged 16 and older, the adult criteria can be applied. Metabolic syndrome cannot be diagnosed in children under 10 years of age, but caution is advised if the waist circumference is at or above the 90th percentile (see **Table 3**).

Table 3. International Diabetes Federation definition of MetS components in children and adolescents

Metabolic syndrome component	Criteria
Waist Circumference	<16 years: ≥ 90th percentile
	≥ 16 years, male: ≥ 90 cm
	≥ 16 years, male: ≥ 80 cm
HDL-c	< 16 years: 40 mg/dL
	≥ 16 years, male: < 40 mg/dL
	≥ 16 years, female: < 50 mg/dL
Triglycerides	≥ 150 mg/dL
Glucose	≥ 100 mg/dL

Source: International Diabetes Federation, The IDF consensus definition of the Metabolic Syndrome in children and adolescents, 2015.

While it originated in the Western world, the Western lifestyle has now spread across the globe, making non-communicable diseases, including MetS, a truly global problem. MetS is no exception and is associated with cardiovascular risk factors and various socioeconomic determinants. However, when measuring MetS in younger populations, definitions result in varying prevalence rates (19).

For instance, in the United States, the prevalence of MetS defined by the modified ATP III criteria is estimated to be approximately 9%, and for the IDF 4.2% based on the National Health and Nutrition Examination Survey (NHANES III) data, which included 1960 children over the age of 12 (49). It's important to consider that pubertal growth in younger individuals has significant health implications, as it involves interactions between early childhood development, specific biological, psychological, and social role changes, as well as wider social determinants. These changes in metabolic traits characterizing the syndrome result in significant individual variability in the categorical diagnosis (19, 33, 52).

1.1.2.1 Clinical implications and therapy in early stages

Clinical experts in consensus agree that early diagnosis and interventions for MetS are essential to improve the prevention of CVD and type 2 diabetes in adulthood (33). To address this issue, two approaches are necessary:

- The development of suitable screening tools for children and adolescents at risk for MetS and its associated comorbidities.
- The implementation of health policies aimed at tackling non-communicable diseases in adults, with a particular emphasis on childhood and adolescent stages.

First, due to controversies surrounding the definition of MetS and the lack of consensus on thresholds for its individual components in children and adolescents, there is no internationally accepted diagnostic pathway for MetS in this population. Nevertheless, several recommendation statements and national guidelines for assessing obesity and its associated comorbidities in children and adolescents are available (53). Obesity appears to be the primary driver for the development of other risk factors for MetS in this demographic. Few longitudinal studies on children and adolescents with MetS exist, which means that long-term cardiovascular and diabetes risks are not well defined, unlike the data available for adults (54-56). In one cohort study involving 771 adults (mean age 38) who had participated in the Lipid Research Clinics study as children and adolescents 22 to 31 years earlier, the incidence of self-reported CVD was more common in adults who exhibited traits of metabolic syndrome as children than in those who did not (19.4% versus 1.5%, odds ratio (OR) 14.6, 95% CI 4.8-45.3) (40). Out of 31 children with metabolic syndrome traits in the initial study, 21 (68%) developed adult metabolic syndrome. Notably, an increasing body mass index (BMI) was strongly associated with the risk of adult metabolic syndrome. Thus,

the definition of MetS may hold clinical utility for risk stratification and therapeutic intervention in pediatrics.

Secondly, while prescription medications for treating certain cardiovascular and metabolic disorders, particularly in cases of overweight and obesity, have been studied through various approaches, the primary therapeutic focus for children and adolescents with obesity—irrespective of a metabolic syndrome diagnosis—is lifestyle modification. This approach emphasizes the reduction of established risk factors, encompassing the promotion of a healthy diet, regular exercise, weight management, and smoking cessation. Middle childhood and adolescence constitute critical stages in child development. Adolescents undergo a transitional phase from childhood to adulthood (57, 58). This period holds significant implications for health as it's when children develop essential skills for building healthy social relationships and learn roles that prepare them for adolescence and adulthood. Adolescents navigate a complex web of interactions involving early childhood development, specific biological and psychological changes, evolving social roles, and broader social determinants (59).

Both stages, middle childhood, and adolescence, present both commonalities and unique aspects, offering an excellent opportunity to emphasize the importance of healthy early childhood development. During adolescence, there is an increased likelihood of engaging in health-harming behaviors, such as excessive alcohol and substance use. These behaviors, combined with emerging social influences like peer pressure to conform to group norms, can establish behavior patterns with implications for current and future health status. While there is often a focus on risky and harmful behaviors during adolescence, these years also provide significant opportunities to shape behavior in ways that promote long-term health and well-being (60, 61).

2. Socioeconomic determinants in Latin America and the Caribbean

2.1. Measurements of socioeconomic determinants

Socioeconomic determinants encompass the social and economic factors that exert influence over an individual's or a population's health and overall well-being. These determinants are pivotal in shaping access to resources, opportunities, and the environments in which individuals live, work, and develop. They wield a substantial impact on health outcomes and inequalities at both the individual and community levels (62).

Key socioeconomic determinants involve a wide range of critical factors such as: socioeconomic status (SES) or classification, income, education, occupation, social support and Networks, housing and neighbourhoods.

One of the determinants that has been widely considered and evaluated as an exposure factor is socioeconomic status, which is described as a concept used to describe an individual's or a family's position within a social and economic hierarchy. This classification includes other socioeconomic factors like income, education, occupation, and wealth to categorize persons and families in different strata, for example high, middle and lowest SES (63). SES does not directly describe causative factors but reflects an individual's relative social and economic standing in society (61).

Methodologically, assessing social and economic factors in populations can be challenging, leading to high levels of missing data. Additionally, the definition of SES often varies between studies, with some indicators serving as proxies for it, such as parental education, occupation, and family income (64, 65).

Certain SES measurement tools have been validated for use with adolescents, comparing parental interviews with adolescents' responses, and the results consistently show agreement between the two (66). However, these findings may not be directly applicable to

younger individuals in Latin America and the Caribbean due to differences in educational and social contexts between Europe, North America, and our own countries.

The absence of an explicit conceptual framework for SES in LAC poses a limitation in clinical research, leading to implications for inference. Firstly, when SES is utilized to control for confounding by other risk factors, proxy indicators for SES may not encompass all the relevant dimensions. This can result in residual confounding by SES (67, 68). For instance, this can occur when SES is operationalized using only the father's occupation, neglecting significant dimensions like the mother's education, which could lead to residual confounding by mother's education (69). This residual measurement error can be particularly problematic when examining the role of SES in racial or geographic disparities, potentially resulting in an underestimation of SES's contribution to such disparities (70).

Secondly, a well-defined intervention is one of the assumptions in causal inference (71). However, in observational studies without a well-defined exposure variable, policy interventions to mitigate the impacts of childhood and adolescent socioeconomic disadvantage on later health outcomes remain unclear.

2.2. The SES and cardiovascular and metabolic health

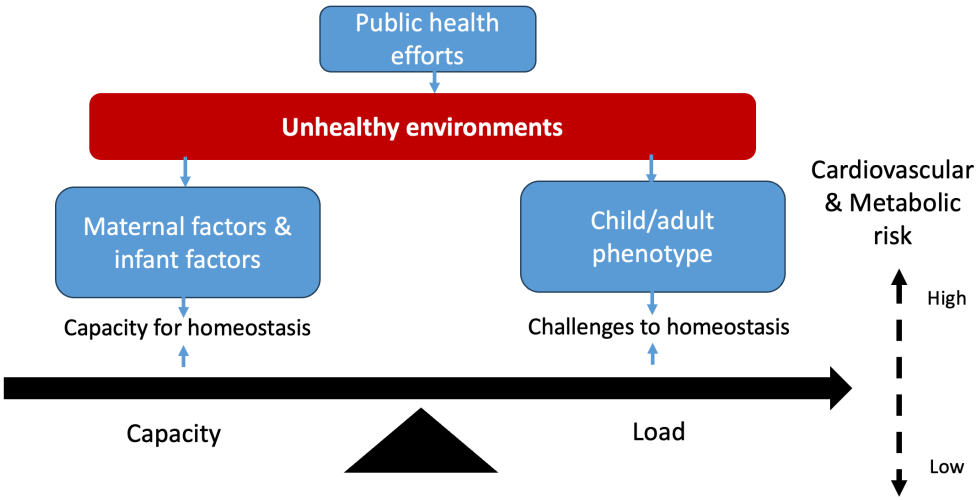
Ample evidence suggests that socioeconomic determinants are linked to lower socioeconomic characteristics and an increased risk of cardiovascular disease (62, 72, 73). While most studies have been conducted in high-income countries, there is emerging evidence that suggests different hypotheses in low-middle-income countries, depending on cardiovascular outcomes. The World Health Organization (WHO) has indicated that the social determinants of health encompass the conditions in which people are born, grow, live, work, and age, including the healthcare system. A range of factors have been identified as social determinants of health, including socioeconomic context, inequality, poverty, social

exclusion, income, public policies, health services, employment, education, housing, transportation, the environment, health behaviors or lifestyles, and social and community support networks (63).

These social determinants of health are primarily responsible for health inequalities, which are understood as unfair and avoidable differences in health status within and between countries. These inequalities can be attributed to factors such as the nutritional environment, air pollution, commercial determinants of health, and improvements in healthcare (74).

Figure 2 illustrates the performance of the capacity-load model, which posits that non-communicable diseases (NCDs) arise due to the inability to maintain metabolic homeostasis, including blood pressure, glycemic control, and arterial health. This model explains how the risk of NCDs is directly influenced by various physiological components and behaviors. It appears that the primary environmental influence on metabolic capacity during early critical windows plays a pivotal role in protecting populations from the risk of NCDs. Clinical societies have recognized the significance of the early social environment in establishing risk trajectories and have encouraged children and adolescents to assess family or community-level risk factors that may expose them to toxic social stress (75).

Figure 2. The capacity-load model of Non-communicable diseases.



Source: Miranda et al. Understanding the rise of cardiovascular diseases in low and middle income countries. Nature. 2019.

III. JUSTIFICATION

These contributions will enhance our understanding at both the national and international levels, providing insights into the spectrum of information concerning the measurement of socioeconomic determinants and measurements in LAC countries. They will contribute to scientific and clinical knowledge, given that the MetS and cardiometabolic components are accountable for an increased risk of type 2 diabetes, and cardiovascular diseases, are linked to all-cause and cardiovascular mortality (74).

In higher-income countries, low socioeconomic levels are associated with poor health outcomes, and some evidence suggests a potential causal pathway for disparities in cardiovascular health among vulnerable populations (76, 77). Despite the evidence from economically developed populations, it is important to note that the cardiovascular and metabolic risk factors associated with this socioeconomic exposure are not consistent across low- and middle-income country populations. In LAC countries, the socioeconomic gradient may vary depending on the stage of nutritional transition a population is experiencing. Many regions are rapidly progressing through this transition, resulting in progressively higher rates of obesity and Metabolic MetS (78). However, there remains a lack of knowledge focusing on clarifying the influence of social, economic, and lifestyle determinants on cardiometabolic risk factors in children and adolescents from less developed countries (11). Furthermore, these results may be guiding community-based healthcare programs and targeted interventions in children and adolescents towards populations with such determinants may impact both health and the economy within the regions.

To elucidate these results, it is crucial to recognize that these measures are vital for mitigating the impact of these diseases on the health and well-being of Latin America and the Caribbean communities. This contributes significantly to the epidemiological methodology by identifying the definitions of exposures related to socioeconomic

determinants within LAC nations and guiding future research projects concerning metabolic syndrome in young and adolescent populations.

IV. OBJECTIVES

1. General objective:

To assess the socioeconomic status and its determinants can be associate to cardiovascular risk factors, mainly those that are components of metabolic syndrome, including insulin resistance, obesity/overweight, abdominal obesity, hypertension and hyperlipidemia in children and adolescents from LAC countries.

2. Specific objectives:

2.1 To determine the magnitude of metabolic syndrome components in Latin America and the Caribbean children and adolescents.

2.2 To analyze the evidence related to socioeconomic status (or determinants by definition) associated with cardiovascular and metabolic components in Latin America and the Caribbean children and adolescents.

V. METHODS

In this session, we will outline each of the objectives of the two studies conducted, along with a description of the methods and statistical analysis used.

Specific objective study 1:

To assess the relationship between SES and metabolic syndrome components in Brazilian adolescents in a population-based ERICA study.

Methods Objective 1:

We performed a cross sectional analytical analysis from the ERICA population-based study to analyze the relationship between socioeconomic status and cardiometabolic components in representative Brazilian adolescents (79). This study was embedded in the ERICA study (Study of Cardiovascular Risk in Adolescents), a population-wide multicenter study among 85,000 students between 12 to 17 years old randomly selected. SES status was measured with the Brazilian Association of survey companies ABEP the Brazilian socioeconomic classification (80). The ERICA study was conducted according to the principles of the Declaration of Helsinki. All procedures were approved by the Committee for Ethics in Research (CEP) of the Institute of Collective Health Studies, in the Universidade Federal do Rio de Janeiro (Process 45/2008) and by the CEP for each Brazilian state involved. All parents/caregivers provided informed consent for those students who were invited to participate and provided blood samples. Furthermore, adolescents gave their informed consent to participate in the study.

Metabolic syndrome presented in younger was defined according to the recent criteria from the International Diabetes Federation for the young population which defines an adolescent who has at least three of the below components (48). Clinical examination in the ERICA study was performed by trained health workers and all measurements were done by duplicate with a maximum variation of 1 cm between the two measurements for quality control purposes.

Height was measured using a digital portable wall mounted Altura Exata® (for a variation of 0.1, the mean of the two values obtained was considered, with a maximum height of 213 cm. Body weight was measured using an electronic P200M Líder® scale P150m (capacity of up to 200 kg and a 50 g variation). Nutritional status classification was based on body mass index calculation (BMI = weight/height^2). BMI (kg/m^2) age-and-sex-specific

z-score curves were considered and plotted according to the World Health Organization 2007 standards (81). Overweight adolescents were considered if the Z-scores were +2 >Z ≥+1 and obese participants were considered if they had Z-scores of Z ≥ +2. Waist circumference (WC) was measured following standardized protocols at the midpoint between the bottom of the last rib and the upper curvature of the iliac crest, using a 1.5 meter-long inextensible measuring tape Sanny®, with a variation of 0.1 cm. Following the criteria from the International Diabetes Federation, abdominal obesity was defined with the following cut-off points in the WC: adolescents younger than 16 years, ≥90th percentile; ≥16 years males, ≥90 cm; ≥16 years females, ≥80 cm (48). Systolic and diastolic blood pressure were validated three times in adolescents, using an automated device Omron® 705-IT model (82). The adolescents were classified based on systolic blood pressure greater than or equal to 130 mmHg or diastolic blood pressure greater than or equal to 85 mmHg, but with a percentile below 95. The adolescents were classified as hypertensive if the systolic or diastolic blood pressure corresponded to the 95th percentile or higher (82).

Trained healthcare professionals collected venous blood samples from the participants after 12 h fasting, to analyze biochemical parameters included in MetS. Plasma and serum were separated within two hours of blood collection and kept between 4 °C and 10 °C during transport to the study laboratory. Fasting glucose, insulin, lipid profile [total cholesterol, high density lipoprotein cholesterol (HDL-c), and triglycerides], and glycated hemoglobin (HbA1c) levels were determined from plasma (mg/dL) (83), according to the Brazilian Society of Pathology methods (84). Very low-density-lipoprotein cholesterol (VLDL-c) was estimated as follows: triglycerides (mg/dL)/2.2. Dyslipidemia levels were analyzed according to Diretriz de Prevenção da Aterosclerose na Infância e na Adolescência (83). Triglyceride levels were defined as altered at values higher than ≥150 mg/dL. Furthermore, low HDL-c was classified as follows: adolescents >16 years old, 40 mg/dL;

≥16 years, male <40 mg/dL; and ≥16 years, female <50 mg/dL. Altered fasting glucose levels were defined as ≥100 mg/dL. Fasting insulin concentrations were also determined and insulin resistance was defined according to the homeostasis model assessment of insulin resistance (HOMA-IR): fasting glucose concentration (mmol/L)*fasting insulin (IU/L)/22.5 (85).

Source: http://www.erica.ufrj.br/index.php/metodos/

Socioeconomic classification and the measurement of co-variables

According to the Brazilian Association of Survey Companies, ABEP, the Brazilian socioeconomic classification aims to estimate the purchasing power of individuals and urban families (80). The stratification of SES was related to criteria such as an individual's and family's consumption capacity and the ability to differentiate between large groups according to the consumption of products and services that are accessible to a significant part of the population. The criterion discrimination procedure considered household characteristics, such as possession and quantity of durable goods, number of bathrooms, employment of domestic workers, and educational qualification of the head of the household during 2013. Each item receives a score and the sum of the scores is associated with one of the following economic grade or stratum: A1, A2, B1, B2, C1, C2, D, and E (where A was higher and E was lower). The sociodemographic information of the participants (sex, age, work employment, lifestyle behavior, and medical history) was assessed through a self-

reporting electronic questionnaire. Furthermore, parents/caregivers had to answer self-reporting questionnaires where the information on family medical history and perinatal care of the student were needed. In this study, the ABEP system was used to divide the population in the following six strata: stratum 1 (D and E - lowest), stratum 2 (C2), stratum 3 (C1), stratum 4 (B2), stratum 5 (B1) and stratum 6 (A1 and A2 - highest). This method allows sufficient sample size (power) per stratum.

In addition, the following variables related to socioeconomic determinants were considered: parent's educational qualification, number of members residing at home, if the adolescents live with their father or mother (or both), number of rooms at home (living room, dining room, kitchen, bedroom, and bathrooms), number of electronic devices (television set, radio, washer, DVD, freezer, car or motorcycle, computer), family income, and the number of house helps in the adolescent's home. Ethnicity was determined based on the race or skin color, and it was classified as follows: white, black, mestizos ("mulattoes", "morena", "cabocla", "cafuza", mameluca"), yellow (oriental), and indigenous. The participant's physical activity was determined from the responses to questions related to time (min/week) spent in different activities such as participating in sports, walking, running, biking, and gymming. For each activity reported, days per week and the number of minutes or hours spent were noted. The total time for physical activity did not consider low intensity activities, such as walking pets, caring for kids, or walking at school. Dietary updates were taken every 24 h, to obtain information about eating habits; the participants with an energy consumption of less than 100 kcal were excluded.

Smoking habits and alcohol consumption were determined by responses to questions related to consumption frequency per day of these substances (86). Exposure to passive smoking was determined by asking whether anyone at home smoked close to the adolescents, and the number of members living at home who smoked (87). Furthermore, to

identify minor psychiatric disorders, adolescents were assessed through the Global Health Questionnaire, 12-items version (GHQ-12) (88).

Statistical analyses

We examined the baseline characteristics, such as sex, age, schooling, lifestyle factors, and cardiovascular and metabolic determinants within the ERICA study population across the pattern of SES defined by the Brazilian 2013 classification. Differences between MetS, its cardiometabolic components, and socioeconomic classes in Brazil were tested using one-way analysis of variance (ANOVA) or Kruskal–Wallis test for continuous variables and Chi-square test for categorical variables, which are not normally distributed. Skewedly distributed variables were log-transformed before modeling. Information was reported as mean (standard errors) or frequency (numbers, percentages), whatever was appropriate. For skewedly distributed variables, median and interquartile ranges were registered.

Multivariate logistic regression models were constructed to address the cross-sectional relation between socioeconomic classes and the following MetS components, in addition to cardiometabolic components in Brazilian adolescents: abdominal obesity, hypertension, hypertriglyceridemia, low HDL levels, and hyperglyceridemia. Linear regression models were used to analyze the relation of continuous cardiovascular and metabolic outcomes, such as BMI, WC, z-BMI scores, total cholesterol, HDL-c, LDL-c, VLDL-c, triglycerides, MAP, and HOMA-IR.

We considered potential confounders based on evidence from previous literature and available data in the ERICA study. These covariates were selected according to the relation

pathway between SES and cardiovascular and metabolic components. Furthermore, these confounders were retained in the model if the β coefficients for main effects changed by more than 10%. The following three multivariable models were performed: model A was adjusted for age and sex; model B was further adjusted for physical activity, passive smoking, parental history of high levels of total cholesterol, and parental history of heart diseases and total energy intake. Analyses were performed using STATA V.14.0 (StataCorp LP, College Station, Texas) using subroutines for complex samples from the software (89).

Specific objective study 2:

To analyze the evidence related to socioeconomic status (or determinants by definition) associated with cardiovascular and metabolic components in Latin America and Caribbean children and adolescents.

Methods Objective 2:

A systematic review was performed to explore the differences between socioeconomic measurements in Latin America and the Caribbean countries as well as cardiovascular and metabolic components in younger. Furthermore, this review highlights areas where there is not enough evidence on this topic. This method was helpful to identify gaps in cardiometabolic health in younger areas in LAC which can be used to guide future research efforts. The protocol of this review was registered with the International Prospective Register of Systematic Reviews (PROSPERO) database (registration number: CRD42020222378) (Supplemental information 1. PROSPERO PDF report). We searched in electronic bibliographic databases such as MEDLINE, EMBASE, LILACS (Bireme), Wok of Science, Scopus, and SciELO. Reference lists of the retrieved articles were searched

for additional publications (**Table 4**). We also contacted the authors of the retrieved papers directly for any additional and unpublished studies. No language limitation was established.

Table 4. Search strategy from November 2020 in Medline/Pubmed, EMBASE, Web of Science, Lilacs/Bireme, Scielo, Scopus

Search number	Query
1	(((Social Class[Mesh] OR Socioeconomic Factors/classification[Mesh] OR Socioeconomic Factors/economics[Mesh] OR Socioeconomic Factors/education[Mesh] OR socioeconomic status [title/abstract] OR social determinants [title/abstract] OR socioeconomic [title/abstract] OR socio-economic [title/abstract] OR socioeconomic inequalities [title/abstract] OR socioeconomic factors [title/abstract] OR socioeconomic level [title/abstract] OR socioeconomic classification [title/abstract] OR socieconomic*)
2	((Cardiovascular System/epidemiology[Mesh] OR Cardiovascular System/etiology[Mesh] OR Cardiovascular System/metabolism[Mesh] OR Cardiovascular System/pathogenicity[Mesh] OR cardiovascular* OR abdominal obesity [title/abstract] OR central obesity [title/abstract] OR obes* OR Obesity, Abdominal[Mesh] OR Overweight[Mesh] OR Hypertension[Mesh] OR hypertens* OR hypertension OR Insulin Resistance[Mesh] OR insulin resistance [title/abstract] OR insulin resistan* OR Hyperlipidemias[Mesh] OR Dyslipidemias[Mesh] OR dyslipid* OR dyslipidemia [title/abstract]) OR (Metabolic Syndrome X[Mesh] OR Metabolic syndrome [title/abstract] OR Metabolic cardiovascular syndrome [title/abstract] OR metabolic cardiovascular syndrome*)))
3	#1 AND #2
4	(Child[Mesh] OR children [title/abstract] OR Adolescent[Mesh] OR Adolescent* OR Adolescent [title/abstract] OR Adult Children[Mesh] OR youth [title/abstract] OR child* OR young* OR childhood)
5	(Latin America[Mesh] OR Latin American countries [title/abstract] OR Latin American [title/abstract] OR Latinamerica*) OR (Colombia[Mesh] OR Colombia[title/abstract] OR Colombia* OR Brazil[Mesh] OR Brazil[title/abstract] OR Brazil* OR Brasil* OR Mexico[Mesh] OR Mexico[title/abstract] OR Mexic* OR Argentina[Mesh] OR Argentina[title/abstract] OR Argentin* OR Peru[Mesh] OR Peru[title/abstract] OR Peru* OR Venezuela[Mesh] OR Venezuela[title/abstract] OR Venezuela* OR Chile[Mesh] OR Chile[title/abstract] OR Chile* OR Ecuador[Mesh] OR Ecuador[title/abstract] OR Ecua* OR Guatemala[Mesh] OR Guatemala[title/abstract] OR Guatemal* OR Cuba[Mesh] OR Cuba[title/abstract] OR Cuba* OR Haiti[Mesh] OR Haiti[title/abstract] OR Haiti* OR Bolivia[Mesh] OR Bolivia[title/abstract] OR Bolivia* OR Dominican Republic[Mesh] OR Dominican Republic[title/abstract] OR Honduras[Mesh] OR Honduras[title/abstract] OR Hondur* OR Paraguay[Mesh] OR Paraguay[title/abstract] OR Paragua* OR Nicaragua[Mesh] OR Nicaragua[title/abstract] OR Nicaragua* OR El Salvador[Mesh] OR El Salvador[title/abstract] OR Salvador* OR Costa Rica[Mesh] OR Costa Rica[title/abstract] OR Costaric* OR Panama[Mesh] OR Panama[title/abstract] OR Panam* OR Puerto Rico[Mesh] OR Puerto Rico[title/abstract] OR Puerto Ric* Or Uruguay[Mesh] OR Uruguay[title/abstract] OR Urugua* OR Guadeloupe[Mesh] OR Guadeloupe[title/abstract] OR Guadeloup* OR Martinique[Mesh] OR Martinique[title/abstract] OR Martiniq* OR Saint Martin[title/abstract] OR Saint Barthelemy[title/abstract]))
6	#4 AND #5
7	#3 AND #6

Table 5. Selection criteria

Study component	Inclusion criteria	Exclusion criteria
Study design	Include cohort, case-control and cross-sectional studies. No language restriction	Exclude letters, abstracts, systematic reviews, meta-analysis, ecological studies and conference proceedings, guidelines.
Population	Include studies conducted among children or adolescents (5 to 18 years old) Include studies conducted in children or adolescents living in Latin America and the Caribbean countries as: Brazil, Mexico, Colombia, Argentina, Peru, Venezuela, Chile, Ecuador, Guatemala, Cuba, Haiti, Bolivia, Dominican Republic, Honduras, Paraguay, Nicaragua, El Salvador, Costa Rica, Panama, Puerto Rico, Uruguay, Guadeloupe, Martinique, Saint Martin, Saint Barthelemy	Exclude studies including pregnant participants. Hospitalized children or adolescents. Exclude studies carried out non-humans.
Exposure	Include studies looking at the effect of socioeconomic status and criteria as family income, home characteristics and public utilities related to cardiovascular and/or metabolic factors.	
Outcome	Include studies looking at the effect on cardiovascular and/or metabolic factors (obesity, overweight, abdominal obesity, insulin resistance, hypertension, dyslipidaemia) in children and adolescents.	

To identify relevant articles between 2016 and 2023, we conducted an extensive literature search in the electronic databases PubMed/MEDLINE, EMBASE, Web of Science, Scopus, SciELO, and LILACS (via Bireme). We performed a search strategy based on the combination of text words and synonyms related to socioeconomic determinants including SES classifications in LAC countries, cardiovascular and metabolic components, or metabolic syndrome components. Relevant terms referring to children or adolescents aged

5–18 years were included. To capture studies that did not explicitly mention socioeconomic classification in the title or abstract, socioeconomic features such as family income, educational level, and public utilities were included in the search strategy. All words were searched using medical subject headings (MeSH) and/or Emtree and free text words in the title or abstract. References of all relevant research articles and reviews were also scrutinized to identify additional potential data sources.

Study selection and data extraction

Independent reviewers worked in pairs to screen the titles and abstracts of the initially identified studies to determine whether these studies met the selection criteria using Rayyan for screening in systematic reviews (90). Any disagreements about selection were resolved through consensus or consultation with a third author. Full text was retrieved for selected titles and contact details of the principal author or other member of the group authoring the paper. The reference list of the full-text articles was checked for any additional unpublished studies. We extracted data from the included articles using a previously designed data collection form. We collected information on source, eligibility of the studies, methods, children or adolescents' characteristics, outcome(s), SES definition, or any of these determinants: family income, parent education level, public utilities, or housing characteristics measured in the younger population. OR, RR or prevalence ratio (PR) with 95% confidence interval (CI) results and miscellaneous (e.g., funding source, key conclusions, correspondence) were also extracted.

Assessment of methodological quality of included articles.

The methodological quality of the included studies was evaluated using the point rating system developed by Wells GA, the Newcastle-Ottawa Scale (NOS) for assessing the

quality of nonrandomized studies in meta-analyses and modified for this study (91) and The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for analytical cross-sectional study (last amended in 2017). Two independent reviewers made judgments based on assessments of study designs and risk of bias as critical appraisal processes. We contacted the investigators for clarification where the data were uncertain or missing.

The scoring for quality of studies and the methodological quality of the included studies are shown in **Table 6**. The scoring criteria assessed methodological factors for sampling and sample size, representativeness of the study participants, exposure and appropriate outcomes measured, and adjustments in the analysis models. Studies were rated as having high (≥10 points), medium (5–9 points), or low (0–5 points) methodological quality.

Table 6. Scoring criteria for quality of observational studies based on JBI checkist for cross-sectional studies

Criteria	*Score*	*Description criteria*
Study design	*0*	For cross-sectional studies
	1	For longitudinal studies (retrospective or prospective)
Population	*0*	If n<500
	1	If n 500 to 2000
	2	If n >=2000
Selection bias	*0*	If no is description for source
		If selected group was volunteers
		If non exposed cohort was draw from different source
		If the representativeness of the cases (in case control studies) was potential for selection biases or not stated
	1	If the individuals were selected in the study somewhat likely to be representative of the target population
	2	If the individuals were selected in the study likely to be representative of the target population
		If the participants were community controls (in case control studies)
		If the participants were consecutive or obviously representative series of cases
		If the cohort are truly representative of the average of the community
		If the cohort is somewhat representative of the average in the community
Exposure	*0*	If the information of SES was from interview not blinded (in case control studies)
		If the information of SES was written self-reported
		If the information about how SES data was collected was not described
	1	If the study used not validated or reliable SES classification

	2	If the study used validated SES classification and it was corroborated by any public document
Outcome	*0*	If the information about components of metabolic syndrome was self-reported
	1	If the study used moderate quality outcome measurement methods:
		Blood pressure: only one measurement in resting position, by a trained observer
		Lipid profile, glucose: non-fasting blood sampling, otherwise well described Abdominal obesity, obesity overweight: anthropometric measurements without less clothes, only one measurement by a trained observer
		Insulin sensitivity: Only either glucose or insulin measures, blood sampling after 12hrs or overnight fast
	2	If the study used adequate outcome measurement methods
		Blood pressure: at least two measurements, in resting position by a trained observer
		Lipid profile glucose levels: blood sampling after 12hrs r overnight fast Insulin sensitivity: both glucose and insulin or a composite measure with blood sampling after 12hr or overnight fast, or an appropriate glucose or insulin tolerance test Abdominal obesity, obesity overweight. At least two anthropometric measures doing by a trainer observer with minimum of clothes
		If the follow up was long enough for outcomes occur
		If the outcome was blinded assessment (in cohort studies)
		If the case definition was adequate with independent validation
		If the controls had no history of the diseases (in case control studies)
Analyses	*0*	If findings were no controlled for at least the 4 key possible covariates mentioned below
	1	If findings are controlled for: age or tanner stage sex, energy intake and at least family history of cardiovascular diseases
	2	If findings are additionally controlled for at least two of the following covariates: physical activity, birth characteristics, sedentary behaviours, diet, sleep duration, depression.

Data synthesis

The prevalence of cardiovascular and metabolic components was estimated by SES, family income, parents' educational level, public utilities, and housing characteristics. Quality synthesis was presented to describe SES definitions and measures in LAC countries. A meta-analysis was used to summarize SES, OR, or PR effects on each outcome: overweight, obesity, obesity and overweight, abdominal obesity, body fat, prehypertension/hypertension, altered glucose levels, altered insulin resistance, altered high-density lipoprotein cholesterol (HDL-c), altered triglyceride levels, and altered low-density lipoprotein-cholesterol (LDL-c) levels. We pooled the study-specific effect measures as OR or PR using a random-effects meta-analysis model to obtain an overall summary estimate of the effect of SES according to the different cardiometabolic outcomes across studies (92). Heterogeneity was assessed using the χ^2 test, Cochrane's statistic and quantified by calculating I^2 (with values of 25%, 50%, and 75% representing low, medium, and high heterogeneity, respectively). Data were analyzed using the R programming language

(version 4.3.2) and the RStudio integrated development environment (version 2022.07.2). Sensitivity analyzes were performed including age and country, to identify the source of the heterogeneity.

VI. RESULTS

Metabolic syndrome components in Brazilian adolescents across SES

We analyzed 36,956 adolescents with a mean age of 14.6 years (SD 3.7), and 18,418 (49.8 %) were boys. SES information was available for 25,822 subjects; 3,414 (11.7 %) of the total sample were from stratum 1 (A1 – A2 highest) and 421 (1.7 %) from stratum 6 (D and E - lowest). **Table 7** presents characteristics of the study population by SES according to the ABEP criteria. Based on its standard definition, MetS was found in 2,6 % of the total population. In unadjusted ANOVA analyses, compared to the adolescents in the low SES group, those in the high SES group were more likely to be white and study in private schools from urban areas, though a higher proportion of girls were from the D-E SES group. Adolescents from the highest SES group had higher physical activity (min per week) than the other strata, while subjects from strata 1, 2, and 3 were the most exposed to passive smoking. More adolescents in A1-A2 SES strata had a parental history of total cholesterol level disorders and diabetes mellitus. Descriptive analyses of SES and cardiometabolic components reflect a higher z score of BMI, total cholesterol, LDL-c, VLDL-c, and triglyceride levels in adolescents from middle to higher SES groups. Nevertheless, lower HDL-c levels were observed in subjects from the lowest SES stratum. There were no differences in total intake (kcal), neither total macronutrients intake, such as carbohydrates and fats, between SES groups.

Figure 3. Flow- chart Brazilian adolescents in the ERICA study

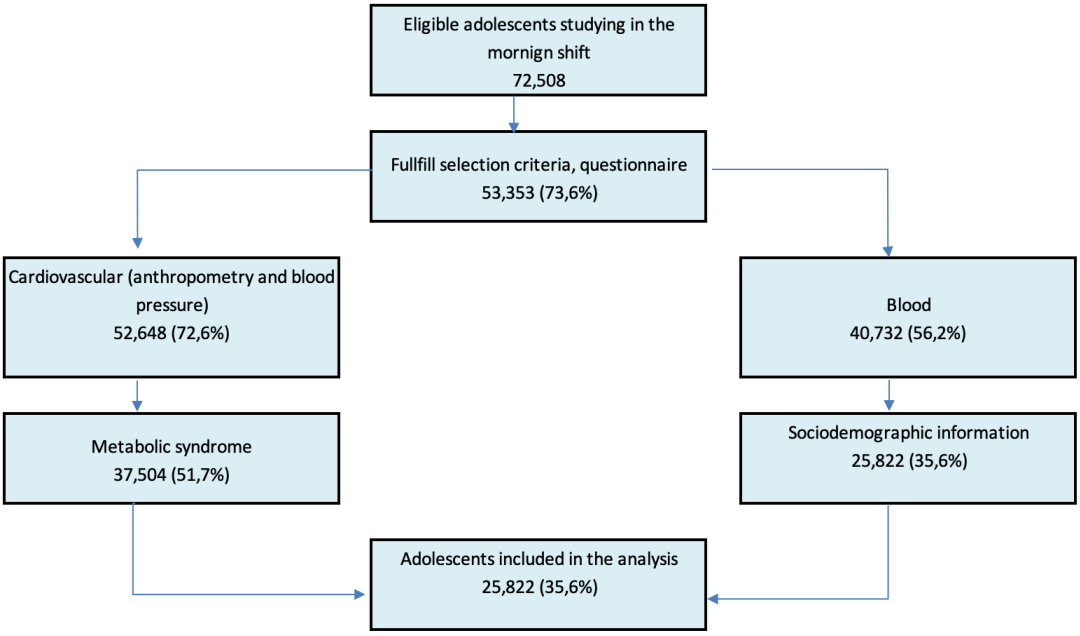


Table 7. Sociodemographic characteristics of the ERICA population (n= 25,822)

Characteristics	Total		HIGHER					LOWER	P-value
			A1-A2 (n=3414)	B1 (n=5406)	B2 (n=8064)	C1 (n=6148)	C2 (n=2369)	D-E (n=421)	
	n	*Mean (SE) or n (%)*	*Mean (SE) or n (%)*	*Mean (SE) or n (%)*	*Mean (SE) or n (%)*	*Mean (SE) or n (%)*	*Mean (SE) or n (%)*	*Mean (SE) or n (%)*	
Sociodemographic									
Age (years)	**36956**	**14.6 (3.7)**	**14.24 (0.09)**	**14.56 (0.07)**	**14.60 (0.04)**	**14.74 (0.06)**	**14.94 (0.09)**	**15.00 (0.17)**	**0.028**
Sex (female)	**25822**	**15650 (50.2)**	**1843 (42.4)**	**3116 (45.9)**	**4906 (50.5)**	**3920 (52.8)**	**1573 (59.8)**	**292 (67.7)**	**0.001**
Type of school (public)	**36956**	**27223 (73.7)**	**744 (28.7)**	**2914 (61.8)**	**6340 (81.4)**	**5647 (93.2)**	**2280 (97.8)**	**410 (99.2)**	**0.001**
Area of school (urban)	**36956**	**36331 (98.3)**	**3404 (99.9)**	**5358 (99.9)**	**7939 (93.4)**	**6002 (92.8)**	**2300 (97.0)**	**406 (91.9)**	**0.001**
Race/ethnicity (white)	**13230**	**13230 (35.0)**	**1854 (56.2)**	**2389 (47.3)**	**2962 (42.4)**	**1783 (33.2)**	**495 (23.1)**	**87 (30.0)**	**0.001**
Parental cholesterol disorders	**25822**	**12870(55.4)**	**2139(62.9)**	**3233(62.2)**	**4534(52.0)**	**3388(50.9)**	**1338(55.8)**	**238(42.6)**	**0.001**
Parental heart diseases	**25.822**	**11577(43.5)**	**1436(41.2)**	**2405(46.4)**	**3597(41.4)**	**2786(42.9)**	**1149(50.0)**	**204(40.1)**	**0.034**
Mental disorders by GHQ-12 (at least 3 items)	**25822**	**8411(30.5)**	**1142(27.1)**	**1764(31.8)**	**2575(30.6)**	**1997(28.5)**	**771(36.3)**	**162(34.2)**	**0.052**
Mental disorders by GHQ-12 (at least 5 items)	**25822**	**4937(17.3)**	**665(15.1)**	**1033(18.9)**	**1502(15.6)**	**1193(17.5)**	**454(23.0)**	**90(15.8)**	**0.014**
Physical sportive activity (min/week) *	**36956**	**190 (0–600)**	**330(90–765)**	**240(10–650)**	**200(0–600)**	**160(0–540)**	**144(0–510)**	**111(0–450)**	**0.001**
Inactive adolescent (0 mins/week physical activity)	**36956**	**15767 (42.7)**	**646(17.5)**	**1336(20.6)**	**2386(26.1)**	**2111(29.0)**	**889(36.4)**	**173(34.6)**	**0.001**
Physical activity (active ≥300 min/week)	**36956**	**11176 (30.2)**	**1828(57.2)**	**2510(47.9)**	**3475(46.9)**	**2415(43.7)**	**888(35.8)**	**145(33.0)**	**0.001**
Active smoking (yes)	25822	642 (1.7)	68 (1.2)	131 (2.4)	151 (1.5)	83 (2.4)	39 (2.2)	4 (1.2)	0.233
Passive smoking (yes)	**25822**	**6597(28.9)**	**658(21.3)**	**1216(27.9)**	**2118(27.2)**	**1746(33.5)**	**722(34.8)**	**137(35.7)**	**0.001**
Alcohol consumption (at least 1 cup in the last 30 days)	36956	7527 (20.4)	998(25.6)	1325(25.8)	1737(20.5)	1214(22.2)	389(16.3)	78(12.8)	0.080
Total energy consumption (kcal) *	36956	2101.2 (1542.5 – 2820.8)	2118.0 (1541.8–2830.8)	2113.3 (1546.7–2827.0)	2145.6 (1574.8–2880.9)	2128.8 (1571.1–2833.9)	2125.0 (1585.1–2846.6)	2073.6 (1621.9–2785.5)	0.358
Total carbohydrate consumption (g) *	36956	279.9 (200.0–382.5)	276.0 (196.7–380.8)	279.7 (199.5–380.9)	287.0 (203.5–390.3)	284.3 (205.2–390.6)	282.3 (203.6–382.8)	287.3 (214.6–382.4)	0.216
Cardiovascular and metabolic measurements									
BMI (kg/cm^2)	25822	21.4 (0.08)	21.8 (0.14)	21.6 (0.21)	21.4 (0.14)	21.4 (0.17)	21.0 (0.14)	21.4 (0.34)	0.142
z score BMI	25822	**0.3 (0.02)**	**0.54 (0.04)**	**0.37 (0.06)**	**0.30 (0.04)**	**0.22 (0.04)**	**0.08 (0.04)**	**0.22 (0.09)**	**0.001**

Waist circumference (cm)	25788	72.2 (0.21)	73.3 (0.42)	72.9 (0.66)	72.2 (0.34)	72.1 (0.42)	71.5 (0.33)	72.0 (0.98)	0.181
Systolic blood pressure (mm/Hg)	25822	111.4 (0.20)	111.3 (0.60)	111.1 (0.72)	111.5 (0.27)	111.9 (0.31)	110.2 (0.50)	110.4 (0.50)	0.877
Diastolic blood pressure (mm/Hg)	25822	66.4 (0.14)	66.5 (0.40)	66.4 (0.45)	66.3 (0.26)	66.4 (0.20)	66.5 (0.34)	64.8 (0.56)	0.834
Mean arterial pressure	25822	81.4 (0.16)	81.4 (0.41)	81.2 (0.52)	81.4 (0.24)	81.6 (0.21)	81.0 (0.33)	80.0 (0.52)	0.841
Total cholesterol (mg/dL)	**25744**	**148.2 (0.52)**	**150.6 (1.46)**	**151.5 (1.2)**	**147.9 (0.94)**	**145.2 (0.77)**	**146.2 (1.2)**	**139.8 (2.5)**	**0.001**
LDL cholesterol levels (mg/dL)	**25731**	**85.3 (0.21)**	**86.3 (0.85)**	**86.8 (0.90)**	**84.8 (0.74)**	**83.3 (0.66)**	**84.2 (0.96)**	**81.5 (2.10)**	**0.043**
VDL cholesterol levels (mg/dL)*	**25742**	**31.8 (24.5–41.8)**	**32.7 (25.5 – 43.2)**	**32.2 (25–42.7)**	**31.2 (24.5–41.8)**	**31.4 (24.5–41.4)**	**31.1(24.5–41.4)**	**31.3(24.0–42.2)**	**0.040**
HDL cholesterol levels (mg/dL)	**25744**	**47.3 (0.30)**	**48.1 (0.55)**	**48.3 (0.56)**	**47.5 (0.50)**	**46.7 (0.45)**	**46.5 (0.60)**	**43.5 (0.51)**	**0.001**
Triglycerides (mg/dL)*	**25742**	**70 (54–92)**	**72(56–95)**	**71 (55–94)**	**70 (54–92)**	**69 (54–91)**	**68.5 (54–91)**	**69 (53–93)**	**0.005**
Glucose level (mg/dL) *	25710	86 (81–90)	85 (81–90)	85 (81–90)	85 (81–90)	85 (81–90)	85 (81–90)	86 (81–91)	0.719
Glucose (HbA1c)*	25780	5.4 (5.2 –5.6)	5.4 (5.1–5.6)	5.4 (5.1–5.6)	5.4 (5.2–5.6)	5.4 (5.2–5.6)	5.4 (5.2–5.6)	5.4 (5.2–5.6)	0.242
Insulin levels*	25717	8 (5.5–11.3)	7.9 (5.7– 11.2)	8.1 (5.6–11.3)	8 (5.6 – 11.3)	7.8 (5.4 – 11.1)	7.8 (5.3 – 10.9)	7.7 (5.3 –10.9)	0.429
HOMA IR*	25618	1.7 (1.1 – 2.4)	1.6 (1.1 – 2.4)	1.7 (1.1 – 2.4)	1.7 (1.1 – 2.3)	1.6 (1.1 – 2.3)	1.6 (1.0 – 2.3)	1.6 (1.0 – 2.3)	0.420
Metabolic syndrome components									
Waist circumference <16 yrs ≥P90 & ≥ 16 yrs M ≥90 cm or F ≥80 cm	25788	4300 (12.7)	418 (12.8)	654 (14.3)	970 (12.0)	707 (12.8)	265 (11.0)	48 (12.8)	0.517
TG ≥150 mg/dL	25742	1667 (4.5)	180 (6.2)	285 (4.6)	361 (4.8)	249 (4.1)	96 (4.6)	13(2.06)	0.362
HDL-c <16 yrs 40 mg/dL & ≥ 16 yrs M <40 mg/dL or F <50 mg/dL	**25744**	**12706 (32.5)**	**1008 (28.5)**	**1677 (28.6)**	**2744 (31.2)**	**2376 (36.8)**	**1002 (38.4)**	**202 (47.6)**	**0.001**
Glucose ≥100 mg/dL	25710	1119 (4.0)	99 (3.5)	165 (5.5)	220 (3.4)	189 (3.9)	60 (2.9)	14 (1.9)	0.101
Blood Pressure Systolic ≥130 mmHg or Diastolic ≥85 mmHg	25822	2625 (8.2)	269 (8.9)	391 (8.1)	589 (7.6)	432 (8.0)	157 (6.5)	22 (8.1)	0.853
Metabolic syndrome at least 3 components present	25607	840 (2.5)	82 (2.6)	119 (2.4)	175 (2.2)	141 (2.6)	51 (1.3)	13 (6.2)	0.198

SE, Standard error; BMI, Body mass index; HDL, High-density lipoprotein; VLDL, very low-density lipoprotein; LDL, low-density lipoprotein; HOMA-IR, homeostatic model assessment for insulin resistance; GHQ-12, Goldberg health questionnaire.

***Values are mean and proportions with a standard error for survey data analysis. Significant p-values are in bold. For skewedly distributed variables, values are median and interquartile range. P values are calculated with a Pearson chi-square statistic converted to a F-statistic for categorical variables, linear regression for continuous variables and Kruskal–Wallis test for skewedly distributed continuous.*

The results of the analyses of MetS components and SES are presented in odds ratios (OR) and 95% confidence intervals (CI) in **Table 8**. The OR for altered triglycerides was higher in the upper SES strata (A1-A2, B1, and B2). Notably, the highest SES group demonstrated a significant minor OR for lower HDL-c for higher SES, when the model was further adjusted for BMI (OR=0.43, 95% CI 0.30 to 0.63). Youngsters from the B1 SES group showed a higher risk of altered glucose (OR=2.59, 95% CI 1.19 to 5.62).
Finally, adolescents from C1 SES groups exhibited less OR against MetS (at least 3 components present) compared to those from the lowest SES (OR=0.19, 95% CI 0.05 to 0.62).

We analyzed cardiovascular and metabolic components measurements across the SES groups after three model covariates adjustments (**Table 9)**. Compared to the other models, the multivariate B model showed a higher BMI z-score in adolescents from A1-A2 SES group (regression coefficient=0.27, 95 % CI 0.09 to 0.45); therefore, this group had a higher risk of being overweight (OR=2.27, 95 % CI 1.14 to 4.53) (**Table 10**). Furthermore, total cholesterol levels are higher in adolescents from higher SES, including higher levels of HDL-c (regression coefficients= 6.11, 95 % CI 4.82 to 7.41), compared with the adolescents from the lowest SES group. We did not find significant regression coefficients regarding mean arterial pressure and HOMA-IR.

Table 8. Association between SES classification and MetS components (n= 25,822)

Metabolic syndrome components	A1-A2	B1	B2	C1	C2	D-E
	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)	
Waist circumference n (%) ***<16yrs ≥P90 & ≥ 16yrs M ≥90cm or F ≥80 cm***	*418 (12.8)*	*654 (14.3)*	*970 (12.0)*	*707 (12.8)*	*265 (11.0)*	*48 (12.8)*
Model A	1.21(0.59; 2.51)	1.33(0.62; 2.82)	1.04(0.53; 2.04)	1.11(0.58; 2.12)	0.89(0.47; 1.69)	*Reference*
Model B	1.14(0.54; 2.37)	1.21(0.57; 2.58)	0.99(0.50; 1.95)	1.04(0.54; 2.01)	0.8(0.43; 1.53)	
TG ≥*150 mg/dL* n(%)	180 (6.2)	285 (4.6)	361 (4.8)	249 (4.1)	96 (4.6)	13(2.06)
Model A	**3.25(1.32; 8.00)**	**2.37(1.10; 5.30)**	**2.43(1.10; 5;36)**	2.08(0.96; 4;51)	2.34(0.92; 5.93)	*Reference*
Model B	**3.06(1.25; 7.59)**	**2.24(1.00; 4.97)**	**2.34(1.06; 5.12)**	2.02(0.93; 4.37)	2.24(0.87; 5.71)	
HDL-c n(%) ***<16yrs 40mg/dL & ≥ 16yrs M <40mg/dL or F <50mg/dL***	1008 (28.5)	1677 (28.6)	2744 (31.2)	2376 (36.8)	1002 (38.4)	*202 (47,6)*
Model A	**0.48(0.32; 0.71)**	**0.45(0.30; 0.69)**	**0.51(0.38; 0.69)**	**0.65(0.45; 0.92)**	0.68(0.46; 1.00)	*Reference*
Model B	**0.47(0.32; 0.69)**	**0.44(0.29; 0.67)**	**0.51(0.38; 0.68)**	**0.64(0.45; 0.91)**	**0.66(0.45; 0.98)**	
Glucose n(%) ***≥100mg/dL***	99 (3.5)	165 (5.5)	220 (3.4)	189 (3.9)	60 (2.9)	14 (1,9)
Model A	1.50(0.70; 3.23)	**2.53(1.15; 5;55)**	1.60(0.76; 3.35)	1.88(0.86; 4.01)	1.51(0.66; 3.50)	*Reference*
Model B	1.69(0.78; 3.60)	**2.63(1.22; 5.68)**	1.67(0.79; 3.51)	1.88(0.86; 4.08)	1.49(0.63; 3.51)	
Blood Pressure n(%) ***SBP≥130mmHg or DBP ≥85mmHg***	269 (8.9)	391 (8.1)	589 (7.6)	432 (8.0)	157 (6.5)	22 (8,1)
Model A	0.97(0.33; 2.86)	0.83(0.29; 2.36)	0.80(0.29; 2.15)	0.86(0.31; 2.38)	0.71(0.25; 2.02)	*Reference*
Model B	0.97(0.32; 0.89)	0.786(0.27; 2.20)	0.78(0.28; 2.28)	0.84(0.30; 2.33)	0.68(0.23; 1.93)	
Metabolic syndrome ***at least 3 components present***	82 (2.6)	119 (2.4)	175 (2.2)	141 (2.6)	51 (1.3)	13 (6,2)
Model A	0.40(0.10; 1.56)	0.36(0.10;1.31)	0.34(0.12; 1.01)	0.40(0.11; 1.41)	**0.21(0.06; 0.69)**	*Reference*
Model B	0.41(0.10; 1.65)	0.35(0.09; 1.24)	0.34(0.11; 1.00)	0.39(0.11; 1.36)	**0.19(0.05; 0.62)**	

M, male; F, female; TG, triglycerides; SBD, systolic blood pressure; DBP, Diastolic blood pressure; HDL, High-density lipoprotein. Significant p-values are in bold.
Values are derived from logistic regression model for survey data and represent OR (95% confidence intervals)

Model A - age and sex
Model B - Model A & parents with cholesterol disorders, history of parents with heart diseases, physical activity, second-hand smoking, and total energy intake

Table 9. Association between cardiometabolic risk factors and SES in the ERICA study (n=25,822)

Cardiovascular and metabolic risk factors	A1-A2		B1		B2		C1		C2		D-E
	β *(95 % CI)*		β *(95 % CI)*		β *(95 % CI)*		β *(95 % CI)*		β *(95 % CI)*		
Waist circumference (cm)											
Model A	1.53	(-0.28; 3.33)	0.90	(-1.23; 3.02)	0.22	(-1.43; 1.86)	0.21	(-1.54; 1.94)	-0.47	(-2.32; 1.38)	*Reference*
Model B	1.42	(-0.21; 3.06)	0.66	(-1.30; 2.62)	0.16	(-1.36; 1.67)	0.09	(-1.56; 1.73)	-0.63	(-2.37; 1.10)	
BMI z score											
Model A	**0.29**	**(0.10; 0.49)**	0.14	(-0.09; 0.37)	0.07	(-0.13; 0.26)	0.00	(-0.20; 0.20)	-0.12	(-0.32; 0.09)	*Reference*
Model B	**0.27**	**(0.09; 0.45)**	0.11	(-0.10; 0.32)	0.06	(-0.12; 0.23)	-0.01	(-0.20; 0.18)	-0.13	(-0.33; 0.07)	
Triglycerides levels (mg/dL)											
Model A	0.10	(-0.02; 0.23)	**0.11**	**(0.01; 0.22)**	0.06	(-0.04; 0.15)	0.01	(-0.08; 0.10)	0.05	(-0.06; 0.16)	*Reference*
Model B	0.10	(-0.04; 0.20)	0.10	(-0.00; 0.20)	0.05	(-0.04; 0.14)	0.00	(-0.08; 0.09)	0.04	(-0.07; 0.14)	
Total cholesterol levels (mg/dL)											
Model A	**12.79**	(7.66; 17.91)	**13.43**	(7.58;19.28)	**9,53**	(4.50;14.56)	**6.64**	(1.70;11.59)	**7.30**	**(2.06;12.55)**	*Reference*
Model B	**11.71**	(6.69; 16.73)	**12.47**	(6.94;17.99)	**8.88**	(3.98;13.78)	**6.16**	(1.42;10.9)	**6.78**	(1.78;11.77)	
HDL cholesterol levels (mg/dL)											
Model A	**5.67**	**(4,42; 6.90)**	**5.70**	**(4.28; 7.13)**	**4.70**	**(3.40; 6.00)**	**3.76**	**(2.44; 5.07)**	**3.21**	(1.83; 4.60)	*Reference*
Model B	**5.64**	**(4.37; 6.91)**	**5.76**	**(4.32; 7.19)**	**4.67**	**(3.31; 6.02)**	**3.77**	**(2.42; 5.11)**	**3.30**	**(1.90; 4.72)**	
LDL cholesterol levels (mg/dL)											

Model A	**5.66**	(1.43;9.89)	**6.30**	(1.38;11,21)	3.98	(-0.14; 8.09)	2.35	(-1.96; 6.67)	3.44	(-0.83; 7.71)	*Reference*
Model B	4.84	(0.75; 8.93)	5.52	(0.87; 10.16)	3.48	(-0.53; 7.49)	1.97	(-2.20; 6.13)	2.99	(-1.10; 7.08)	
VLDL cholesterol levels (mg/dL)											
Model A	0.10	(-0.02; 0.23)	**0.11**	**(0.01; 0.22)**	0.06	(-0.03; 0.15)	0.01	(-0.08; 0.10)	0.05	(-0.06; 0.16)	*Reference*
Model B	0.08	(-0.04; 0.20)	0.10	(-0.00; 0.19)	0.05	(-0.04; 0.13)	0.00	(-0.08; 0.09)	0.04	(-0.07; 0.14)	
Mean arterial pressure (mmHg)											
Model A	1.68	(0.32; 3.03)	1.40	(0.14; 2.66)	1.51	(0.41; 2.61)	1.67	(0.63; 2.72)	1.03	(-0.18; 2.24)	
Model B	1.68	(0.32; 3.02)	1.40	(0.14; 2.66)	1.51	(0.41; 2.61)	1.67	(0.29; 2.71)	1.03	(-0.18; 2.23)	*Reference*
HOMA-IR											
Model A	-0.05	(-0.19; 0.08)	-0.08	(-0.20;0.05)	-0.05	(-0.180.07)	-0.04	(-0.17;0.09)	-0.08	(-0.21;0.05)	
Model B	-0.05	(-0.19; 0.08)	-0.08	(-0.20;0.05)	-0.06	(-0.18; 0.06)	-0.04	(-0.170.09)	-0.09	(-0.21;0.05)	*Reference*

BMI, Body mass index; HDL, High-density lipoprotein; VLDL, very low-density lipoprotein; LDL, low-density lipoprotein; HOMA-IR, homeostatic model assessment for insulin resistance. Significant p-values are in bold. Values are derived from linear regression model for survey data and represent coefficients (95% confidence intervals)
Model A - age and sex
Model B - Model A & parents with cholesterol disorders, history of parents with heart diseases, physical activity, second-hand smoking, and total energy intake

Table 10. Association between SES classification and obesity and overweight

Overweight and obesity	A1-A2	B1	B2	C1	C2	D-E
	OR (95 % CI)	***OR (95 % CI)***	***OR (95 % CI)***	***OR (95 % CI)***	***OR (95 % CI)***	
Overweight	9.8 (0.7)	10.6(1.3)	8.4(0.8)	9.2(0.9)	6.2(0.9)	9.5(3.4)
Model A	**2.33 (1.16;4.67)**	1.74 (0.82;3.68)	1.79 (0.81; 3.95)	1.37 (0.64; 2.93)	1.47 (0.64; 3.38)	*Reference*
Model B	**2.27 (1.14;4.53)**	1.68 (0.80; 3.56)	1.77 (0.81; 3.88)	1.35 (0.63; 2.90)	1.45 (0.63; 3.37)	

M, male; F, female; TG, triglycerides; SBD, systolic blood pressure; DBP, Diastolic blood pressure; HDL, High-density lipoprotein. Significant p-values are in bold.
Values are derived from the logistic regression model for survey data and represent OR (95% confidence intervals)
Model A - age and sex
Model B - Model A & parents with cholesterol disorders, history of parents with heart diseases, physical activity, second-hand smoking, and total energy intake

Socioeconomic classifications and indicators associated with cardiovascular and metabolic components in Latin America and Caribbean children and adolescents.

The initial literature search retrieved 7.362 references, of which 409 were selected after title and abstract screening for full-text review. Finally, 64 references from 58 studies were determined to be eligible and included in this systematic review (**Figure 4**). Included studies reported 591,471 children and adolescents from ten LAC countries, 43 studies reported SES index described in **Table 11** and 23 references included other socioeconomic determinants like family income, parent's educational levels, housing characteristics, and public utilities (**Table 12**).

There were 347,366 participants from Costa Rica in one study (93), 177,806 participants from Brazil (47 studies) (94-139), 33,285 from Peru (3 studies) (140-142), 33,160 from Colombia (4 studies) (143-146), 14,144 from Mexico (2 studies) (147, 148), 4,178 from Venezuela (two studies) (149, 150), 1,150 from Argentina (1 study) (151), 1,139 from Chile (2 studies) (152, 153), 560 from Guatemala (1 study) (154), and 250 from Puerto Rico (1 study) (155). Fifty nine of the studies were cross-sectional studies (92.1%), and three were followed by cohort studies and two case-control studies. The included studies described sample sizes ranging from 161 to 347,366 participants. The mean age of participants ranged from 7 to 16.5 years. Most of the studies (92.3%) had low or middle methodological quality while 5 studies (3.2%) were of high quality. **Figure 5** describes the cardiovascular and metabolic outcomes variables measured in the included studies. Blood pressure and hypertension were the most outcomes measured in this review following overweight, obesity and overweight and obesity (**Figure 6**).

Figure 4. Flow diagram for the selection of studies evaluating the association between socioeconomic status in Latin America and the Caribbean countries and metabolic syndrome components in young adults (aged 5–19 years)

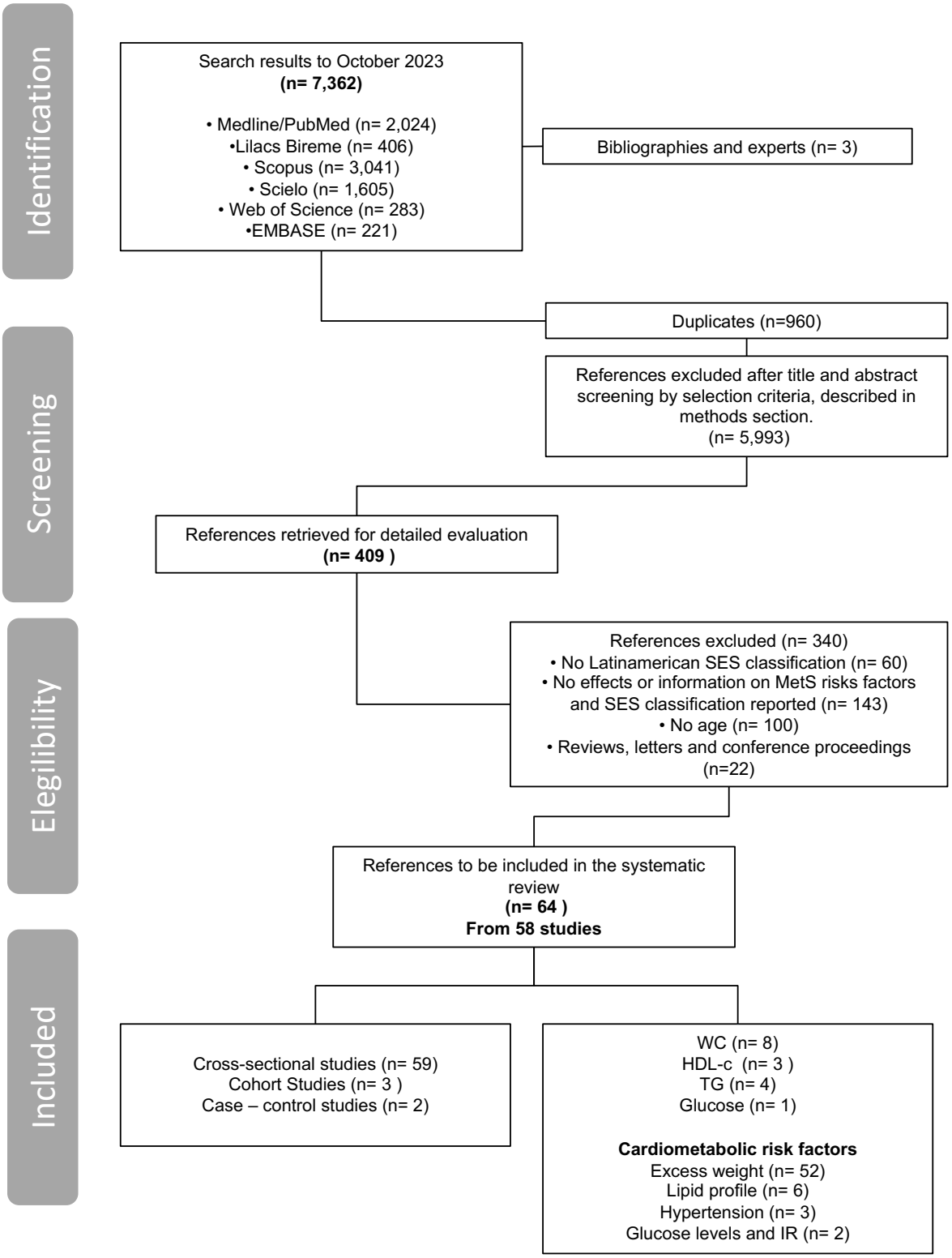


Figure 5. Quality assessment of included studies.

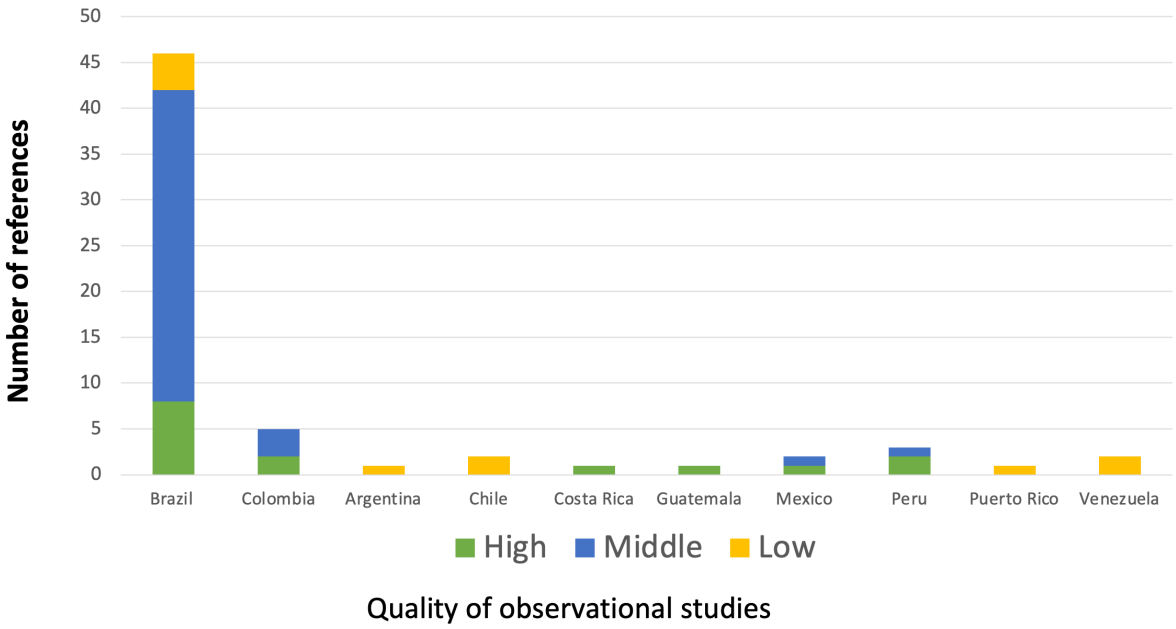
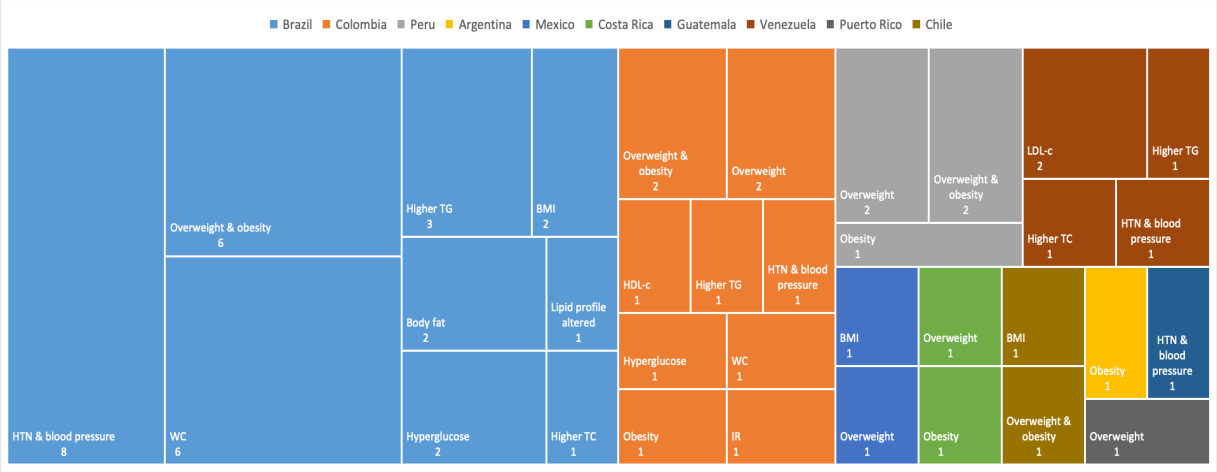


Figure 6. Cardiovascular and metabolic outcomes measured by country.



HTN, hypertension; WC, waist circumference; BMI, body mass index; TG, triglycerides; IR, insulin resistance

Table 11. Characteristics of included studies by SES and Socioeconomic determinants in Latin America and the Caribbean.

N°	Study	Country	Sample size	Age	Male (%)	Female (%)	SES classification	Cardiometabolic outcome	Quality
1	Gamboa-Gamboa T, 2021	Costa Rica	347.366	6 - 17	55,2	44,8	Distric socioeconomical satus	Overweight and obesity	High
2	Hércules E, 2020	Brazil	80.782	5 - 10	50,8	49,2	ABEP 2018**	Overweight, obesity	Low
3	Rincon-Pabon D, 2019	Colombia	18.177	13 - 17	49,8	50,2	DANE and SISBEN***	Obesity	High
4	Conde WL, 2018	Brazil	16.556	11 - 19	50	50	ABEP 2015**	Overweight	Medium
5	Hobold E, 2015	Brazil	5.962	6 - 17	49,3	50,7	ABEP 2011**	Overweight, obesity	Medium
6	Guedes DP, 2011	Brazil	5.100	6 - 18	46,5	53,5	ABEP 2007**	Obesity, overweight	Medium
7	Curi-Quinto K, 2020	Peru	5.008	15 - 19	0	100	Wealth index by the National Institute of Statistics and Informatics	Overweight and obesity	Medium
8	Assunção MC, 2012	Brazil	4.452	11 - 15	49,2	51	Index of assets constructed based on 18 socioeconomic indicators	Obesity	Medium [b]
9	Rodríguez-Morales PAJ, 2011	Venezuela	4.017	6 - 19	54,9	45,1	Graffar- Méndez Castellano	HTA	Low
10	McDonald CM, 2009	Colombia	3.075	5 - 12	48,5	51,5	DANE and SISBEN***	Overweight and obesity	Medium
11	Guedes DP, 2010	Brazil	2.849	6 - 18	48,9	51,1	ABEP 2007**	Overweight	Medium
12	Farias Júnior JC de, 2016	Brazil	2.768	14 - 18	44,5	55,5	ABEP 2009**	Overweight	Low
13	Farias Júnior JC de, 2008	Brazil	2.402	14 - 18	44,3	55,7	ABEP 2010**	Overweight and obesity	Medium
14	Bozza R, 2014	Brazil	1.742	11 - 18	47,9	52,1	ABEP 2009**	Waist circumference, body fat	Medium
15	Fradkin C, 2018	Brazil	1.738	11 - 13	49	51	ABEP 2008-2009**	Overweight, obesity	Medium
16	Preston EC, 2015	Peru	1.737	7 - 8	50,4	49,6	Socioeconomic indicator constructed based on consumer durables index quartiles	Overweight and obesity	High
17	Muraro AP, 2015	Brazil	1.716	0 - 11	50,7	49,3	ABEP 2008**	BMI	Medium [b]
18	Netto-Oliveira ER, 2010	Brazil	1.634	6 - 8	49,2	50,8	ABEP 2008**	Overweight and obesity	Low
19	Rech RR, 2010	Brazil	1.442	7 - 12	50,0	50,0	Barros and Victora National Economic Indicator ****	Overweight and obesity	Medium
20	Costanzi CB, 2009	Brazil	1.413	7 - 12	50,5	49,5	Barros and Victora National Economic Indicator ****	HTA	Medium
21	Bergmann ML, 2011	Brazil	1.294	7 - 12	50,0	50,0	Barros and Victora National Economic Indicator ****	Total cholesterol	Medium

22	Buitrago - Lopez A, 2015	Colombia	1.282	6 - 10	51,1	48,9	DANE and SISBEN***	Overweight and obesity, total cholesterol, insuline resistance, HTA, TG-c altered, HDL-c altered	High
23	Bozza R, 2016	Brazil	1.242	11 - 17	48,0	52,0	ABEP 2008**	HTA	Medium
24	Reuter CP, 2019	Brazil	1.201	7 - 17	45,4	54,6	ABEP 2011**	HTA	Low
25	Carneiro CS, 2017	Brazil	1.169	12 - 18	46,9	53,1	ABEP 2008**	Overweight	Low
26	de Souza S, 2022	Brazil	1.152	11 - 15	44,0	56,0	Brazilian Economic Classification Criteria	Waist circumference, TG-c altered, HDL-c altered, glucose altered, blood pressure altered	High
27	Quadros TM, 2016	Brazil	1.139	6 - 18	44,4	55,6	ABEP 2015**	Lipid profile altered, HTA, glucose level altered	Medium
28	Nascimento-Ferreira MV, 2014	Brazil	1.014	14 - 19	45,2	54,8	ABEP 2008**	Overweight, obesity, HTA, waist circumference	High
29	Moraes AC, 2013	Brazil	991	14 - 18	45,5	54,5	ABEP 2006**	Waist circumference	Medium
30	de Moraes AC, 2015	Brazil	991	14 - 18	45,5	54	ABEP 2003**	HTA	High
31	Farias Júnior JC de, 2011	Brazil	782	14 - 17	45,1	54,9	ABEP 2005**	Overweight and obesity, HTA	Medium
32	Gordia AP, 2011	Brazil	608	14 - 20			ABEP 2000**	Overweight and obesity	Low
33	Silva DA, 2012	Brazil	601	14 - 17	55,2	44,8	ABEP 2008**	Body fat, waist circumference	Medium
34	Pickens CM, 2020	Guatemala	560	10 - 14	46,6	53,4	Socioeconomic indicator constructed based on 5 household-level	HTA	Medium
35	Ribas SA, 2014	Brazil	557	6 - 19	47,2	52,8	ABEP 2011**	Overweight, HTA, LDL-c altered, HTA, TG-c altered	Low
36	Silva DAS, 2012	Brazil	464	14 - 17	42,5	57,5	ABEP 2008**	Waist circumference	Low
37	Gambardella AMD, 2014	Brazil	400	8 - 17	52,8	47,3	Barros and Victora National Economic Indicator ****	Overweight, waist circumference	Low
38	Jimenez-Mora MA, 2020	Colombia	385	12 - 17	38,4	41,9	DANE and SISBEN***	Overweight	Low
39	Carvalho Francescantonio Menezes IH, 2009	Brazil	339	16 - 18	48,3	51,7	ABEP 2003**	Overweight and obesity	Medium[a]
40	de Carvalho Cremm E, 2012	Brazil	229	6 - 10	52,4	47,6	ABEP 2006**	Overweight	Medium
41	Santos NF dos, 2020	Brazil	179	10 - 19	33,0	67,0	ABEP 2016**	Overweight	Medium
42	Ruiz N, 2012	Venezuela	161	7 - 9	57,8	42,2	Graffar- Méndez Castellano	Total cholesterol altered, TG-c altered, HDL-c altered, LDL-c altered	Low

**ABEB, Brazil Criterion of Economic Classification; ** Socioeconomic indicator by Barros and Victoria, which considers the use of 13 variables to produce the National Economic Indicator; ***Colombian government classification DANE and SISBEN; ****Socioeconomic indicator by Graffar- Méndez Castellano based on 4 components*

[a]Case-control study assessed by New Casttle Otawa tool; [b] Cohort study assessed by New Casttle Otawa

Table 12. Other socioeconomic determinants studied in Latin America and the Caribbean.

N°	Study	Country	Sample size	Age	Female (%)	SES classification	Cardiometabolic outcome	Quality
1	Álvarez-Dongo D, 2012	Peru	26.540	5 - 19	48,8	Family income, parents educational level	Overweight and obesity	Medium
2	Neutzling MB, 200	Brazil	13.715	10 - 19	49,4	Family income	Overweight and obesity	Medium
3	Hernández B, 2003	Mexico	10.901	5 - 11	50,9	previous month	Overweight and obesity	Medium
4	Ocampo T, 2010	Colombia	10.187	5 - 17	49,3	Family income, parents educational level	Overweight and obesity	Medium
5	Hallal PC, 2012	Brazil	4.452	0 - 15	67,0	Trajectorie of socioeconomic position sum of the salaries of all household members in the	Obesity, HTA	High
6	Mendez N, 2016	Mexico	3.243	5 - 11	53,3	Family income	Obesity, overweight	Medium
7	Bernardo C de O, 2012	Brazil	2.863	7 - 14	51,3	Family income, parents educational level	Overweight and obesity	Medium
8	Berria J, 2013	Brazil	2.595	8 - 13	100,0	Parents educational level	Overweight and obesity	Medium
9	Cardoso Lde O, 2011	Brazil	1.632	15	55,1	Parents educational level	Obesity	Medium
10	Leal VS, 2012	Brazil	1.435	5 - 19	57,4	Family income, parents education level, housing characteristics, public utilities	Overweight and obesity	Low
11	Souza MCC de, 2014	Brazil	1.187	6 - 14	24,1	Family income	Overweight and obesity	Medium
12	Orden AB, 2019	Argentina	1.150	6 - 12	52,9	Parents educational level	Obesity	Low
13	Magalhães VC , 2003	Brazil	1.027	15 - 20	47,6	Family income	Overweight and obesity	Medium
14	Azar A, 2015	Chile	900	nr - nr	49,00	Parents educational level	Overweight and obesity	Low
15	Campagnolo PD, 2008	Brazil	810	10 - 19	59,4	Parents educational level	Overweight	Medium
16	Corso ACT, 2012	Brazil	638	6 - 10	52,7	Family income, parents educational level	Obesity, overweight	Medium
17	Matsudo VKR, 2016	Brazil	564	9–11		Family income, parents educational level	Overweight and obesity	Medium
18	de Pinho L, 2014	Brazil	535	11 - 17	68,0	Family income	Overweight and obesity	Medium
19	Caixeta HCV, 2020	Brazil	486	6 - 8	52,5	Family income, parents educational level	Overweight and obesity	Low
20	Rodrigues V,K 2016	Brazil	485	9 - 11	51,0	Family income, parents educational level	Overweight and obesity	Low
21	Guimarães LV, 2006	Brazil	474	6 - 11	49,8	Family income, parents education level, housing characteristics	Overweight	Medium [a]
22	Rivera-Soto WT, 2010	Puerto Rico	250	7 - 10	49,0	Family income, public utilities	Overweight	Low
23	Adjemian D, 2007	Chile	239	7 - 9	Not reported	Family income, parents education level, housing characteristics	BMI	Low

[a]*Case-control study assessed by New Casttle Otawa tool*

Obesity and overweight related with SES

Overweight, obesity and overweight and obesity were reported in 37 references and were measured by different classifications: WHO age and sex cut-off by BMI z scores, International Obesity Task Force (IOTF), sex-specific ratios of weight and height according to Centers for Diseases Control and Preventions Guidelines, Cole et al, BMI cut-off thickness, other particularly cut-off definitions.

The overall prevalence of overweight was 17.9% (95 % CI 14% –21%, n=15 studies, I2=99.9) measured in six countries (Brazil, Colombia, Costa Rica, Mexico, Peru and Puerto Rico). The prevalence of overweight is 21% higher in children and adolescents from higher SES group compared to the mid-low SES group (PR = 1.21, 95% CI 1.28 – 1.35; I^2 47%, p=0.13) and 28% in adolescents >12 yrs (PR= 1.28, 95% CI 1.07 – 1.53; I^2 62%, p=0.01) (**Table 13 and figure 7**). Adolescents >12 yrs old showed for obesity a 1.66 prevalence rate (95% CI 1.30-2.13, I^2 64%, p= 0.03) higher backgrounds compared with middle-low SES (**Table 15 and figure 8**). Related to SES determinants such as family income and family education definition, studies showed highly variable effects on obesity described in six studies (**Table 16**). When overweight and obesity were measured as a whole outcome, we found significant differences in high SES compared to middle-low SES (PR = 1.92, 95 % CI 1.58–2.35; I^2 85% p< 0.01) (**Figure 9 and table 17**). We observed that these results were consistent showing higher risk of obesity and overweight in higher status compare with lower, when sensitivity analyzes were performed by age (> 14 yrs: PR = 1.74, 95 % CI 1.33–2.29; I^2 77% p< 0.01) (**Figure 10**).

Obesity and overweight were risk factors in adolescents with higher family income compared to those with lower incomes (**Table 18**). Additional socioeconomic determinants, such as public utilities, were studied in a Brazilian study that showed higher risk in higher

SES strata than in lower SES strata (**Table 19**). Finally, family education level was studied in Chile, Brazil, and Colombia, showing variability in their results.

Figure 7. Overweight by age in children and adolescents from high SES compared with middle-low SES in Latin America and the Caribbean

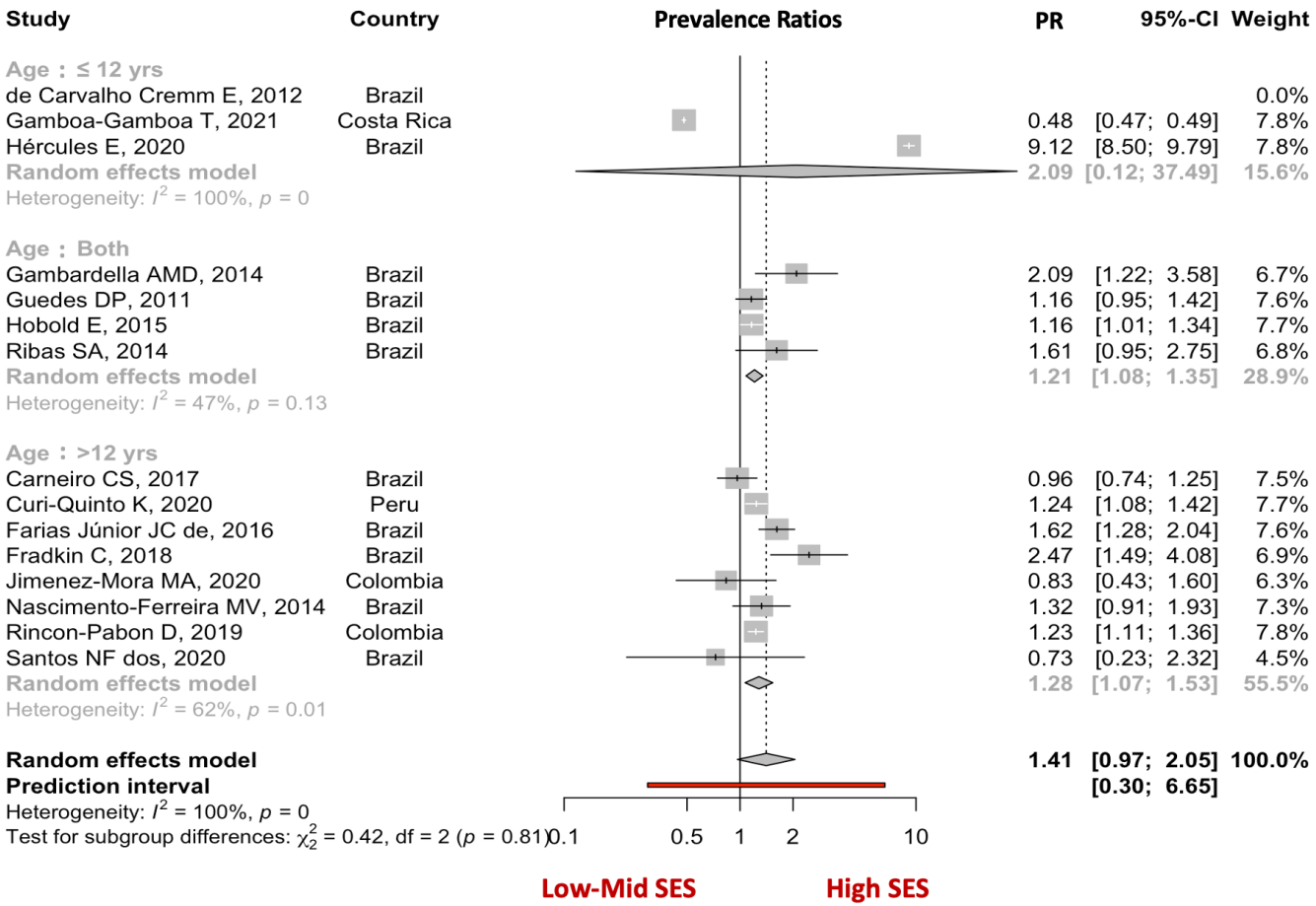


Table 13. Overweight in high SES compared with Low and middle SES in Latin Americans youth (n=140,105)

Study	Country	Population size	Age (yrs)	Female n(%)	Prevalence (%)	Low SES n(%)	Middle SES n(%)	High SES n(%)	Definition
Carvalho Francescantonio Menezes IH, 2009	Brasil	229	6-10	109 (47.6)	7.0	NR	NR	NR	BMI-for-age, following the growth curves proposed by WHO.
Guedes DP. 2010	Brasil	2849	6-18	1457(51.1)	10.2	NR	NR	NR	BMI reference values proposed by the IOTF
Guedes DP. 2011	Brasil	5100	6-18	2730(53.5)	6.2	182(7.86)	229(14.5)	147(12.3)	BMI-for-age, following the growth curves proposed by WHO.
Ribas SA. 2014	Brasil	557	6-19	294(52.9)	11.5	8(7.7)	27.1(9.1)	25(16.2)	BMI-for-age, following the growth curves proposed by WHO.
Gambardella AMD. 2014	Brasil	400	8-17	189(43.7)	21.3	16(8.0)	23(23)	28(28)	BMI-for-age, following the growth curves proposed by WHO.
Jimenez-Mora MA. 2020	Colombia	385	12-17	62(41.9)	23.3	95(42.6)	29(24.0)	18(43.9)	BMI-for-age, following the growth curves proposed by WHO.
Santos NF dos. 2020	Brasil	179	10-19	120(67.0)	20.1	12(13.5)	20(27.8)	4(22.2)	BMI-for-age, following the growth curves proposed by WHO.
Rincon-Pabon D. 2019	Colombia	18177	13-17	9133(50.2)	13	1562(12.4)	203(12.5)	593(15.0)	BMI-for-age, following the growth curves proposed by WHO.
Conde WL. 2018	Brasil	16556	11-19	8278(50.0)	21				BMI reference values proposed by the IOTF
Fradkin C. 2018	Brasil	1738	11-13	881(51.0)	11.7	77(6.3)	52(12)	22(23.4)	Sex-specific ratios of height by age according to Centers for Disease Control and Prevention guidelines.
Carneiro CS. 2017	Brasil	1169	12-18	621(53.1)	21.2	13(25)	15324.9)	140(27.9)	BMI-for-age, following the growth curves proposed by WHO.
Hércules E. 2020	Brasil	80782	5-10	39719(53.1)	19.6	53423(38.4)	1606(40.3)	15467(49.7)	BMI-for-age, following the growth curves proposed by WHO.
Curi-Quinto K. 2020	Peru	5008	15-19	5008(100)	24.8	401(21.2)	399(24.2)	397(27.2)	BMI-for-age, following the growth curves proposed by WHO.
Hobold E. 2015	Brasil	5962	6-17	3023(50.7)	15.0	18(11.2)	392(14.3)	486(15.9)	BMI reference values proposed by the IOTF
Nascimento-Ferreira MV. 2014	Brasil	1014	14-19	506(54.8)	13.1	5(8.6)	46(11.8)	82(14.5)	BMI-for-age, following the growth curves proposed by WHO.
Gamboa – Gamboa T, 2021	Costa Rica	347366	6-12	168955	19.1	18696 (18.6)	34888 (19,9)	15357 (21.6)	BMI-for-age, following the growth curves proposed by WHO.

BMI; Body mass index; IOTF, International Obesity Task Force; WHO, World Health Organization.
Public Health Nutr. 2013 Apr;16(4):625-30
BMJ 2000; 320:1240-3
CDC growth charts: United States. Adv Data *(2000) 314:1–27*
** Data are prevalence by socioeconomic status reported by the cross-sectional studies.*

Table 14. Overweight by parents educational, family income, public utilities, and housing characteristics in Latin Americans youth

Study	Country	Population size	Age (yrs)	Girls %	Prevalence %	Low	Middle	High	Definition
							Parents educational level		
Campagnolo PD, 2008	Brasil	810	10-19	59.4	17.8	1.06 (0.71;1.58)	1.33 (0.9;1.94)	Reference	BMI-for-age, following the growth curves proposed by WHO.
de Carvalho Cremm E, 2012	Brasil	229	6-10	47.6	38	1.98 (1.03;3.8)		Reference	BMI-for-age, following the growth curves proposed by WHO.
Guedes DP, 2011	Brasil	5100	6-18	53.5	6.2	Reference	1.44 (0.16;1.91)	1.93 (1.32;2.85)	BMI-for-age, following the growth curves proposed by WHO.
Corso ACT, 2012	Brasil	638	6-10	52.7	15.4	0.9 (0.74;1.09)	0.4 (0.14;1.08)	Reference	BMI reference values proposed by the IOTF
Ribas SA, 2014	Brasil	557	6-19	52.8	11.5	Reference	1.6 (0.96;2.68)	2.17 (1.17;1.02)	BMI-for-age, following the growth curves proposed by WHO.
Corso ACT, 2012	Brasil	638	6-10	52.7	15.4	0.91 (0.75;1.12)	0.44 (0.18;1.08)	Reference	BMI reference values proposed by the IOTF
Guimarães LV, 2006	Brasil	474	6-11	49.8	.	Reference	1.38 (0.76;2.49)	1.91 (1.12;3.26)	BMI-for-age, following the growth curves proposed by WHO.
							Family income		
Guimarães LV, 2006	Brasil	474	6-11	49.8	.	Reference	1.31 (0.81;2.14)	3.75 (1.82;7.71)	BMI-for-age, following the growth curves proposed by WHO.
Rivera-Soto WT, 2010	Puerto Rico	250	7-10	49	11.3	1.76 (1.00;3.12)		Reference	Sex-specific ratios of height by age according to Centers for Disease
							Public utilities		
Rivera-Soto WT, 2010	Puerto Rico	250	7-10	49	11.3	1.13 (0.65;1.96)		Reference	Sex-specific ratios of height by age according to Centers for Disease
							Housing characteristics		
Guimarães LV, 2006	Brasil	474	6-11	49.8	.	Reference		2.67 (1.8;3.95)	BMI-for-age, following the growth curves proposed by WHO.

BMI, Body mass index; CDC, Centers of disease control and prevention; IOTF, International Obesity Task Force; WHO, World Health Organization.
a Data are OReffect size and 95%CI from unadjusted reported by two cross-sectional studies.
b Data are OR effect size and 95%CI from adjusted models by sex, age, family income, mother's age, number of siblings, Parents BMI, physical activity, and sleep duration.
Public Health Nutr. 2013 Apr;16(4):625-30
BMJ 2000; 320:1240-3

CDC growth charts: United States. Adv Data *(2000) 314:1–27*

Table 15. Obesity in higher SES compared with low-middle SES in younger population from (n=122,233) Latin Americans.

Author, year	Country	Study design	N	Age (yrs)	Female (n)	Prevalence n(%)	Low SES (%)	Middle SES (%)	High SES(%)	Obesity definition
Curi-Quinto K, 2020	Peru	Cross-sectional	5008	15-19	33503	326(6.5)	3.3	7.2	7.9	BMI < 18·5 kg/m2
Rincon-Pabon D, 2019	Colombia	Cross-sectional	18177	13-17	9133	546(3.0)	2.6	4.4	3.6	BMI-for-age, following the growth curves proposed by WHO.
Fradkin C, 2018	Brasil	Cross-sectional	1738	11-13	881	136(7.8)	6.2	6.3	18.1	BMI ≥95th percentile
Guedes DP, 2011	Brasil	Cross-sectional	5100	6-18	2730	112(2.2)	1.5	2.2	3.5	BMI-for-age, following the growth curves proposed by WHO.
Hércules E, 2020	Brasil	Cross-sectional	80782	5-10	39719	25203(31.2)	27.5	31.9	31.7	BMI-for-age, following the growth curves proposed by WHO.
Hobold E, 2015	Brasil	Cross-sectional	5962	6-17	3023	614(10.3)	5.0	4.9	10.2	BMI reference values proposed by the IOTF
Assunção MC, 2012	Brasil	Cohort	4452	11-15	2260	473(10,.6)	7.9	10.4	14.1	BMI-for-age, following the growth curves proposed by WHO.
Nascimento-Ferreira MV, 2014	Brasil	Cross-sectional	1014	14-19	556	38(3.7)	1.7	2.8	4.6	BMI-for-age, following the growth curves proposed by WHO.
Gamboa – Gamboa T, 2021	Costa Rica	Cross-sectional	347366	6-12	168955	48978 (14.1)	12.2	15.1	15.9	BMI-for-age, following the growth curves proposed by WHO.

**Data are prevalence by socioeconomic status reported by the studies. BMI; Body mass index; IOTF, International Obesity Task Force; WHO, World Health Organization.*

Public Health Nutr. 2013 Apr;16(4):625-30
BMJ 2000; 320:1240-3
CDC growth charts: United States. Adv Data *(2000) 314:1–27*

Figure 8. Obesity by age in high SES compared with low-middle SES in Latin America and the Caribbean younger

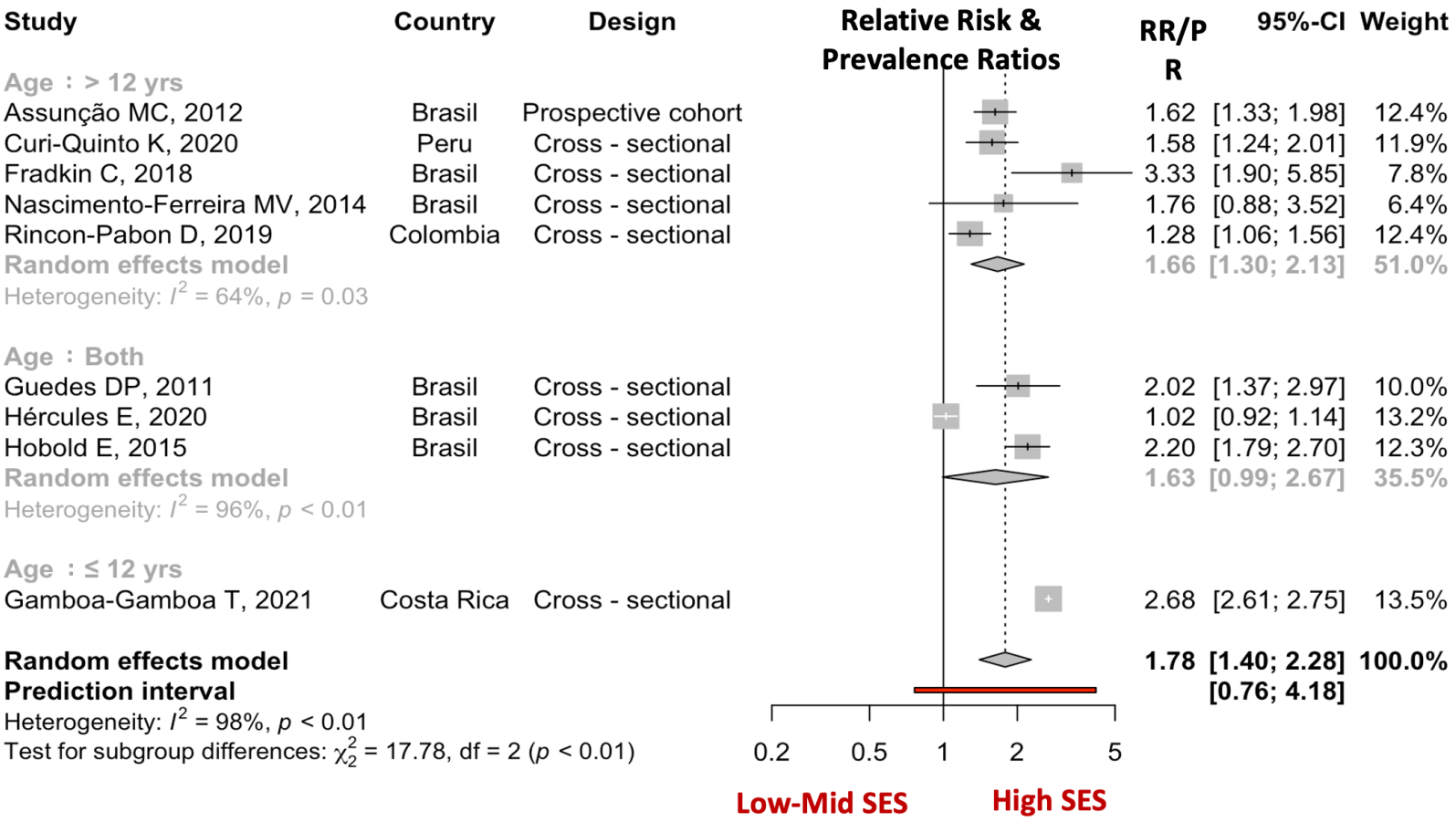


Table 16. Obesity by family income and family educational level in younger population from (n=17,491) Latin Americans.

Study	Study design	Country	N	Age Min	Age Max	Female %	Family Income definition	Prevalence (%)	Low level[a]	Middle level[a]	High level[a]	Obesity definition
Hallal PC, 2012	Cohort	Brasil	4452	0	15	67.0	Salaries of all household members	8.7	0.8 (0.5;1.4)[a]	1.2 (0.7;2.0)[a]	Reference	BMI-for-age, following the growth curves proposed by WHO.
Corso ACT, 2012	Cross sectional	Brasil	638	6	10	52.7	Per capita income: < R$ 200,00; $ 200,00 to R$ 399,99; ≥ R$ 400,00	6.1	Reference	1.57 (1.14;2.15)[a]	1.28 (0,92;1.77)[a]	BMI reference values proposed by the IOTF
Mendez N, 2016	Cross sectional	Mexico	3243	5	11	53.3	Minimum Daily Salaries, the National Department of Employment and Social Welfare according to the type of work.	26.8	1.85 (1.21;2.72)[a]	1.69 (1.21;2.35)[a]	Reference	BMI-for-age, following the growth curves proposed by WHO.
							Family education definition					
Cardoso Lde O, 2011	Cross sectional	Brasil	1632	.	16	55.1	Years of schooling of the head of household (0–7; 8–10; >=11)	17.2	Reference	1.47 (0.9;1.89)	1.31 (1.06; 2.03)	BMI-for-age, following the growth curves proposed by WHO.
Corso ACT, 2012	Cross sectional	Brasil	638	6	10	52.7	Paternal educational level	6.1	1.17 (0.82;1.67)[a]	1.00 (0.31;3.23)[a]	Reference	BMI reference values proposed by the IOTF
Corso ACT, 2012	Cross sectional	Brasil	638	6	10	52.7	Maternal educational level	6.1	1.25 (0.85;1.84)[a]	0.97 (0.3;3.14)[a]	Reference	BMI reference values proposed by the IOTF
Guedes DP, 2011	Cross sectional	Brasil	5100	6	18	53.5	Parents education (years): >=4; 5-8;9-11;>=12	.	Reference	1.89 (1.48;2.36)[a]	2.12 (1.41;2.91)[a]	BMI-for-age, following the growth curves proposed by WHO.
Orden AB, 2019	Cross sectional	Brasil	1150	6	12	52.8	Parental education	12.1	Reference	0.78 (0.6;1.0)	0.5 (0.32;0.76)	BMI reference values proposed by the IOTF

BMI; Body mass index; IOTF, International Obesity Task Force; WHO, World Health Organization.
[a] Data are effect size (OR/PR) and 95%CI from adjusted models by sex, age, number of siblings, socioeconomic strata.
Public Health Nutr. 2013 Apr;16(4):625-30
BMJ 2000; 320:1240-3
CDC growth charts: United States. Adv Data *(2000) 314:1–27*

Figure 9. Overweight & obesity in high SES compared with middle-low SES by country

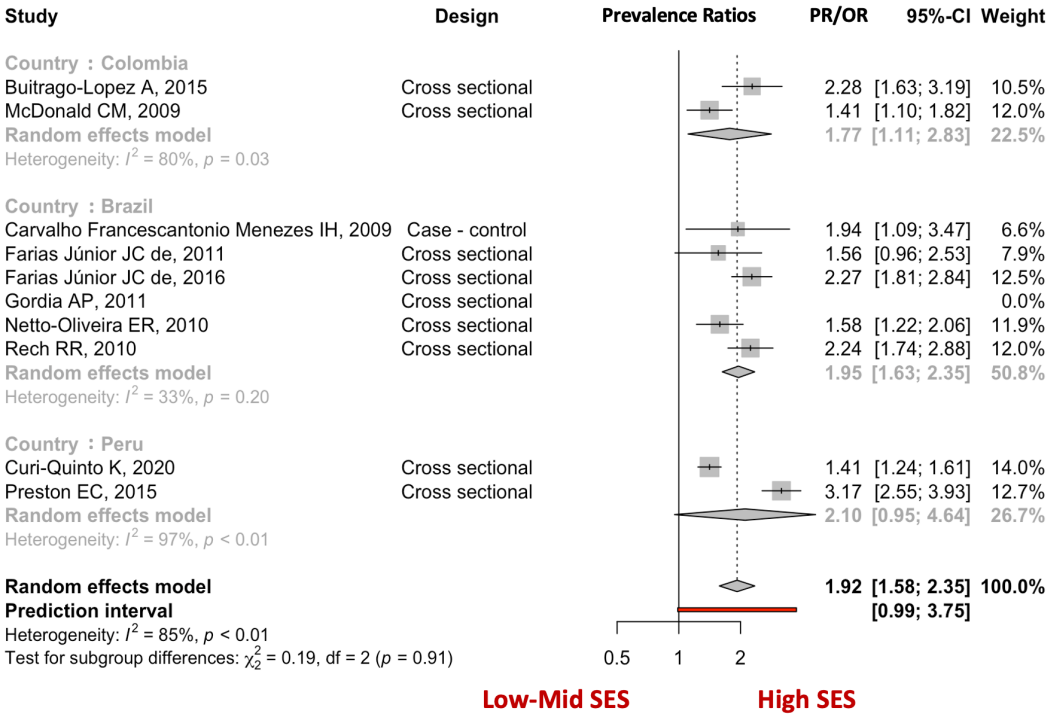


Figure 10. Overweight & obesity in high SES compared with middle-low SES by age

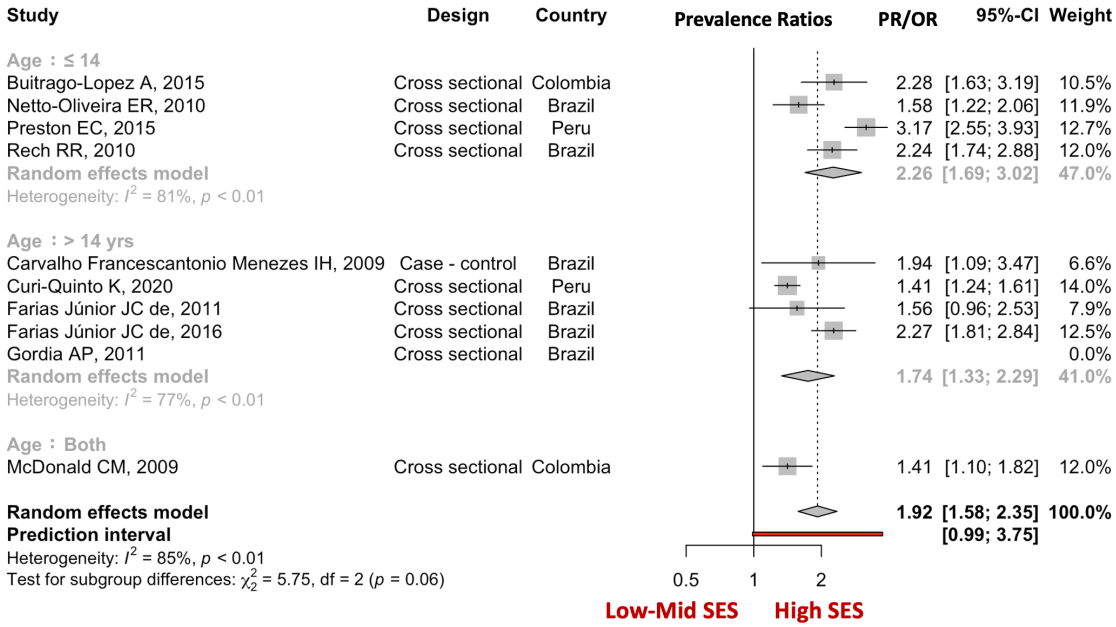


Table 17. Overweight and obesity in high SES compared with Low and middle SES in Latin Americans youth (n=18,309)

Author, year	Country	N	Age min	Female %	Prevalence n(%)	Low SES n(%)	Middle SES n(%)	High SES n(%)	Overweight and obesity definition
Buitrago - Lopez A, 2015	Colombia	1282	6-10	627 (48.9)	237 (18.5)	96 (32.5)	77 (19.6)	64 (30.5)	CDC age-and-sex-specific BMI z-scores.
Carvalho Francescantonio Menezes IH, 2009	Brasil	339	16-18	175 (51.7)	106 (31.2)	37 (34.7)	-	69 (29.7)	Body Mass Index (BMI) ≥ 85 percentile.
Quadros TM, 2016	Brasil	608	14-20	-	79(12.9)	11.8	11.7	(35.5)	BMI-for-age, following the growth curves proposed by WHO.
Farias Júnior JC de, 2011	Brasil	782	14-17	429 (54.9)	79 (10.1)	12 (7.8)	22 (8.7)	48 (12.9)	BMI reference values proposed by the IOTF
McDonald CM, 2009	Colombia	3075	5-12	1585 (51.5)	394 (12.8)	212 (18.3)	164 (12.5)	243 (17.7)	BMI reference values proposed by the IOTF.
Netto-Oliveira ER, 2010	Brasil	1634	6-8	830 (50.8)	351 (21.5)	19 (16.7)	233 (20)	109 (28.5)	BMI reference values proposed by the IOTF
Rech RR, 2010	Brasil	1442	7-12	721 (50.0)	403 (27.9)	22 (17.6)	100 (28.1)	209 (30.2)	BMI reference values proposed by the IOTF
Preston EC, 2015	Brasil	1737	7-8	862 (49.6)	483 (27.8)	210 (13.6)	-	264 (42.0)	BMI-for-age, following the growth curves proposed by WHO.
Curi-Quinto K, 2020	Peru	5008	15-19	5008 (100)	1567 (31.3)	464 (24.5)	518 (31.4)	513,1 (35.1)	BMI-for-age, following the growth curves proposed by WHO.
Farias Júnior JC de, 2008	Brasil	2402	14-18	1339 (55.7)	240 (10.0)	120 (22.8)	151 (12.6)	162 (17.6)	BMI reference values proposed by the IOTF

BMI, Body mass index; CDC, Centers of disease control and prevention; IOTF, International Obesity Task Force; IOTF, International Obesity Task Force; WHO, World Health Organization.
Public Health Nutr. 2013 Apr;16(4):625-30. BMJ 2000; 320:1240-3. CDC growth charts: United States. Adv Data *(2000) 314:1–2*

Table 18. . Overweight and obesity by family income and family educational level in younger population from Latin America and the Caribbean (n=17,491)

Study	Country	Population size	Age	Female %	Prevalence	Family Income	Low estrata	Middle estrata	High estrata	Definition
de Pinho L, 2014	Brasil	535	11-17	68,0	99(18.5)	Capita income by month	Reference		1.99(1.01; 3.93)	BMI-for-age, following the growth curves proposed by WHO.
Leal VS, 2012	Brasil	1435	5-19	57,4	191(13.3)	Capita income by month	Reference		1.77 (1.25;2.51)	BMI-for-age, following the growth curves proposed by WHO.
Matsudo VKR, 2016	Brasil	485	9-11	51,0	220(45.3)	Capita income by month	Reference	1.18 (0.67;2.09)	1.07 (0.55;2.09)	BMI-for-age, following the growth curves proposed by WHO.
Ocampo T, 2010	Colombia	10187	5-17	49,3		Capita income by month The DHS Wealth Index.	Reference	2.14 (1.63;2.81)	3.18(2.38;4.27)	BMI reference values proposed by the IOTF
Souza MCC de, 2014	Brasil	1187	6-14	24,1	290(24.4)	Capita income by month	Reference	1.71 (0.97; 3.03)	2.00 (1.09;3.67)	BMI-for-age, following the growth curves proposed by WHO.
Bernardo C de O, 2012	Brasil	2863	7-14	51,0	1080(37.7)	Capita income by month	Reference	1.00 (0.66;1.51)	Girls: 1.05 (0.55;1.98) Boys: 1.12 (0.74;2.00)	BMI reference values proposed by the IOTF
Álvarez-Dongo D, 2012	Peru	8100	5-9	49,1	1557(19.2)	Capita income by month	Reference		1.8 (1.5;2.2)	BMI reference values proposed by the IOTF
Álvarez-Dongo D, 2012	Peru	18540	10-19	48,7	2390(12.9)	Capita income by month	Reference		1.7 (1.4;1.9)	BMI-for-age, following the growth curves proposed by WHO.
Neutzling MB, 200	Brasil	13715	10-19		165(1.2)	Capita income by month	Reference	Boys: 1.39 (1.05;1.84) Girls: 1.3 (1.08;1.57)	Boys: 3.27 (2.27;4.56) Girls: 2.12 (1.64;2.75)	CDC age-and-sex-specific BMI z-scores. population.
Magalhães VC , 2003	Brasil - North	266	15-20	47,6	46(18)	Capita income by month	Reference	Boys: 2.24 (0.69; 7.2) Girls: 1.04 (1.44; 2.45)	Boys: 10.13 (2.83; 36.27) Girls: 0.80 (0.26; 2.51)	CDC age-and-sex-specific BMI z-scores.
Magalhães VC , 2003	Brasil - Soul	854	15-20	49,3	197(23)	Capita income by month	Reference	Boys: 3.32 (0.51; 21.52) Girls: 1.37 (0.52; 10.40)	Boys: 8.70 (1.17; 32.34) Girls: 0.41 (0.51; 3.66)	CDC age-and-sex-specific BMI z-scores.
						Public utilities				
Leal VS, 2012	Brasil	1435	5-19	57,4	191(13.3)	General water supply, sewage, and garbage collection network	Reference		1.26 (0.79; 2.01)	BMI-for-age, following the growth curves proposed by WHO.

						Family education				
Azar A, 2015	Chile	900		49,0	171(19)	Maternal education level	Reference	0.66 (0.34;1.34)	0.46 (0.21;0.98)	BMI-for-age, following the growth curves proposed by WHO.
Caixeta HCV, 2020	Brasil	486	6-8	52,5	92(18.9)	Maternal education level	Reference		0.80 (0.98;1.59)	BMI-for-age, following the growth curves proposed by WHO.
Matsudo VKR, 2016	Brasil	564	9-11	50,9	220(39.0)	Parental education level (maternal and paternal)	Reference	0.99 (0.64;1.52)	0.75 (0.41; 1.37)	BMI-for-age, following the growth curves proposed by WHO.
Hernández B, 2003	Mexico	10901	5-11	50,9	2126(19.5)	Maternal education level	Reference	1.41 (1.08;1.85)	1.32 (1.01; 1.73)	BMI reference values proposed by the IOTF
Matsudo VKR, 2016	Brasil	485	9-11	51,0	220(45.3)	Maternal education leve	Reference	1.06 (0.55;2.02)	0.9 (0.54; 1.48)	BMI-for-age, following the growth curves proposed by WHO.
Preston EC, 2015	Brasil	1737	7-8	49,6	483(27.8)	Maternal education level	Reference	2.26 (1.70; 3.00)	3.16 (2.21;4.52)	BMI-for-age, following the growth curves proposed by WHO.
Ocampo T, 2010	Colombia	10187	5-17	49,3		Maternal education level	Reference	1.43 (1.03; 1.97)		BMI reference values proposed by the IOTF
Álvarez-Dongo D, 2012	Peru	8100	5-9	49,1	1557(19.2)	Without education	0.7 (0.4;1.2)	0.9 (0.7;1.0)	Reference	Para evaluar el BMI-for-age, following the growth curves proposed by WHO.
Álvarez-Dongo D, 2012	Peru	18540	10-19	48,7	2390(12.9)	Without education	3.2 (1.0; 10.7)	3.9 (2.5;6.2)	Reference	BMI-for-age, following the growth curves proposed by WHO.
Bernardo C de O, 2012	Brasil	2863	7-14	51,0	1080(37.7)	Parental education level (maternal and paternal)	Reference	Boys: 1.09(0.83; 1.42) Girls: 1.06 (1.00; 1.29)	Boys: 1.51(1.17;1.95) Girls: 0.82(0.59; 1.14)	BMI reference values proposed by the IOTF

BMI, Body Mass Index; BMI equal to or above the 85th percentile of the North American reference population In NHANES
**WHO, World Health Organization, definition as BMI for age (Z scores) in order to assess nutritional status. Public Health Nutr. 2013 Apr;16(4):625-30*
***IOTF, International Obesity Task Force definition as sex- and age-matched BMI curves. BMJ 2000; 320:1240-3*
CDC growth charts: United States. Adv Data *(2000) 314:1–27*
a Data are effect size and 95% CI from unadjusted reported by two cross-sectional studies.
b Data are effect size and 95% CI from adjusted models by sex, age, rural/urban residence, number of living people at home, physical activity, residence situation, sexual maturity, utilities at home (e.g. freezer, tv, radio, stove

Waist circumference, body mass index, body fat, and SES

Abdominal obesity in young individuals was studied across SES in Brazil and Colombia (n=10,231). The definition of abdominal obesity differs between studies proposed by the International Obesity Task Force, and Taylor et al. defined abdominal obesity as measured by dual-energy X-ray absorptiometry in children and adolescents, Macarthy et al. and Fernandez et. al (**Table 19**). The overall effect of waist circumference was OR= 1.30, 95 % CI: 0.66–1.93, compared to low and middle SES (I^2= 88.8%) (**Figure 11**). Body mass index (BMI) was assessed in three studies (kg/m^2) age-sex-specific z-scores according to the centers for disease control and prevention and growth references. In adolescents aged 6–10 years from Brazil, Colombia, and Chile (n=3, 237), BMI showed beta coefficients increasing when SES was higher (**Table 20**). Finally, body fat (BF) was analyzed in two cross-sectional studies from Brazil in adolescents aged 11–18 years (n=2,333). The mean of the three measurements was considered in the predictive equations of body fat % (triceps and calf skinfolds, and body fat %). Effect measures showed an OR closer to 1 for BF in adolescents with high SES compared with those with low SES (OR= 0.94 and 1.21) (**Table 21**).

Table 19. Abdominal obesity (waist circumference) by SES in Latin Americans youth (N= 7,926)

Study	Country	Design	N	Age	Female n(%)	Prevalence % (n)	Low SES % (n)	Middle SES % (n)	High SES % (n)	Waist circumference measurement / Definition
Silva DA, 2012	Brasil	Cross-sectional	1065	14-17	599 (56,0)	4.3 (46)	2 (9)	4.8 (10)	6.7 (27)	Waist-to-hip ratio, and the conicity index as screening, as measured by dual-energy X-ray absorptiometry, by Taylor definition.
Berria J, 2013	Brasil	Cross-sectional	2456	8-17	2456 (100)	8 (195)	8.4 (103)	-	7.4 (92)	Waist-to-hip ratio, and the conicity index as screening, as measured by dual-energy X-ray absorptiometry, by Taylor definition.
Moraes AC, 2013	Brasil	Cross-sectional	991	14-18	540 (54,5)	36 (358)	38.1 (23)	42.2 (114)	33 (221)	WHO definition as abdominal obesity Waist Circumference measured using a metal tape measure (nearest centimetre) at the mid-point between the iliac crest and last rib. The diagnosis of abdominal obesity (non-obese and obese) was based on cut-off points developed for adolescents by Taylor et al. (2000).
Gambardella AMD, 2014	Brasil	Cross-sectional	400	8-17	189 (47.3)	27.3 (109)	16 (16)	29 (29)	32 (64)	Waist-to-hip ratio, and the conicity index as screening, as measured by dual-energy X-ray absorptiometry, by Taylor definition.
Bozza R, 2016	Brasil	Cross-sectional	1732	11-18	902 (52,1)	12.2 (213)	12.9 (73)	11.9 (128)	11.5 (12)	Waist circumference percentiles Mexican-American by Fernandez.
Buitrago - Lopez A, 2015	Colombia	Cross-sectional	1282	6-10	627 (48.9)	10.2 (131)	7.5 (51)	10.5 (41)	18.8 (39)	Waist circumference percentiles Mexican-American by Fernandez.
de Souza S, 2022	Brazil	Cross-sectional	1152	6-17	654 (53)	72 (63.3)	NR	NR	NR	90th percentile for age and sex were considered elevated

WHO, World Health Organization. Nr, Not reported
Taylor RW,. Am J Clin Nutr. 2000; 72: 490-5.
Fernandez JR, J Pediatr. *2004;145:439–44.*

Figure 11. Waist circumference altered in children and adolescents from higher SES compared to lower SES in Latin Americans

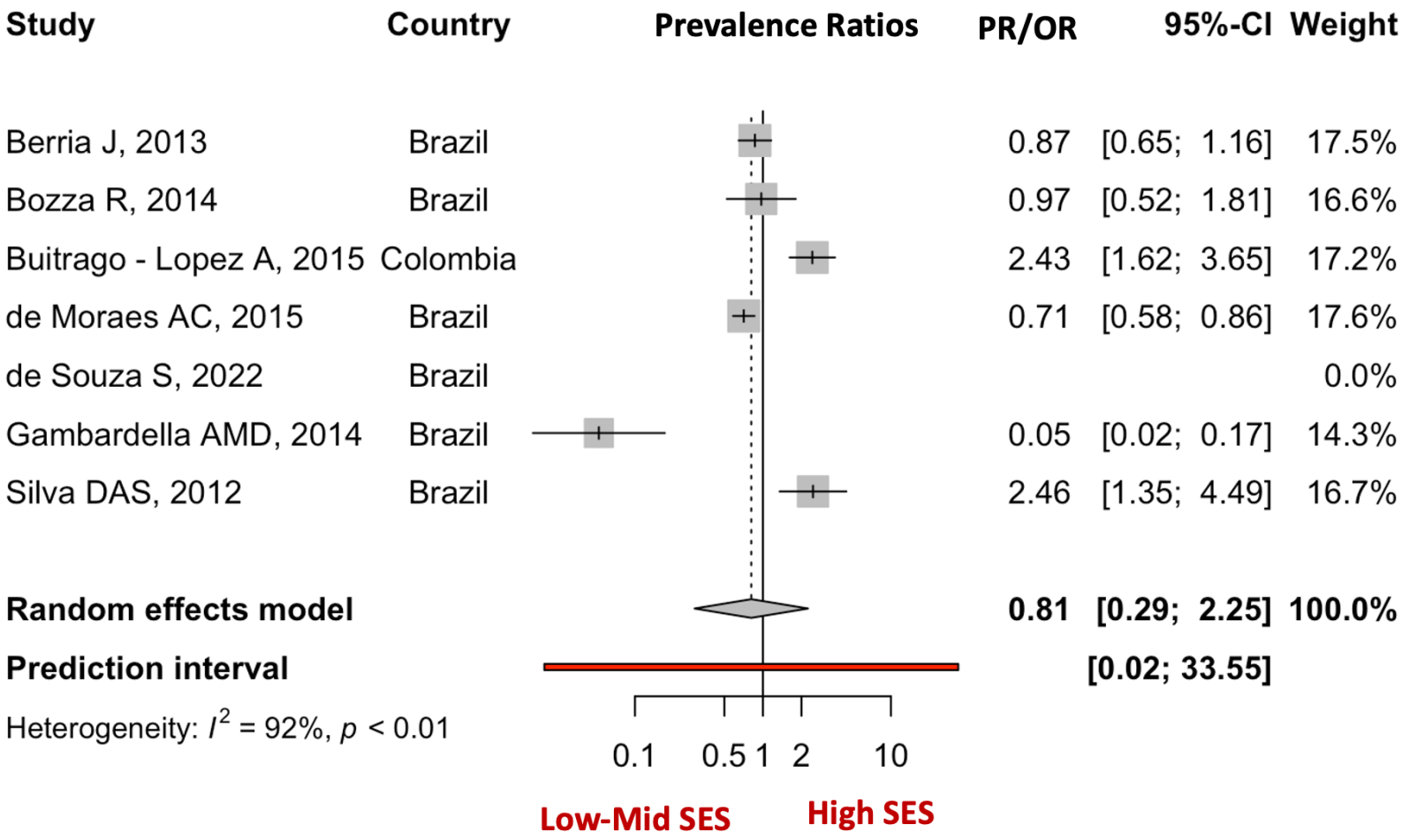

Study
Country
Prevalence Ratios
PR/OR
95%-CI
Weight
Berria J, 2013 Brazil 0.87 [0.65; 1.16] 17.5%
Bozza R, 2014 Brazil 0.97 [0.52; 1.81] 16.6%
Buitrago - Lopez A, 2015 Colombia 2.43 [1.62; 3.65] 17.2%
de Moraes AC, 2015 Brazil 0.71 [0.58; 0.86] 17.6%
de Souza S, 2022 Brazil 0.0%
Gambardella AMD, 2014 Brazil 0.05 [0.02; 0.17] 14.3%
Silva DAS, 2012 Brazil 2.46 [1.35; 4.49] 16.7%
Random effects model 0.81 [0.29; 2.25] 100.0%
Prediction interval [0.02; 33.55]
Heterogeneity: I^2 = 92%, p < 0.01
0.1
0.5
1
2
10
Low-Mid SES
High SES

Table 20. Body mass index in children and adolescents in Latin America and the Caribbean by SES (n=3,237)

Author, year	Country	Design	N	Age min	Age max	Female %	BMI Mean (SD)[a] or median (IQR)[b]	BMI measurement	Low SES	Middle SES	High SES
Muraro AP, 2015	Brasil	Cohort	1716	0	11	49.3	Boys: 0,19 (0.11; 0.28) Girls: 0.28 (0.20;0.36)	BMI-for-age, following the growth curves proposed by WHO.	Reference	0.14 (0.06; 0.22)	0,39 (0.29;0.48)
Buitrago - Lopez A, 2015	Colombia	Cross-sectional	1282	6	10	48.9	-0.03 (1.11)	Body mass index (BMI; kg/m2) age-and-sex-specific z-scores were calculated according to the 2000 CDC Growth references.	-0.41 (1.06)	0,10 (1.08)	0.28 (1.12)
Adjemian D, 2007	Chile	Cross-sectional	239	7	9	.	.	BMI were calculated from Kg2 and m2	17.4 (16.3-20.0)	-	18,2 (16.4; 20.3)

Data are presented as a [a]Mean (SD) or [b]median (IQR)
BMI, Body mass index; CDC, Centers of disease control and prevention; WHO, World Health Organization.
Public Health Nutr. 2013 Apr;16(4):625-30
BMJ 2000; 320:1240-3

Table 21. Body fat (skinfolds measurement) by SES in Latin Americans youth (N=2,333)

Author, year	Country	Design	N	Age min	Age max	Female %	Body fat measurement	Low SES	Middle SES	High SES
Bozza, et al., 2014	Brasil	Cross-sectional	1732	11	18	52,1	The triceps and calf skinfolds were measured following the recommendations of Callaway et al., and BF% was estimated as proposed by Slaughter et al. predictive equations.	Reference	1,1 (0,71; 1,17)[a]	1,08 (0,88;1,33)[a]

Silva, et al., 2012	Brasil	Cross-sectional	601	14	17	44,8	The outcome (high BF) was analyzed by the sum of two skinfolds—R2SF (triceps subscapular), classified according to Lohman, T. G. (1992), as: low (R2SF\13 or \15 mm), normal (R2SF between 13 and 22 mm or between 15 and 27 mm) and high (R2SF[22 or[27 mm) for males and females, respectively. The skinfolds were measured according to standard procedures described by Petroski, E. L. (2009), using scientific calipers with accuracy of 0.1 mm. Low and normal ratings were grouped due to the low number of adolescents (n = 52) included in the low rating.	Reference	Boys: 1,06(0,96; 1,17)[b] Girls: 0,95 (0,88;1,03)[b]	Boys: 1,21(1,09;1,34)[b] Girls: 0,94(0,85;1,02)[b]

BF, Body Fat.
a Data are effect size OR and PR reported and 95%CI from adjusted models by BMI, Height, triceps skinfolds, scapular skinfolds, aerobic fitness.
b Data are effect size OR and PR reported and 95%CI from adjusted models by BMI, Height, triceps skinfolds, scapular skinfolds, aerobic fitness.

Glucose levels altered and insulin resistance and SES

We analyzed the glucose levels and insulin resistance reported in the original studies by SES. Glucose levels and insulin resistance by SES determinants data were available from two LAC countries of 3,573 participants aged 6–18 years reporting a mean prevalence of 5,2% (SD 2,0) (Brazil and Colombia). All studies used the National SES description, and one of them used family income (monthly income) and maternal education as SES description analyses. Quadros et al. described altered glucose levels in 1,139 Brazilian youths using National SES description and reported higher prevalence in the middle and higher SES groups (7.3% and 6.4%, respectively) than in the lower SES group (5.6%). In Colombian children fasting glucose of 80.2 mg/dL was reported to be higher in middle strata compared with lower SES groups). When the Brazilian income family was measured, participants with higher income had 22.7% children with fasting glucose level compared to those with low income (8.3%). Insulin resistance defined as HOMA-IR ≥90th percentile in Colombian children showed OR (middle SES OR= 2.22, 95% CI 1.15–4.29 and OR= 1.52, 95% CI 0.7–3.27) in the higher SES groups (**Table 22**).

Table 22. Glucose levels altered and Insulin resistance by socioeconomic determinants in population 6 to 18 aged (N=2,421) in Colombia and Brazil

Study	Country	Study design	Population size	Age min	Age max	Female %	Definition	Prevalence %	Low *	Middle *	High *
Glucose levels altered										***socioeconomic status***	
Quadros TM, 2016	Brazil	Cross-sectional	1139	6	18	55.6	Fasting glucose levels ≥ 100mg/dL.	6.5	1.14 (0.55;2.39)	1.29 (0.79;2.09)	Reference
Buitrago - Lopez A, 2015	Colombia	Cross-sectional	1282	6	10	48.9	Fasting glucose levels ≥ 100mg/dL.	6.3	Reference	0.2 (-1.01; 1.42)	-2.39(-3.83;0.94)
de Souza S, 2022	Brazil	Cross-sectional	1152	6	17	53.0	Fasting glucose levels ≥ 110mg/dL.	2.9	1.0 (0.98-1.02)	1.0 (0.96-1.05)	Reference
Insulin resistance											
Buitrago - Lopez A, 2015	Colombia	Cross-sectional	1282	6	10	48.9	IR was defined as HOMA-IR ≥90th centile	10.5	Reference	2.22 (1.15;4.29)	1.52 (0.7;3.27)
Glucose levels altered										***Family income***	
Quadros TM, 2016	Brasil	Cross-sectional	1139	6	18	55.6	Fasting glucose levels ≥ 100mg/dL.	6.5	Reference	-	1.15(0.73;1.81)
										Maternal educational level (yrs)	
Quadros TM, 2016	Brasil	Cross-sectional	1139	6	18	55.6	Fasting glucose levels ≥ 100mg/dL.	6.5	Reference	1.74(0.88;3.42)	1.77(0.91;3.45)

a Data are effect size and 95%CI from unadjusted reported by two cross-sectional studies.
b Data are effect size and 95%CI from adjusted models by sex, age, sleep duration, health care access, ethnicity, passive smoking, paternal overweight/obesity, BM, birth weight, breastfeeding, physical activity, sleep duration, sedentary behavior.

Lipid profile levels and SES

Significant variations in lipid profile concentration levels were analyzed in six studies, involving 5,585 children and adolescents aged 6 to 18 years from Brazil, Venezuela, and Colombia. The prevalence of higher TC levels was estimated from two studies in Brazil and Venezuela at 32.7% (SD 2.7). Altered TC levels were observed in 18% (SD 9.9) of young individuals from Brazil, Colombia, and Venezuela. Two studies from Colombia, Brazil, and Venezuela reported data on low levels of HDL-c across SES with an 8.2% prevalence (SD 4.5) (**Table 23**). The forest plot (**Figure 12**) shows the overall effects according to lipid component levels in young Latin Americans and Caribbeans of higher SES compared with low SES. Family income and educational level were also analyzed as SES determinants describing no significant effects on dyslipidemia (**Table 24**).

Figure 12. Lipid profile altered in high SES compared with low middle SES in young from Latin America and the Caribbean

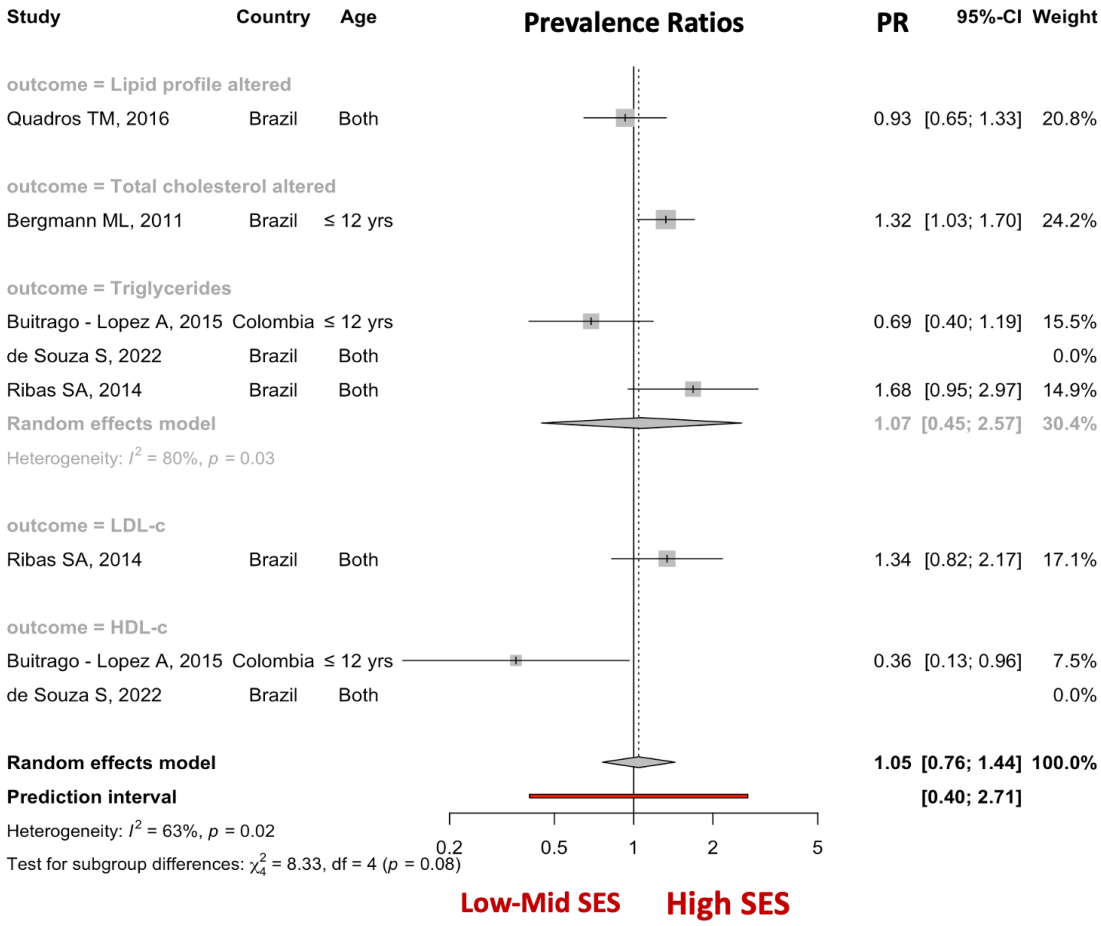


Table 23. Lipid profile levels altered by socioeconomic determinants in population 6 to 18 aged (N=6 755) in Latin American adolescents.

Author, year	Country	N	Age min	Age max	Female n(%)	Dyslipidemia n(%)	Outcome definition	Low SES	Middle SES	High SES
Quadros, et al., 2017	Brasil	1139	6	18	633 (55,6)	697 (61,2)	Any of lipid levels altered according to Athesoclerosis in Pediatric and adolescense prevention.	268 (60,1)	343 (62,4)	84 (59,6)
Total colesterol n(%)										
Bergamnn, et al., 2011	Brasil	1294	7	12	721 (50)	445 (34,4)	Tertiles and second tertile considered as "normal" and the top tercile was considered increased.	30 (24,1)	111 (31,3)	245 (35,5)
Ruiz, et al., 2012	Venezuela	161	7	9	68 (42,2)	143,0 (30,6)	According to Friedewald, LDL-c= [Colesterol total - (HDLc + Triglicéridos/5)].	133,8 (23,8)[a]	150,9 (33,2)[a]	145 (31,8)[a]
Triglycerides n(%)										
Buitrago-Lopez, et al., 2015	Colombia	1282	6	10	627 (48,9)	131 (10,2)	High triglyceride level was defined as triglycerides (mmol/L) ≥90th centile	83 (14,9)	33 (8,4)	16 (7,7)
Ribas, et al., 2014	Brasil	557	6	19	294 (52,8)	94 (16,9)	NCEP definition	18(17,9)	17,5 (6,0)	22 (14,1)
Ruiz, et al., 2012	Venezuela	161	7	9	68 (42,2)	66 (32,8)	According to Friedewald, LDL-c= [Colesterol total - (HDLc + Triglicéridos/5)].	65,6 (31,6)[a]	80,4 (35,8)[a]	47,3 (18,0)[a]
de Souza S, 2022	Brazil	1152	6	17	645(56%)	165 (14,3)	Values of TG higher or equal to 110 mg/dL.	NR	NR	NR
LDL-c n(%)										
Ribas, et al., 2014	Brasil	557	6	19	294 (52,8)	89 (15,8)	NCEP definition	15(14,7)	45 (15,2)	30 (19,2)
Ruiz, et al., 2012	Venezuela	161	7	9	68 (42,2)	85,1 (25,8)	According to Friedewald, LDLc= [Colesterol total - (HDLc + Triglicéridos/5)].	83,4 (21,2)[a]	88,0(28,0)[a]	85,8 (27,9)[a]
HDL-c n(%)										
Buitrago-Lopez, et al., 2015	Colombia	1282	6	10	627 (48,9)	126 (9,82)	HDL-c was defined as HDL-c (mmol/L) ≤10th centile	50 (13,2)	9,2 (36,2)	4,3 (9,03)
Ruiz, et al., 2012	Venezuela	161	7	9	68 (42,2)	39,2 (11,8)	According to Friedewald, LDLc= [Colesterol total - (HDLc + Triglicéridos/5)].	36,7 (9,2)[a]	33,1 (8,5)[a]	49,9 (11,1)[a]
de Souza S, 2022	Brazil	1152	6	17	645(56%)	37 (3,2)	HDL-C lower or equal to 40 mg/dL were considered altered.	NR	NR	NR

HDL-c, High Density Lipoprotein cholesterol; LDL-c, Low Density Lipoprotein cholesterol; NCEP, The National Cholesterol Education Program.
Data are showed as a number and percentages.
a Data are mean and standard deviation.

Table 24. Lipids levels altered by parents educational and family income in youth Latin Americans

Study	Country	N	Age min	Age max	Female n(%)	Dyslipidemia n(%)/ definition		Family income	Low Strata	Middle Strata	High strata
Quadros TM, 2016	Brazil	1139	6	18	633 (55.6)	697 (61.2)	Any of lipid levels altered according to Athesoclerosis in Pediatric and adolescense prevention.	Family income (minimun salary) 2011 = R$ 545,00 e 2012 = R$ 622,00.	Reference[b]		1.01 (0.91; 1.11)[b]
								Education level			
Quadros TM, 2016	Brazil	1139	6	18	633 (55.6)	697 (61.2)	Any of lipid levels altered according to Athesoclerosis in Pediatric and adolescense prevention.	Maternal education level	Reference[b]	1.09 (0.95; 1.24)[b]	1.00 (0.87; 1.15)[b]
						Triglycerides n(%)/ definition					
Ribas SA, 2014	Brazil	557	6	19	294 (52.8)	94 (16.9)	NCEP definition	Maternal education level (yrs) <=8; 9 a 12; >=13	Reference[a]	1.17 (0.54; 2.54)[a]	1.29 (0.66; 2.53)[a]
						LDL-c n(%)/ definition					
Ribas SA, 2014	Brazil	557	6	19	294 (52.8)	94 (16.9)	NCEP definition	Maternal education level (yrs) <=8; 9 a 12; >=13	Reference[a]	0.53 (0.51; 1.42)[a]	0.87 (0.49; 1.82)[a]

NCEP, The National Cholesterol Education Program.
a Data are effect size and 95%CI from unadjusted reported by studies.
b Data are effect size and 95%CI from adjusted models by sex, age, race, number of members living at home, school localization, socioeconomic status, BMI, sexual maturation, physical activity, watching tv time.

Blood pressure levels altered and SES

Thirteen studies evaluated blood pressure levels across socioeconomic determinants from Brazil, Colombia, and Guatemala in 19,641 young individuals aged 6–19 years. Blood pressure was measured as a continuous variable (four studies and eight studies used the National High Blood Pressure Education Program percentiles definition to describe prehypertensive and hypertensive young individuals, one used the Task Force Report on High Blood Pressure in Children and Adolescents, one used the Task Force Report on High Blood Pressure adapted for Venezuelans, one used the National Heart, Lung, and Blood Institute and American Academy of Pediatrics guidelines definition and two studies used the VI Brazilian Guidelines on Hypertension. The prevalence of hypertensive and prehypertensive adolescents mean was 9.8% (SD 16,7) and a ranged from 3.2% to 27,0%. Of the 11 studies that estimated effect measures, 7 studies showed a higher risk in higher SES compared with lower SES strata (**Table 25**). Models were adjusted for variables such as sex, age, physical activity, sleep duration, health care access, ethnicity, passive smoking, paternal overweight/obesity, BMI, sedentary behavior, food security, waist circumference, and family history of hypertension. Monthly family income, parents' educational level, and houses with good sanity conditions in children and adolescents from Brazil and Venezuela showed increasing systolic blood pressure in higher strata as well as higher risk measures (**Table 26).**

Table 25. Systolic and diastolic blood pressure altered by socioeconomic status in Latin American adolescents. (n= 10,181)

Study	Country	N	Age	Female n(%)	Blood pressure/hipertensión/ prehypertension definition	N(%) or mean (SD)	Low SES	Middle SES	High SES
Buitrago - Lopez A, 2015	Colombia	1282	6-10	627 (48.9)	NHBPEP definition	41 (3.2)	Reference[a]	0.96 (0.34; 2.71)[a]	1.14 (0.34;3.87)[a]
Costanzi CB, 2009	Brazil	1413	7-12	700 (49.5)	SBP and/or DBP ≥ percentile 90 e < 95 were prehypertensive	76 (5.4)	Reference[a]	1.11 (0.89; 1.39)[a]	1.69 (1.38; 2.6)[a]
Farias Júnior JC de, 2011	Brazil	782	14-17	429 (54.9)	SBP and/or DBP ≥ percentile 90 were hypertensive.	83 (10.3)	3.1 (1,54;6,25)	1.73 (0.84;3.57)	Reference
Ribas SA, 2014	Brazil	557	6-19	294 (52.8)	The Task Force Report on High Blood Pressure in Children and Adolescents	40 (7.2)	Reference	1.36 (0.77;2.39)	1.19 (0.73;1.94)
Pickens CM, 2020	Guatemala	560	10-14	299 (53.4)	NHBPEP definition)	45 (8.0)	1.12 (0.39; 3.19)[a]	1.55 (0.58;4.11)[a]	Reference [a]
Reuter CP, 2019	Brazil	1201	7-17	656 (54.6)	Brazilian Guidelines on Hypertension, for adolescents	194 (16.2)	1.04 (0.93;1.16)	1.01 (0.97; 1.05)	Reference
Bozza R, 2016	Brazil	1242	11-17	646 (52.0)	NHBPEP definition	235 (18.9)	1.30 (0.27;6.35)[a]	0,89 (0.50; 1.59)[a]	Reference[a]
Quadros TM, 2016	Brazil	1139	6-18	633 (55.6)	SBP and/or DBP ≥ percentil 95 were classificated as hypertensive.	307 (27.0)	0.84 (0.63;1.13)	0.88 (0.66;1.17)	Reference
Moraes AC, 2013	Brazil	991	14-18	540 (54.5)	NHBPEP definition	Boys: 119 (118.4; 120.9) Girls: 107.0 (106.0; 108.0)	Reference [a]	Boys: 4.22 (-1.85; 10.3)[a] Girls: 2.55 (-1.11; 6.23)[a]	Boys: 0.82 (-5.99; 7.64) [a] Girls: -0.48 (-5.09; 4.14)[a]
de Moraes AC, 2015	Brazil	991	14	540 (54.5)	NHBPEP definition	Boys: 69.0(68.1; 69.9) Girls: 67.1(66.2; 68.0)	Reference	Boys: -0.19 (-4.92;4.54)[a] Girls: 0.86(-2.45; 4.1)[a]	Boys: -0.34 (-5.65; 4.97)[a] Girls: -0.36 (-4.5; 3.8)[a]
Nascimento-Ferreira MV, 2014	Brazil	1014	14	556 (54.8)	NHBPEP definition	Boys: 120.9 (26.4) Girls: 95.1 (17.1)	Reference	Boys: 1,18 (0.41; 3.9)[a] Girls: 0,99 (0.55;1.76)[a]	Boys: 2,27 (0.76;6,78)[a] Girls: 1.42(0.73; 2.78)[a]

de Souza S, 2022	Brazil	1152	6-17	44 (56)	Brazilian Guidelines on Hypertension, for adolescents	21.4 (246)	0.98 (0.89-1.08)	1,03 (0.99-1.07)	Reference

AAP, American Academy of Pediatrics; NHLBI, The National Heart, Lung, and Blood Institute; NHBPEP, National High Blood Pressure Education Program. Systolic (SBP) and diastolic BP (DBP)
The NHBPEP definition as age-sex-and-height-specific systolic and/or diastolic BP≥90th centile to indicate high BP.
The Task Force Report on High Blood Pressure in Children and Adolescents
Brazilian Guidelines on Hypertension, which define normal BP as below the 90th percentile for gender, age and height. Children with high SBP and/or DBP (90th percentile or above) were defined as borderline or hypertensive.
a Data are effect size and 95%CI from unadjusted reported by studies.
b Data are effect size and 95%CI from adjusted models by sex, age, physical activity, sleep duration, health care access, ethnicity, passive smoking, paternal overweight/obesity, BMI, sedentary behavior, food security, waits circumference, family history of hypertension.

Table 26. Systolic and diastolic blood pressure altered by family income, housing characteristics and parents' education level in Latin American adolescents. (n= 11,738)

Study	Country	N	Age min	Female n(%)	Family income	Definition of Blood pressure	Blood pressure n(%) / mean (SD)	Low strata	Middle strata	High strata
Hallal, et al., 2012	Brasil	4452	0-15	2283 (67.0)	Trajectories of socioeconomic position	SBP and/or DBP mean values	SBP: 119.4 (9.8) DBP: 67.6 (6.2)	SBP: -1.2(-0.24;-0.1) DBP: -0.6(-1.5; 0.2)	SBP: 0.1 (-1.3; 1.3) DBP: 0.3 (-0.6;1.1)	SBP: (0.1 (-1.3; 1.14) DBP: 0,0 (-1.0;1.0)
Quadros, et al., 2017	Brasil	1139	6-18	633 (55.6)	Minimum salary: in 2011 = R$ 545,00 and in 2012 = R$ 622,00.	SBP and DBP ≥ percentil 95	307 (27.0)[a]	Reference		1.04 (0.86;1.26)
Rodríguez-Morales, et al., 2011	Venezuela	4017	6-19	1812 (45.11)	Family income monthly	According to the Task Force with an adaptation for Venezuelans.	52.7 (4.62) [a]	Reference[c]		1.20(1.13;1.53)[c]
					Housing characteristics					
Rodríguez-Morales, et al., 2011	Venezuela	4017	6-19	1812 (45.11)	Housing characteristics		52.7 (4.62) [a]	Reference[c]		1.63 (1.6; 1.7) [c]
					Parents education level					
Rodríguez-Morales, A. J._2011	Venezuela	4017	6-19	1812 (45.11)	Education mother	According to the Task Force with an adaptation for Venezuelans.	52.7 (4.62) [a]	Reference[c]		1.33 (1.31; 1.35) [c]
Quadros, et al., 2017	Brasil	1139	6-18	633 (55.6)	Parental education	SBP and/or DBP pressure ≥ 95 percentil	307 (27.0) [a]	Reference[c]	0.95 (0.74; 1.21) [c]	0.84 (0.65; 1.09) [c]
Moraes, et al., 2015	Brasil	991	14-18	540 (54.5)	Education Father secondary	The NHBPEP definition populations.	Boys: 119.6(120.9) Girls: 107.0(106.0)	Reference	Boys: 2.09 (-2.72;6.91) Girls: -1.61 (-5.32;2.1)	Boys: 1.58 (-3.86;7.01) Girls: -0.56 (-4.96;3.83)

		The NHBPEP definition populations.	Boys: 69.0 (68.1) Girls: 67.1 (66.2)	Reference	Boys: 1.01 (-2.7;4.71) Girls: -0.49 (-3.81;2.82)	Boys: 0.92 (-3.62;5.11) Girls: 0.58 (-4.51;3.35)
Education mother.		The NHBPEP definition populations.	Boys: 119.6(120.9) Girls: 107.0(106.0)	Reference	Boys: 0.47 (-4.37;5.3) Girls: 0.67 (-2.93;4.27)	Boys: 1.52 (-3.69;6.73) Girls: 0.51 (-3.52;-4.54)
		The NHBPEP definition populations.	Boys: 69.0 (68.1) Girls: 67.1 (66.2)	Reference	Boys: 0.27 (-3.45;4.0) Girls: -0,48 (-3.71;2.74)	Boys: 2.37 (-1.65;6.38) Girls: 1,17 (-2.44;4.78)

DBP, Diastolic Blood Pressure; NHBPEP, National High Blood Pressure Education Program; SBP, Systolic Blood Pressure.
aData are values and percentages
b Data are mean and standard deviation
c Data are effect size and 95%CI from unadjusted reported by studies.
Data are effect size and 95%CI from adjusted models by sex, age, maternal schooling, birth weight, birth order, pubertal status, skin color, members living in the same house, type of school, socioeconomic national status, physical activity, time watching tv
TRAJECTORIE OF SOCIOECONOMIC POSITION sum of the salaries of all household members in the previous month, expressed in the Brazilian currency (1 Brazilian real 2 US dollars), thus generating continuous variables. The variables were then divided into tertiles.
The NHBPEP definition as age-sex-and-height-specific systolic and/or diastolic BP≥90th centile to indicate high BP

VII. DISCUSSION

The multicentric study of Brazilian adolescents revealed that being in higher socioeconomic strata is protective against having at least three components of Metabolic Syndrome (MetS). However, the prevalence of MetS, defined by IDF criteria, did not significantly differ across various socioeconomic strata. These results indicate how possible future Brazilian generations from lower backgrounds are likely to present a considerable burden of cardiovascular diseases in adulthood (6, 55, 156). Nevertheless, we notably found, that associations were observed when evaluating each socioeconomic component individually, especially for triglycerides, HDL-c, and glucose.

Higher socioeconomic status was associated with a higher risk of triglyceride alterations but was protective against altered high-density lipoprotein cholesterol (HDL-c) in schooled Brazilian adolescents. Furthermore, our study also found a positive association between higher socioeconomic status and the odds ratio of altered glucose as a MetS component. Our findings showed that higher socioeconomic status increased the risk of obesity but lowered the risk of triglyceride alterations. These results differ from studies in more economically prosperous societies, where lower socioeconomic status is associated with a higher prevalence of MetS components (16, 156, 157). LAC population is under nutritional transition and analyzing these components, high income refers to the most accommodative monetary policy and is influential regarding the provision of motor affordances in the home environment for infants and adolescents as has been shown in separate Brazilian studies (119). This could be due to the exposure of adolescents to modern living conditions using technology and more access (especially around schools) to ultra-processed food which have been associated with higher serum concentrations of blood lipids in younger populations (8, 15, 158).

These findings also could be attributed to genetic patterns (family history of cardiovascular diseases), considering that in the ERICA study, adolescents from higher SES groups had a higher percentage of parental history of cholesterol level disorders and diabetes mellitus than those in the lower SES groups. Higher SES groups also showed a parental history of dyslipidemias, in contrast to the findings of the lower strata, which showed a parental history of diabetes and heart diseases.

Waist circumference was not associated with SES in Brazilian adolescents or children from LAC. However, we found overweight and obese adolescents from higher socioeconomic status exhibited higher BMI z-scores in children and adolescents in LAC. It would be interesting to study this component as a referent of abdominal obesity in younger included in a definition of MetS (45). Our study emphasizes the importance of evaluating metabolic syndrome components individually and reevaluating their significance in adolescents. These results emphasized the importance of understanding the evolution of cardiometabolic components in the early stages of life to understand when cardiovascular disease develops very early as a chronic condition especially, overweight and obesity, lipid profile, and glucose levels.

Some limitations of our studies need to be described for these findings. These thesis results come from cardiometabolic outcomes and SES measured in a cross-sectional manner and secondary data from cross-sectional studies in LAC with a length population for the systematic review, therefore these findings should not be interpreted as causality. The definition of socioeconomic status in Brazil may not accurately capture lifestyle factors, and future research should explore neighborhood-level factors.

Nevertheless, a population-wide multicenter study randomly selected Brazilian samples. Although the ERICA careful one-on-one clinical measurements of cardiometabolic

variables, data from lifestyle and parental history were self-administrated digital questionnaires measured.

On the other hand, this is the first attempt to systematically review described cardiovascular and metabolic measures, socioeconomic status, and determinants in children and adolescents across LAC countries. We found higher heterogeneity, especially in socioeconomic indicators. This study highlights the need for standardized measures and longitudinal data to understand metabolic syndrome components in younger populations and indicators to assess living conditions such as neighborhood-level factors in our populations. Despite increasing awareness, metabolic syndrome and its risk factors persist among young populations in LAC countries due to socioeconomic challenges. Early interventions promoting healthy lifestyle choices are crucial for breaking the cycle of metabolic syndrome in childhood and ensuring a healthier future generation.

VI. THESIS CONCLUSION

In this thesis context, which includes a population from one of the largest national multicenter studies in Latin America and the Caribbean involving adolescent populations, and a large body of evidence of children and adolescents, it exhibits prevalence of metabolic syndrome components like those found in developed countries. What sets it apart from evidence from higher-income countries, which shows that environmental factors such as social, economic, political, and commercial factors contribute to the rise in the frequency of MetS among the lower socioeconomic status, is that in our population, it is alarming that these prevalence are not limited to lower socioeconomic strata but extend to increasing frequencies in middle and upper strata, especially concerning on overweight and obesity.

High serum lipid concentrations, especially elevated levels of TG, increased significantly among schooled adolescents from Brazil with middle and higher SES. Remarkably, higher levels of HDL-c as a cardiovascular health indicator were also increasing directly across

different SES categories. This trend was also observed in markers for overweight and obesity. These findings may be explained carefully regarding tendencies and patterns prevalent in LAC, such as quality of diet in our countries.

In adolescents from LAC, MetS as a combination of cardiovascular and metabolic components did not show differences across SES strata. The worldwide definition of metabolic syndrome has been studied as a constellation of cardiovascular and metabolic risk factors but has proven to be challenging to apply in populations with varying cultural and geographic characteristics due to differences in definitions, leading to limitations in comparing data from different studies. This MetS concept of childhood and adolescence is primarily utilized in research, and this definition is not frequently employed by clinicians due to the lack of consensus in pediatric populations. This issue can result in suboptimal reporting of results and may present difficulties in identifying adolescents at risk of cardiovascular problems.

Instead, our results demonstrate how the MetS components have been studied in population-based research in LAC younger population and identify some hypotheses to understand the individual components of MetS among younger LAC populations and its relations with SES. The components of the metabolic syndrome, along with various measurement methods, exhibit variability within our pediatric populations. This emphasizes the need for increased focus on validating and standardizing these measurements for children and, most importantly, adolescents. This standardization would facilitate their inclusion in research endeavors and preventive care programs during the early stages of life, particularly in LAC countries.

These results should be analyzed with caution, given their origins in population-based studies. Nonetheless, several factors may explain this phenomenon. First, LAC populations exhibit variations in conditions related to geography, culture, and inequality determinants,

which are characteristic of this continent and contribute to challenges in maintaining a healthy lifestyle. Second, the "double burden of malnutrition," involving the increasing consumption of ultra-processed foods, is a consequence of population transition and has affected generations at the individual, household, and community levels, leading to obesogenic environments and stunted growth. This suggests that the patterns of living, particularly regarding food and healthy behaviors like physical activity, are shaped by this burden. Children exposed to this double burden may not reach their full potential and could struggle to make healthy choices as they transition into adulthood. Third, urbanization due to migration affects individuals across various socioeconomic groups. Children and adolescents, regardless of their socioeconomic status, are exposed to political, economic, pollution, and environmental factors with limited attention to promoting healthy patterns within populations.

Finally, our results described how an explicit conceptual framework for socioeconomic status in LAC is a limitation in clinical research making some important implications in methodology to be dealt with, such as residual confounding and underestimation of the exposure.

VII. FINAL CONSIDERATIONS

Despite these results from population-based studies let's draw some future considerations to consider from a methodological research, clinical, and public health management perspective.

Important population-based efforts to understand the rise of cardiometabolic diseases in LAC have been done. Nevertheless, it is imperative to follow up on this population to clarify risk factors as well as on screening to detect and treat not just cardiovascular and metabolic diseases but all non-communicable diseases. Nowadays, LAC countries have been affected

by migration and migrants serve as tracers of how exposure to different environments affects cardiometabolic adaptations and responses. On the other hand, this limitation affects the study in terms of methodology and possible residual confounding and causality between socioeconomic determinants and cardiometabolic risk factors. Thus, prospective studies become a challenge to deal with. That is relevant to include new methods and technologies such as georeferentiations or artificial intelligence will be beneficial. The ERICA study is in the second phase of its population-based research, which includes a follow-up of this population.

Upcoming studies must be directed to prioritizing adolescents and youth. There must also be a focus on reducing the exposure of adolescents and young people to risk factors for cardiometabolic disease. Multifaceted intersectoral efforts are imperative that seek to recognize the interactions between environmental and economic factors, social norms and children and adolescents' personal choices about their health. It is increasingly necessary to incorporate a process of developing relationships that enable stakeholders to work together to address health-related issues and promote well-being to achieve positive health impact and outcomes, especially to encourage youth populations. This information will be applicable to consider strategies that target young people for cardiometabolic disease prevention, and deal with significant changes an individual's health trajectory into adulthood.

It is imperative for national governments to enhance healthcare, with a particular focus on cardiovascular and metabolic surveillance, and allocate funding for the effective implementation and expansion of proven interventions. This is crucial for making progress in addressing cardiometabolic diseases and non-communicable diseases in LAC countries. To achieve this, it is essential to tailor interventions to the specific needs of this vulnerable population, as general prevention campaigns aimed at the entire population may not be

sufficient. By identifying and comprehending the social determinants of cardiometabolic risk factors in the younger population of LAC, valuable insights can be gained for health policymakers and the development of future prevention strategies for children and adolescents in our communities.

This thesis discusses alternative hypotheses and limitations in large population-based efforts. Therefore, we hope that this information contributes to future epidemiological research and addresses the gaps in our understanding of childhood and adolescent cardiovascular and metabolic health. Our findings may provide a basis for guiding community-based healthcare programs toward populations with these determinants, unquestionably impacting both the health and the economy in the regions.

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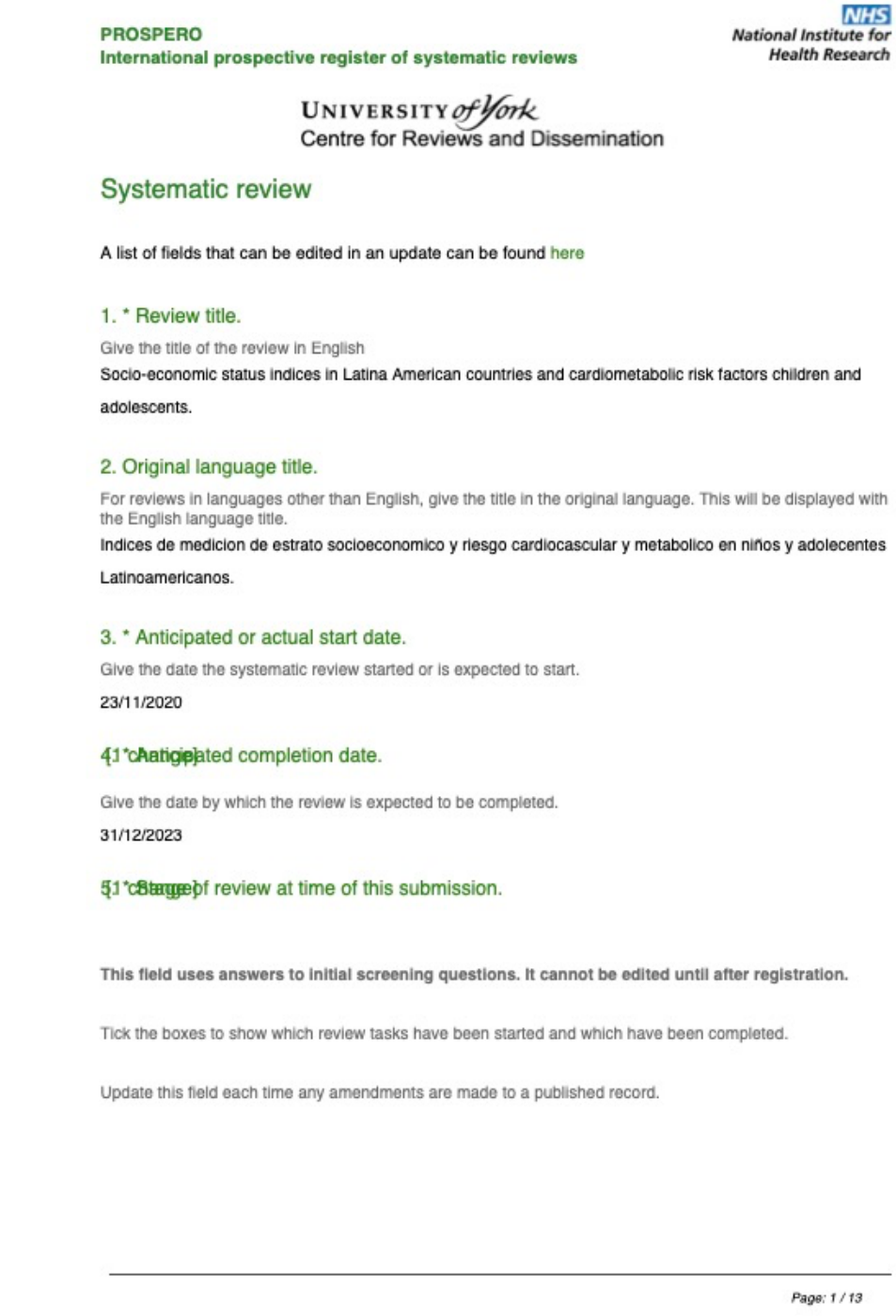
IX. Attachments

Prospero registration



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Systematic review

A list of fields that can be edited in an update can be found here

1. * Review title.

Give the title of the review in English

Socio-economic status indices in Latina American countries and cardiometabolic risk factors children and adolescents.

2. Original language title.

For reviews in languages other than English, give the title in the original language. This will be displayed with the English language title.

Indices de medicion de estrato socioeconomico y riesgo cardiocascular y metabolico en niños y adolecentes Latinoamericanos.

3. * Anticipated or actual start date.

Give the date the systematic review started or is expected to start.

23/11/2020

4. * Anticipated completion date.

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Update this field each time any amendments are made to a published record.

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