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Progression of obesity and abdominal obesity after the COVID-19 pandemic in Colombia: a comparison of two cross-sectional population-based studies

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ABSTRACT

Introduction We explored the changes in the prevalence and distribution of excess body adiposity in urban Colombia after the COVID-19 pandemic and associated lockdown.

Methods We executed a population-based, stratified, multi-stage study of individuals aged 2–80 years from five Colombian cities, between November and December 2022. We explored the prevalences of excess adiposity measures and their association with socioeconomic variables and contrasted the results with the previous wave of the study, conducted in 2018.

Results We studied 2115 individuals (83.5% adults, 51.7% female). Between 2018 and 2022, the adult prevalence of excess body weight (EBW, body mass index >25 kg/m^2) increased by 4.5% in males and decreased by 0.6% in females. Women had almost twice the prevalence of obesity as men. The prevalence of obesity for underage females soared from 7.6% in 2018 to 18.4% in 2022. Abdominal obesity increased by 10.3% in men, up to 39.8%. Adult female obesity was negatively associated with socioeconomic status (SES) (OR 2.01 (95% CI 1.33 to 3.04) for lowest SES relative to highest). Abdominal obesity among women in the lowest SES reached 55.2% in 2022. There was a strong negative relationship between education and EBW among women, the OR of obesity for women with only primary education relative to college graduates was 2.48 (95% CI 1.52 to 4.06).

Conclusions The obesity epidemic worsened in urban Colombia after the COVID-19 pandemic and associated lockdown, especially among adult males and underage females. The burden of excess adiposity is concentrated in women from disadvantaged groups.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The COVID-19 pandemic and its associated lockdown resulted in widespread behavioural changes that may have promoted the progression of the obesity epidemic. It is essential to document the evolution of excess body adiposity in Latin American countries after the COVID-19 pandemic.

WHAT THIS STUDY ADDS

⇒ Obesity among underage females more than doubled in this 4-year period, and abdominal obesity increased by 10.3% among adult men. We found strong negative associations between adult female obesity and both socioeconomic status and educational level.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Public health measures to curb the obesity epidemic in Colombia and other Latin American countries should focus on socially disadvantaged individuals and emphasise education and equitable access to preventative and therapeutic interventions for obesity.

INTRODUCTION

Weight gain increases the risk of cardiovascular disease, diabetes, metabolic-associated fatty liver disease, several types of cancer and death from any cause.[1] A worrisome worldwide increase in both overweight and obesity has taken place in recent years.[2] Abdominal obesity, reflected by an abnormally high waist circumference, is independently related to the same health risks[3] and is also increasing in most of the world. Abdominally obese persons, even with a normal body mass index (BMI), bear health risks comparable to those of obese individuals.[3]

The situation is particularly alarming among children and adolescents. The WHO estimates that around 39 million children under the age of 5 were overweight or obese in 2020, and over 340 million children and adolescents aged 5–19 were overweight or obese in 2016.[4] Even though the prevalence of obesity tends to be higher in developed countries, there has been a dramatic rise in obesity and obesity-related conditions in

Central America, South America and the Caribbean over the last few decades.[5 6] In this Latin American context, the phenomenon can be described as a rapidly advancing epidemic,[2] especially among the socially and economically disadvantaged.[7]

This nutritional transition in Latin America could have been fuelled by the SARS-CoV-2 outbreak and subsequent lockdown. During this public health contingency, multiple measures were taken to reduce the number of affected individuals, such as the use of face masks, social distancing and self-quarantine. Out of these measures, confinement was associated with factors that could lead to a positive energy balance, such as decreased outdoor physical activity, changes in eating patterns, lack of sleep, mental health diseases and exposure to obesogenic environments.[8]

Recent data from urban Colombia showed large prevalences of adult and underage overweight, obesity and abdominal obesity, especially among females,[7] but the evolution of these indicators after the COVID-19 pandemic is unknown. Analysis of this trend is of great importance, as body weight excess and COVID-19 have a bidirectional relationship: At the individual level, excess body weight (EBW) is a risk factor for COVID-19 infection and severity, while at the population level, measures taken to contain the COVID-19 pandemic may result in physical inactivity and a poorer diet, which promote weight gain.

Thus, the aim of this study was to explore the changes in the prevalence of excess body adiposity with the COVID-19 pandemic and associated lockdown in the urban population of Colombia, and to examine how these changes varied across different population segments represented by social determinants of health.

METHODS

The Colombian Study of Nutritional Profiles

Colombian Study of Nutritional Profiles (COPEN) was a population-based, cross-sectional, multistage sampling survey that included subjects from five cities of Colombia, each one representing a geographical region, as follows: Bogotá (Central region), Barranquilla (Caribbean region), Cali (Pacific region), Medellin (Northwest region) and Bucaramanga (Northeast region). The sampling frame was obtained from the 2018 Colombian census performed by the Colombian National Department of Statistics (Departamento Nacional de Estadística—DANE).[9] Information about socioeconomic status (SES) was obtained from the National Superintendence of Public Services, and cartography was obtained from the National Geostatistical Frame developed by DANE. The sample was stratified by city, sex, age and SES of the household. In each stage of sampling, we selected cartographic sectors, blocks, households and individual participants. To balance the sample by sex, we chose women from each selected household from the oddly numbered side of each street, while we selected men from the evenly numbered side of each street. To select participants in each household, we used a Kish grid listing home males or females aged 2 or older according to the location, and the participant was randomly selected. For selected participants younger than 13 years, a parent or guardian provided the information. All data were collected between November and December of 2022. Sampling errors, defined as the absolute deviation of the estimator (in this case, prevalence of obesity) relative to the true population parameter in either direction,[10] were 5.0% for Barranquilla, 4.0% for Bogotá, 5.5% for Bucaramanga, 4.9% for Cali and 4.8% for Medellin. Total sampling error was 2.1%. The 2018 and 2022 surveys were performed in the same cities, using the same sampling frame, sample design and inclusion/exclusion criteria, so they are similarly representative of the target population in the five cities.

Participants

Participants were individuals between the ages of 2 and 80, born in Colombia and residents of one of the five previously mentioned cities. Exclusion criteria were individuals receiving haemodialysis or peritoneal dialysis therapy or with any disability that could prevent the adequate fulfilment of the study questionnaire.

Measurements

For each participant, we collected information regarding sex, date of birth, SES, educational level, marital status and employment status using a standardised questionnaire. The SES used for statistical analyses was the one registered in DANE for each particular block. For anthropometric measurements, we started with a brief introduction highlighting the importance of the accuracy of the measurements to be performed. We measured weight and height in all participants and waist circumference in patients aged 18 or older. Weight was measured using digital scales with a 200 kg capacity and a 100 g sensitivity, which were calibrated prior to the beginning of the study and weekly afterwards. Height was measured using a portable stadiometer supported on a solid surface and keeping an adequate technique: the participant had to be standing straight and with heels and calves contacting the stadiometer. Waist circumference was measured by an observer in a sitting position, using a flexible metallic measuring tape positioned directly over the skin of the participant, at the midpoint between the last rib and the anterosuperior iliac crest. Measurements were performed in duplicate, and if there was a discrepancy between measures greater than 100 g for weight, 1 cm for height or 1 cm for waist circumference, a third measurement was taken. We employed the average of each anthropometric measurement for analyses. Each participant provided a capillary blood sample to measure glucose and completed a food frequency questionnaire.

For the effects of this study, we defined children and adolescents as participants aged 2 to <18 years.

Throughout this report, we also employ the term underage participants to refer to this same group.

For participants aged 18 and older, we interpreted BMI using the categories proposed by the WHO: underweight (BMI <18.5 kg/m^2), normal weight (BMI ≥18.5 and ≤25 kg/m^2), overweight (BMI >25 and <30 kg/m^2) and obesity (BMI ≥30 kg/m^2). For participants aged 24–59 months, we interpreted BMI according to the BMI-for-age Z-score tables of the WHO[11]: Overweight or at risk of overweight (Z-score >1 and ≤3) and obesity (Z-score >3). For participants 5–17 years, overweight was defined as a Z-score >1 and ≤2, and obesity as a Z-score >2.[10] We defined abdominal obesity according to cut-offs for Latin American adults,[12] as a waist circumference ≥94 cm for men and ≥90 cm for women. For analyses including educational level, we only included participants aged 18 or older.

SES in Colombia is classified by DANE in six strata, with stratum one being the lowest and stratum six the highest. Residential dwellings are classified according to their physical characteristics and surroundings, considering data on public services, access routes, land use, land valuation, topography and property characteristics. Data on SES are very well established, updated and freely available. SES has a significant correlation with household income.[13] We analysed SES in four categories corresponding to stratum 1, stratum 2, stratum 3 and strata 4–6, as sociodemographic, income and human development indicators are more similar for individuals living in strata 4–6 than within the other strata.[14]

Data analysis

Prevalences were estimated using sex, age, city and SES-specific sample weights based on the complex multistage sampling design of the study. We calculated the prevalence of EBW (which encompassed overweight and obesity categories), as well as the distribution of BMI categories by SES, city and education level (the latter only for adult participants). The prevalence of abdominal obesity was also calculated by the same criteria, though only for adults. We also estimated the OR for the association between adiposity measures and the sociodemographic variables sex, SES or educational level, using univariable binary logistic regression. Except for the exposure variable sex, all association analyses were performed stratifying by sex. Given that the two waves of COPEN did not include exactly the same individuals, we descriptively contrasted the results between 2022 and COPEN 2018. We tested the significance of observed changes in prevalences using a binomial logistic regression model in which the participants' cohort was included as predictor, and the presence or absence of each diagnosis was the outcome. As our study is purely descriptive and does not aim to attribute the observed changes in prevalences to individual risk factors, or adjust for confounders, the p value can be interpreted only as a reflection of whether the observed change is larger than would be expected purely by chance. All analyses were two-tailed and performed at a 5% significance level using SPSS for Windows, V.21.

RESULTS

The study sample comprised 2115 individuals (1768 adults and 347 children and adolescents). The majority of adults were female, while most underage participants were male. Most participants belonged to SES 2 or 3. About two-thirds of adults had an educational level of high school or lower, and only about a fifth completed college or postgraduate education (table 1).

Our results showed that EBW (overweight+obesity) in adults progressed from 57.5% (95% CI 55.0% to 59.9%) to 59% (95% CI 56.8% to 61.3%) between 2018 and 2022 (p=0.39): Males experienced a 4.5% increase from 49.0% (95% CI 45.3% to 52.6%) to 53.5% (95% CI 50.0% to 56.9%) (p=0.31), while females showed a slight decrease, from 65.4% (95% CI 62.1% to 68.6%) to 64.1% (95% CI 61.1% to 67.1%) (p=0.90). Total adult obesity increased from 21.3% (95% CI 19.3% to 23.3%) to 21.8% (95% CI 19.9% to 23.8%) (p=0.012), also with a marked difference between sexes. Even though the prevalence of obesity increased by 3% from 12.6% (95% CI 10.2% to 15.0%) to 15.6% (95% CI 13.0% to 18.1%) among men (p=0.052) and decreased by 1.8%, from 29.4% (95% CI 26.3% to 32.5%) to 27.6% (95% CI 24.8% to 30.3%) among women (p=0.70); female adults continue to be much more affected by obesity than men (almost twice as much). The difference in prevalences was 16.8% in 2018, and 12.0% in 2022 (figure 1A). Over the study duration, there was a significant difference in the odds of obesity between sexes, with an OR of 2.39 for women relative to men (95% CI 2.01 to 2.83) (online supplemental table 1). The prevalence of overweight (BMI >25 and <30 kg/m^2) rose between the two waves of the study, from 36.2% (95% CI 33.8% to 38.6%) to 37.2% (95% CI 35.0% to 39.4%), although this increase was not statistically significant (p=0.93).

For children and adolescents (aged 2 to <18), despite an apparent stabilisation of EBW between 2018 and 2022 at a figure close to 30%, there was a marked discrepancy by sex. Females had a 7.2% increase (from 28.7% (95% CI 21.5% to 36.0%) to 35.9% (95% CI 27.3% to 44.5%), p=0.031), while for males there was a non-significant decrease, from 35.3% (95% CI 29.2% to 41.4%) to 26.6% (95% CI 20.9% to 32.4%) (p=0.071) (figure 1B). Of concern, the prevalence of obesity for underage females more than doubled during the observation period, from 7.6% (95% CI 3.3% to 11.8%) in 2018 to 18.4% (95% CI 11.5% to 25.3%) in 2022 (p=0.078). The prevalence of overweight in the same group remained essentially unchanged. Contrastingly, the prevalence of obesity for underage males did not progress, and overweight actually decreased by almost 9% points.

The mean waist circumference value increased from 87.3±13.0 cm in 2018 to 88.7±13.1 cm in 2022 (p=0.004), increasing by 2.4 cm among men (from 88.1 to 90.5 cm,

Table 1 Characteristics of the study sample

	Adults (age ≥18)			Children and adolescents (age <18)		
	Male	Female	Total	Male	Female	Total
n	794 (44.9)	974 (55.1)	1768	227 (65.4)	120 (34.6)	347
Age group, years						
2 to <5	–	–	–	29 (12.8)	22 (18.3)	51 (14.7)
5 to 11	–	–	–	97 (42.7)	49 (40.9)	146 (42.1)
12 to 17	–	–	–	101 (44.5)	49 (40.8)	150 (43.2)
18 to 39	288 (36.3)	309 (31.7)	597 (33.8)	–	–	–
40 to 59	193 (24.3)	332 (34.1)	525 (29.7)	–	–	–
60 to 80	313 (39.4)	333 (34.2)	646 (36.5)	–	–	–
Socioeconomic status*						
1	114 (14.4)	152 (15.7)	266 (15.1)	54 (23.8)	29 (24.2)	83 (23.9)
2	196 (24.7)	260 (26.8)	456 (25.9)	71 (31.3)	43 (35.8)	114 (32.9)
3	245 (30.9)	288 (29.7)	533 (30.2)	53 (23.3)	31 (25.8)	84 (24.2)
4–6	237 (29.9)	270 (27.8)	507 (28.8)	49 (21.6)	17 (14.2)	66 (19.0)
City						
Barranquilla	123 (15.5)	165 (16.9)	288 (16.3)	68 (30.0)	28 (23.3)	96 (27.7)
Bogota	214 (27.0)	287 (29.5)	501 (28.3)	56 (24.7)	43 (35.8)	99 (28.5)
Bucaramanga	128 (16.1)	145 (14.9)	273 (15.4)	34 (15.0)	14 (11.7)	48 (13.8)
Cali	158 (19.9)	170 (17.5)	328 (18.6)	51 (22.5)	25 (20.8)	76 (21.9)
Medellin	171 (21.5)	207 (21.3)	378 (21.4)	18 (7.9)	10 (8.3)	28 (8.1)
Educational level†						
Elementary school or less	246 (31.0)	358 (36.8)	604 (34.2)	–	–	–
High school	273 (34.4)	310 (31.8)	583 (33.0)	–	–	–
Technical or associate degree	119 (15.0)	165 (16.9)	284 (16.1)	–	–	–
College or higher	156 (19.6)	141 (14.5)	297 (16.8)	–	–	–

Data are expressed as n (percentage).
*According to Colombia's official Statistics Department-DANE, using criteria about land use, public utilities, access routes, topography, land valuation and property characteristics of the property inhabited by the household. A socioeconomic status of 1 is lowest and 6 is highest.
†Reported and analysed only for participants aged 18 or older.
DANE, Departamento Nacional de Estadística.

p=0.008) and by 0.5 cm among women (from 86.5 to 87.0 cm, p=0.11). As a result, the prevalence of abdominal obesity increased in both sexes, but the change was dramatically superior among men. Already in 2018, the prevalence of abdominal obesity was close to 30% for men and to 40% for women. By 2022, almost two out of five adult men (39.8% (95% CI 36.4% to 43.2%)) and women (42% (95% CI 38.9% to 45.0%)) had abdominal obesity. The absolute increment was 10.3% among men (p=0.001) and 3.2% (p=0.066) among women. As a result, the proportion of abdominal obesity has almost levelled up between sexes (figure 2).

EBW and abdominal obesity across the main five cities of Colombia

Among adult men, EBW showed an increase in the three largest cities: Bogotá (+4.4%), Medellín (+9.6%) and Cali (+3.6%). In 2022, Barranquilla (21.9%) and Bucaramanga (21.3%) had the highest rates of male obesity. In the case of women, EBW decreased in all cities except for Medellín, which had a 4.6% increase. Adult female obesity was most prevalent in Cali (39.2%) and Bucaramanga (32.7%). In contrast to the trends in adults, among male children and adolescents EBW decreased in the three largest cities (Bogotá −11.6%, Medellín −14.2%, Cali −3.2%). Female children and adolescents experienced an increase in EBW and obesity in all cities except for Medellín, where it remained stable. The increases in underage female obesity were very pronounced in Cali (26.1%) and Bucaramanga (13.3%). For the most part, male abdominal obesity increased in all cities, but remained constant among females.

Association between adiposity measures and SES

Adult men showed an increment in EBW prevalence in all SES (figure 3A), most noticeably in the highest strata (SES 4–6, +7.7%). Meanwhile, women showed a decrease in EBW in all SES except for stratum 3, where

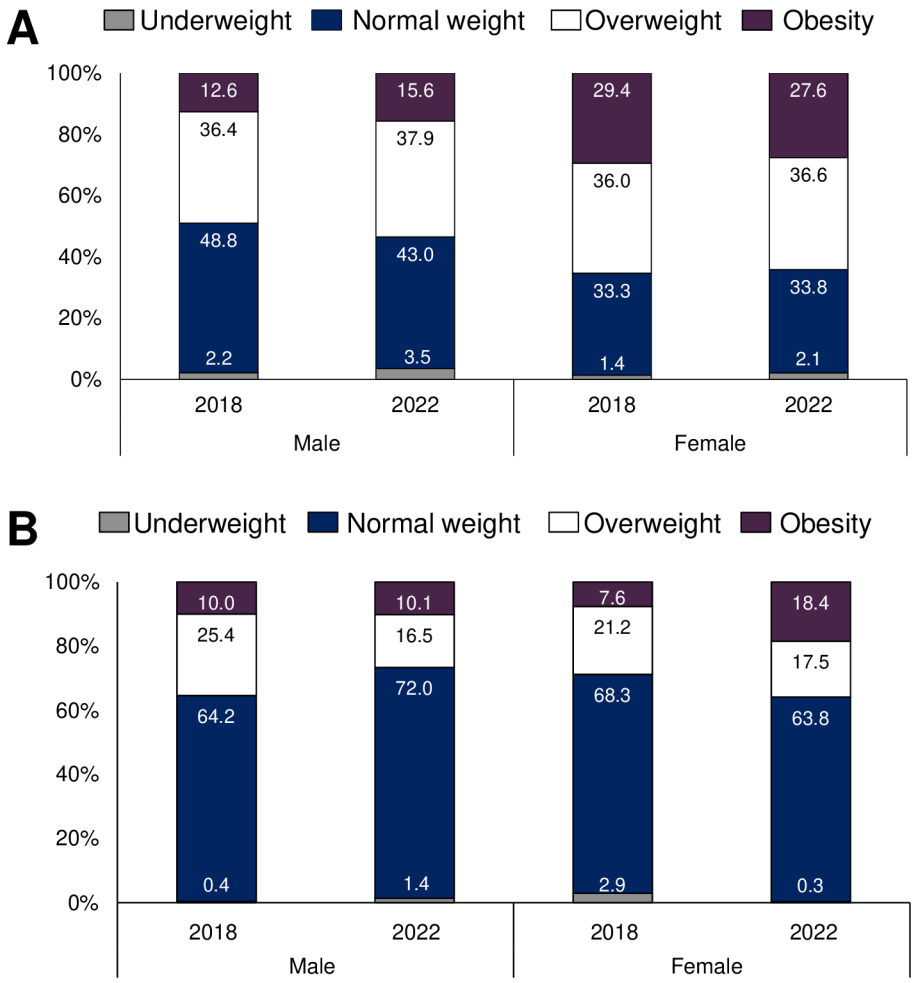

Figure 1 Distribution of urban Colombians across body mass index categories in 2018 and 2022. (A) Adults, (B) children and adolescents.

the prevalence increased by 6.4%. Importantly, in both surveys, there was a very clear negative association between female obesity (BMI ≥30) and SES, so that the prevalence in SES1 more than doubles that in SES 4–6 (figure 3B). Compared with SES 4–6, the odds of obesity were significantly higher only among women for SES1 (OR 2.15 (95% CI 1.56 to 2.96)) and SES2 (OR 2.03 (95% CI 1.53 to 2.68)) (online supplemental tables 2 and 3).

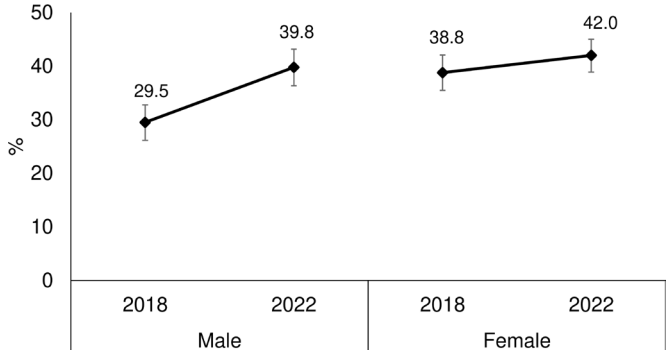

Figure 2 Prevalence of abdominal obesity among Colombian urban adults in 2018 and 2022. Error bars represent the 95% CI of prevalences.

The relationship between SES and EBW, and its evolution between 2018 and 2022, was quite different among children and adolescents. In 2022, while males showed a twofold higher proportion of EBW in the highest relative to the lowest SES, females showed the exact opposite association. Both males and females of SES1 showed an important increase in EBW, but the magnitude was much larger (33.7%) for females. Even though EBW in the highest SES diminished between 2018 and 2022 for both males and females, the prevalence of female obesity in this same stratum increased by 14.3% (online supplemental figure 1).

Similar to EBW, abdominal obesity increased between 2018 and 2022 in men of all strata, with the largest change in SES3 (+16.2%) and SES 4–6 (+11.2%) (online supplemental figure 2). Women showed a higher prevalence of abdominal obesity compared with males, except for SES 4–6 in 2022. Of note, female abdominal obesity increased the most in SES1 (+11.1), up to a dramatic 55.2%. Abdominal obesity was significantly more prevalent among women in SES1 (OR 1.79 (95% CI 1.32 to 2.43)), SES2 (OR 1.56 (95% CI 1.21 to 2.02)) and SES 3 (OR 1.47 (95% CI 1.14 to 1.89)),

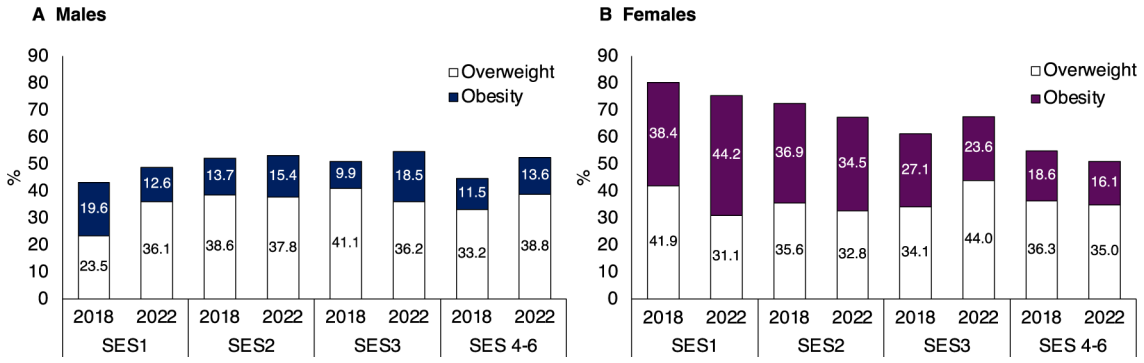

Figure 3 Distribution of body weight excess in urban adults across socioeconomic strata in 2018 and 2022. SES, socioeconomic status.

compared with those in SES 4–6 (online supplemental table 3).

Association between adiposity measures and educational level

We found a clear negative relationship between educational level and total EBW only among women (figure 4). In both 2018 and 2022, female EBW decreased markedly with higher education. Women with college or higher education showed the largest decrease in the prevalence of obesity between the two study waves (−6.8%). As a result, the prevalence of obesity among women with only elementary education was drastically higher than among women with a college degree (OR 2.97 (95% CI 2.17 to 3.96)) (online supplemental table 3). Compared with women with the highest education, the OR for obesity was also significantly higher for those with only high school (OR 2.25 (95% CI 1.60 to 3.17)) or only a technical degree (OR 2.09 (95% CI 1.43 to 3.06)) (online supplemental table 3).

In general, there was a negative association between education and abdominal obesity only among women in both surveys (online supplemental figure 3 and tables 2, 3). Between 2018 and 2022, men of all education levels exhibited an increment in the prevalence of abdominal obesity, while females presented a slight decrease. Abdominal obesity was markedly more prevalent among women with only elementary education (OR vs college graduates 2.93 (95% CI 2.17 to 3.96)) (online supplemental table 3).

Underweight

Although small, the overall prevalence of adult underweight among urban Colombians increased from 1.8% (95% CI 1.1% to 2.4%) in 2018 to 2.7% (95% CI 2.0% to 3.5%) in 2022 (p=0.92). We found a worrisome increment of 8.6% points in underweight among adult men of the lowest SES (online supplemental figure 4).

DISCUSSION

In this population-based study of individuals from the main cities of Colombia, we analysed the evolution of excess adiposity before vs after the COVID-19 pandemic. Despite an apparent stabilisation of EBW, we observed a sizeable increase in obesity (BMI ≥30 kg/m^2) and abdominal obesity, centred in adult men. Women in a disadvantaged social position, reflected by a lower SES or lower educational attainment, were much more severely affected by all forms of excess adiposity. The pandemic was also associated with negative changes in the progression of the obesity epidemic among female children and adolescents. After slow and decades-long improvements in the rates of undernutrition, we observed an apparent surge in underweight centred on poorer, adult men.

Our data show a marked increase in obesity prevalence among adults, with a slight increase in children and a narrowing gap between sexes. This pattern has been described as 'phase 2' of the obesity transition,[15] which may have been accelerated by the COVID-19 pandemic. In both waves of COPEN, women had more EBW, obesity

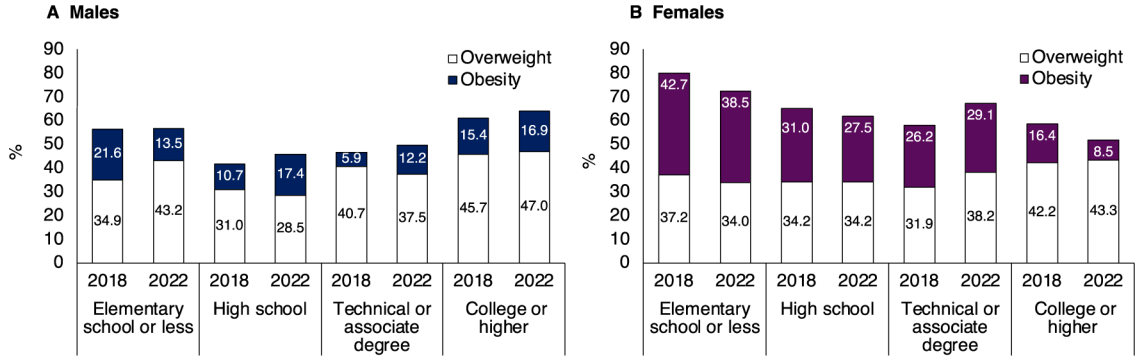

Figure 4 Distribution of body weight excess in urban adults across maximum attained educational levels in 2018 and 2022.

and abdominal obesity, about one-third of women are obese, while only one in seven men is. A recent meta-analysis of sex-specific disparities in low-income and middle-income countries (LMICs) found odds of obesity threefold as high for women relative to men.[16] For Latin American countries, the OR of obesity was 2.17 comparing women vs men, and the prevalence of female obesity was 28%, which are surprisingly close to the values we encountered for 2022.[15] In concordance with our results, a study of urban populations from southern Latin American countries found higher adiposity among women than men.[17]

Several physiological and sociocultural factors may explain the greater affectation of women by excess adiposity. Some sex-specific conditions like polycystic ovary syndrome,[18] menopause[19] and pregnancy[20] are associated with increased calorie intake, reduced energy expenditure or altered hormonal action. In developing countries, the recent years have witnessed a marked reduction in labour-associated physical activity and increased consumption of energy-dense foods, affecting more females than males.[20] Finally, women in a more disadvantaged social position may have cultural perceptions about body size that favour this gender disparity.[21] Importantly, EBW negatively impacts the biological production and bioavailability of vitamin D, negatively influencing bone health among women, who are already at a greater risk of osteoporosis compared with men.[22]

In this regard, we found a negative relationship between EBW and social standing in women, but no clear association in men. In a recent analysis of obesity and wealth/education indices in Latin America,[23] most countries presented the same strong negative association between female education and obesity that we identified. Also, the previously mentioned study in southern countries of South America[17] found obesity and abdominal obesity to be less common among female college graduates (OR 0.42, 95% CI 0.34 to 0.53). In a different region, a study in South Korea found an obesity prevalence twice as high among women with 12 or less years of formal education (34.3%) vs those with ≥13 years (16.0%).[24] In the above-mentioned study of obesity in Latin America,[23] there was no correlation between obesity and wealth in Colombia at the time. Our results show that this situation has changed, and Colombia has now moved to a later stage of the nutrition transition, in which obesity is much more prevalent among women of lower SES (28.1% points difference between extreme categories).

Multiple factors may explain our findings concerning SES, education and body adiposity. Reliable information about healthy eating might be more accessible to people with more advanced education, and prevailing cultural beliefs about body image may be more in line with a normal weight in these population segments.[25] Also, the prices of fruits and vegetables may be higher in urban environments, limiting their accessibility to families with lower income and driving them to consume cheap, calorie-dense, carbohydrate-rich foods.[26] In addition, poor urban neighbourhoods may be more exposed to an unsafe environment, which discourages the practice of outdoors physical activity.

Despite the predominance of excess adiposity among women, one of our most dramatic findings was its rapid rate of absolute increase among urban males: 4.5% in EBW, 3% in obesity and 10.3% in abdominal obesity in just 4 years. According to a recent worldwide systematic review, between 11.1% and 72.4% of individuals reported increases in body weight during and after the COVID-19 pandemic lockdown.[27] The term 'covibesity' has been coined to name this rapid weight gain induced by factors associated with the COVID-19 lockdown.[28] We observed a stronger association of this contingency with obesity among men, perhaps because they tended to be more physically active than women before these restrictions.[29] An interesting study of COVID-19 survivors in Italy found that individuals with EBW tended to gain extra weight and abdominal fat after the COVID infections, the net increase at 3 months being proportional to the initial weight loss during the acute disease.[30] Similar findings have been reported for male adults in Spain.[31]

We found an alarming increase in underage female obesity, concentrated in SES1 (24%). Data show that the BMI of children and adolescents has stabilised since 2000 in high-income countries but has continued to increase in LMIC.[2] A global meta-analysis of studies in children and adolescents showed a significant increase in the odds of obesity during the COVID-19 lockdown (OR 1.17 (95% CI 1.06 to 1.29)).[32] Sadly, the advance of obesity is focused on children, adolescents and women from the poorest segments of society. A completely unexpected result was the increase in underweight among men of SES1. Here, the explanation is perhaps more economic in nature: Usually men from this stratum work informal jobs happening outdoors (ie, as construction workers, street vendors, etc). These activities were severely limited by the lockdown, leading to even more restricted income and deficient nutrition.

The strengths of this study are its population base, complex probabilistic sample design and careful execution, all of which make it a reliable representation of most of the urban Colombian population. Also, the study personnel were extensively trained, and constant supervision and validation rules were implemented to guarantee data quality.

Among the limitations of the study, one of the most relevant is the lack of information about the rural setting and about how this population was affected by the COVID-19 lockdown. Given that EBW is increasing rapidly among Latin American women,[2] future studies will need to focus on the evolution of EBW in the rural setting in this part of the world, with a particular focus on women. Also, because it was a joint analysis of two separate cross-sectional studies and not a longitudinal follow-up, we did not have data on the incidence of cardiometabolic complications at the individual participant level. Additionally, the study did not collect information on

pharmacological therapies, physical activity or physical function.

Despite the importance of early years in the predisposition to obesity later in life, we had a limited number of participants between the ages of 2 and 5 (100 participants in 2018, 78 in 2022), so we were unable to perform reliable inferences specifically for this age group. It is also important to highlight that, while the study showed a progression in the prevalence of EBW and obesity in some population segments, we did not have the information to identify all of the variables mediating on this association, which are multiple and would exceed the scope of the study.

In summary, the COVID-19 pandemic and associated lockdown were accompanied by an accelerated rate of expansion of obesity and abdominal obesity in urban Colombia. This association was much stronger in socially disadvantaged population segments, especially poorer or less educated women. Our results also suggest that improving the access of women to economic equality and higher education, more than strategies narrowly focused on obesity or nutrition, may result in greater impact against the obesity epidemic in our context. While our results are generally of national scope and limited by the lack of data on variables mediating the observed associations, these findings may inform health policy-makers from other countries in Latin America and the global south.

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Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Participants aged 14–80 provided written informed consent. For participants aged 14 or below, a parent or legal guardian provided written informed consent. In addition, participants aged 7–13 provided written assent, while for participants aged 2–6 informed consent was obtained from the adult responsible for the child. All study procedures were performed according to the principles of the Declaration of Helsinki and local rules and regulations as stated by Resolution 8430 of 1993 of the Colombian Ministry of Health. The study was approved by the IRB of Universidad de los Andes (Comité de Ética de la Vicerrectoría de Investigaciones), according to minute 1618 of 25 November 2022.

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Data availability statement Data are available on reasonable request. Deidentified data and a data dictionary will be available on request to the corresponding author according to a formal research proposal. The data will be available only for research and non-commercial purposes carried out by individuals with academic or public health institutions. Data access will need agreement and approval by the local ethics committee.

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REFERENCES

1 Guh DP, Zhang W, Bansback N, *et al*. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. *BMC Public Health* 2009;9:88.
2 Abarca-Gómez L, Abdeen ZA, Hamid ZA, *et al*. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *The Lancet* 2017;390:2627–42.
3 Janssen I, Katzmarzyk PT, Ross R. Waist circumference and not body mass index explains obesity-related health risk. *Am J Clin Nutr* 2004;79:379–84.
4 WHO Multicentre Growth Reference Study Group. Obesity and overweight. Available: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight [Accessed 04 Jan 2024].
5 Miranda JJ, Herrera VM, Chirinos JA, *et al*. Major cardiovascular risk factors in Latin America: a comparison with the United States. The Latin American Consortium of Studies in Obesity (LASO). *PLoS ONE* 2013;8:e54056.
6 Ruilope LM, Nunes Filho ACB, Nadruz W Jr, *et al*. Obesity and hypertension in Latin America: Current perspectives. *Hipertens Riesgo Vasc* 2018;35:70–6.
7 Jimenez-Mora MA, Nieves-Barreto LD, Montaño-Rodríguez A, *et al*. Association of Overweight, Obesity and Abdominal Obesity with Socioeconomic Status and Educational Level in Colombia. *Diabetes Metab Syndr Obes* 2020;13:1887–98.
8 Zachary Z, Brianna F, Brianna L, *et al*. Self-quarantine and weight gain related risk factors during the COVID-19 pandemic. *Obes Res Clin Pract* 2020;14:210–6.
9 Departamento Administrativo Nacional de Estadística – DANE. Censo nacional de población y vivienda. 2018. Available: https://www.dane.gov.co/index.php/estadisticas-por-tema/demografia-y-poblacion/censo-nacional-de-poblacion-y-vivenda-2018 [Accessed 04 Jan 2024].
10 Sarndal C-E, Swenson B, Wretman J. Model Assisted Survey Sampling. Springer-Verlag, 1992.
11 WHO Multicentre Growth Reference Study Group. Body-mass-index -for-age standards, Available: https://www.who.int/childgrowth/standards/bmi_for_age/en [Accessed 04 Jan 2024].
12 Aschner P, Buendía R, Brajkovich I, *et al*. Determination of the cutoff point for waist circumference that establishes the presence of abdominal obesity in Latin American men and women. *Diabetes Res Clin Pract* 2011;93:243–7.
13 Bushnell D, Hudson RA. Social strata division. In: Hudson RA, ed. *Colombia: A Country Study*. 5th edn. Washington, D.C: Federal Research Division, Library of Congress, 2010: 101–3.
14 Departamento Administrativo Nacional de Estadística. Metodología de estratificación socioeconómica urbana para servicios públicos domiciliarios. Bogotá, Colombia DANE; 2015. Available: https://www.dane.gov.co/files/geoestadistica/estratificacion/ManualdeRealizacion.pdf [accessed 04 Jan 2024]
15 Jaacks LM, Vandevijvere S, Pan A, *et al*. The obesity transition: stages of the global epidemic. *Lancet Diabetes Endocrinol* 2019;7:231–40.

16 Rocha T, Melson E, Zamora J, *et al*. Sex-Specific Obesity and Cardiometabolic Disease Risks in Low- and Middle-Income Countries: A Meta-Analysis Involving 3 916 276 Individuals. *J Clin Endocrinol Metab* 2024;109:1145–53.
17 Lanas F, Bazzano L, Rubinstein A, *et al*. Prevalence, Distributions and Determinants of Obesity and Central Obesity in the Southern Cone of America. *PLoS ONE* 2016;11:e0163727.
18 Zeng X, Xie Y-J, Liu Y-T, *et al*. Polycystic ovarian syndrome: Correlation between hyperandrogenism, insulin resistance and obesity. *Clin Chim Acta* 2020;502:214–21.
19 Opoku AA, Abushama M, Konje JC. Obesity and menopause. *Best Pract Res Clin Obstet Gynaecol* 2023;88:102348.
20 Mamun AA, Kinarivala M, O'Callaghan MJ, *et al*. Associations of excess weight gain during pregnancy with long-term maternal overweight and obesity: evidence from 21 y postpartum follow-up. *Am J Clin Nutr* 2010;91:1336–41.
21 Kanter R, Caballero B. Global gender disparities in obesity: a review. *Adv Nutr* 2012;3:491–8.
22 Di Filippo L, De Lorenzo R, Giustina A, *et al*. Vitamin D in Osteosarcopenic Obesity. *Nutrients* 2022;14:1816.
23 Jiwani SS, Carrillo-Larco RM, Hernández-Vásquez A, *et al*. The shift of obesity burden by socioeconomic status between 1998 and 2017 in Latin America and the Caribbean: a cross-sectional series study. *Lancet Glob Health* 2019;7:e1644–54.
24 Chung W, Lim S. Factors contributing to educational differences in obesity among women: evidence from South Korea. *BMC Public Health* 2020;20:1136.
25 Quiroga-Padilla PJ, Gaete PV, Nieves-Barreto LD, *et al*. Social inequalities shape diet composition among urban Colombians: The Colombian Nutritional Profiles cross-sectional study. *Public Health Nutr* 2021;25:1–30.
26 Darmon N, Drewnowski A. Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: a systematic review and analysis. *Nutr Rev* 2015;73:643–60.
27 Bakaloudi DR, Barazzoni R, Bischoff SC, *et al*. Impact of the first COVID-19 lockdown on body weight: A combined systematic review and a meta-analysis. *Clin Nutr* 2022;41:3046–54.
28 Khan MA, Moverley Smith JE. "Covibesity," a new pandemic. *Obes Med* 2020;19:100282.
29 Fernando Gómez L, Duperly J, Iván Lucumí D, *et al*. Nivel de actividad física global en la población adulta de Bogotá (Colombia). Prevalencia y factores asociados. *Gac Sanit* 2005;19:206–13.
30 Di Filippo L, De Lorenzo R, Cinel E, *et al*. Weight trajectories and abdominal adiposity in COVID-19 survivors with overweight/obesity. *Int J Obes (Lond)* 2021;45:1986–94.
31 Martínez-de-Quel Ó, Suárez-Iglesias D, López-Flores M, *et al*. Physical activity, dietary habits and sleep quality before and during COVID-19 lockdown: A longitudinal study. *Appetite* 2021;158.
32 Chang T-H, Chen Y-C, Chen W-Y, *et al*. Weight Gain Associated with COVID-19 Lockdown in Children and Adolescents: A Systematic Review and Meta-Analysis. *Nutrients* 2021;13:3668.