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The Burden of Obesity in Argentina (2005–2022): The Role of Socioeconomic Status and Gender in Shaping BMI Trends

La carga de la obesidad en Argentina (2005-2022): El papel del estatus socioeconómico y el género en la configuración de las tendencias del IMC

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Declaration of interests
The authors declare no conflicts of interest.

Abstract

Introduction. Understanding Body Mass Index (BMI) trends over time is essential for addressing the global overweight and obesity pandemic and its associated health risks. However, evidence from low- and middle-income countries remains limited. This study analyzed long-term BMI trends in Argentina (2005-2018), examining variations by age, sex, and socioeconomic status (SES), and comparing patterns according to the presence of obesity-related chronic diseases in adults.

Method. Data were obtained from repeated cross-sectional, population-based Argentine surveys: the National Risk Factors Survey (2005, 2009, 2013 and 2018; n = 126,590). Age specific BMI trends were estimated using three-age moving medians. Polynomial curves were fitted to estimate the age at maximum BMI (maxBMI) and its corresponding value in the general population according to sex, SES, and chronic conditions (hypertension and type 2 diabetes mellitus).

Results. A steady increase in mean BMI was observed across survey waves. Overall, maxBMI was reached between approximately 58–61 years of age, and its value was similar for men and women; however, women reached maxBMI at slightly older ages. The low SES group showed both a higher maxBMI and an earlier age at maxBMI

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Ethics statement
This study was approved by the Institutional Research Committee of Hospital Nacional de Clínicas, Universidad Nacional de Córdoba (approval no. PV-2020-0077606-UNC-SCT#FCM), and registered with the Provincial Health Research Registry (RePIS No. 4060). All participants provided written informed consent prior to participation.

Data availability
All data supporting the findings of this study are available within the article and its Supplementary Information.

Author Contributions
Stefano Staurini: data curation, visualization, writing – original draft, writing – review & editing.
Camila Niclis: conceptualization, investigation, methodology, supervision, writing – review & editing.
Alberto Rubén Osella: methodology, supervision, validation, visualization, writing – review & editing.
Silvia Menchón: formal analysis, supervision, writing – review & editing.
Pablo Manuel Roman: conceptualization, formal analysis, methodology, supervision, writing – review & editing.
Laura Rosana Aballay: conceptualization, funding acquisition, investigation, methodology, supervision, writing – review & editing.

Generative AI declaration
Generative AI was used during the preparation of this manuscript. The tool employed was ChatGPT (OpenAI, GPT-4–based model). Its use was limited to language editing and minor stylistic refinement of specific sections of the manuscript, including wording adjustments in the abstract and discussion. The AI was not used for data analysis, statistical modeling, interpretation of results, figure generation, or the development of scientific content. All AI-assisted outputs were carefully reviewed, critically edited, and validated by the authors, who assume full responsibility for the accuracy, originality, and scientific integrity of the final manuscript.

than the high SES group. Additionally, individuals with hypertension or type 2 diabetes exhibited a higher maxBMI, which occurred at earlier ages than in participants without these conditions.

Conclusions. BMI increased steadily in Argentina during the study period, with differences according to sex, SES, and health status. Unlike conventional approaches based on average BMI values, age-specific BMI curves allow for a life-course perspective on obesity dynamics. This approach highlights the importance of considering these factors when monitoring BMI as population health indicator, especially among socially disadvantaged groups.

Keywords

Primary: body mass index; obesity; health status indicators; social class; chronic disease.

Secondary: overweight; sex; social determinants of health; health inequality indicators; health impact assessment.

Resumen

Introducción. Comprender las tendencias del índice de masa corporal (IMC) a lo largo del tiempo es esencial para abordar la pandemia mundial de sobrepeso y obesidad y los riesgos para la salud asociados. Sin embargo, existe escasa evidencia sobre este fenómeno en los países de ingresos bajos y medios. Este estudio analiza las tendencias del IMC a largo plazo en Argentina (2005-2018), examinando las variaciones por edad, sexo y estatus socioeconómico (ESE), y comparando los patrones según la presencia de enfermedades crónicas relacionadas con la obesidad en adultos.

Métodos. Los datos se obtuvieron de estudios poblacionales argentinos con diseños transversales repetidos: la Encuesta Nacional de Factores de Riesgo (2005, 2009, 2013 y 2018; n = 126 590). Las tendencias del IMC por edad se calcularon utilizando medianas móviles de tres edades. Se ajustaron curvas polinómicas para estimar el IMC máximo (IMCmáx) en la población general y de forma estratificada por sexo, ESE y enfermedades crónicas (hipertensión y diabetes mellitus tipo 2).

Resultados. Se observó un aumento constante del IMC medio en todas las ediciones de la encuesta. En general, el IMCmáx se alcanzó alrededor de los 58-61 años, y su valor fue similar para hombres y mujeres; sin embargo, las mujeres alcanzaron el IMCmáx ligeramente más tarde. El grupo de nivel socioeconómico bajo mostró un IMCmáx más alto y a edades más tempranas que el grupo de nivel socioeconómico alto. Además, las personas con hipertensión o diabetes tipo 2 mostraron un IMCmáx más elevado, que se produjo a edades más tempranas que en los participantes sin estas afecciones.

Conclusiones. El IMC está aumentando en Argentina, con diferencias según el sexo, el ESE y el estado de salud. A diferencia de los enfoques convencionales basados en la media, las curvas de IMC específicas por edad permiten una perspectiva del ciclo de vida sobre la dinámica de la obesidad. Este enfoque destaca la importancia de tener en cuenta estos factores al utilizar el IMC como indicador de salud, especialmente entre las poblaciones socialmente desfavorecidas.

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Palabras clave

Principales: índice de masa corporal; obesidad; indicadores de salud; clase social; enfermedad crónica.

Secundarias: sobrepeso; sexo; determinantes sociales de la salud; indicadores de desigualdad en salud; evaluación del impacto en la salud.

Introduction

Obesity, internationally recognized as a pandemic, is one of the most common metabolic diseases worldwide and constitutes a significant burden on healthcare systems [1]. Along with overweight, it is associated with a wide range of consequences, including low-grade systemic inflammation, heart disease, increased all-cause and cause-specific mortality rates, and adipose tissue inflammation as a key mediator in the development of obesity-related cancers [1].

Body Mass Index (BMI) is a validated tool for monitoring population nutritional status. Increased BMI correlates with health risk factors [2] and is commonly used to classify overweight and varying degrees of obesity severity. BMI aids not only in measuring obesity but also in guiding public health policies aimed at preventing and controlling non-communicable diseases (NCDs) [3], which are responsible for over 80% of global deaths and 74% of premature deaths occurring before the age of 70 years. Although BMI is widely used for population surveillance, it is a proxy for adiposity rather than a direct measure of body fat. BMI is associated with cardiometabolic risk at the population level, yet its association with health outcomes varies by age, sex, and ancestry, and it does not capture fat distribution or body composition. Consequently, BMI is useful for monitoring trends and comparing subpopulations, while clinical assessment of obesity should consider complementary measures (e.g., waist circumference, body composition) and health impairments. In large-scale population surveillance, where direct clinical measurements are often unavailable, BMI remains the most feasible and widely accepted metric. Therefore, in this study we interpret BMI as a population indicator. Accordingly, we interpret BMI as a population indicator of weight status and early health deterioration, not as a diagnostic of excess adiposity in individuals [4].

BMI has been associated with socioeconomic status (SES) [5]. Additionally, the intersection of biological sex and gender roles significantly shapes weight trajectories across the life course due to distinct hormonal profiles, metabolic changes, and socio-cultural body standards [5]. Higher BMI levels have increased worldwide, with a marked shift toward lower socio-economic groups in low and middle-income countries [6]. In Argentina, similar trends have been observed, particularly among individuals from lower SES groups [5]. On the other hand, BMI differences contribute to widening the socio-economic gap, thereby influencing economic development [7]. High BMI impacts working-age individuals (18-60 years), posing economic challenges, such as higher healthcare costs, reduced workforce productivity, and lower economic growth [8]. Recent global and regional evidence underscores that the economic burden of obesity is unsustainable, accounting for a significant and rising percentage of total national healthcare expenditures through both direct medical costs and indirect productivity losses [5]. These implications also extend to older age groups (≥ 60 years), who typically present higher healthcare utilization and associated economic burden, thereby further increasing overall healthcare expenditures [9].

Behavioral patterns in BMI, alongside the prevalence of type 2 diabetes mellitus (T2DM) and hypertension (HTA), serve as valuable indicators for tracking nutritional status trends across different age groups, sexes, and SES. These insights provide a deeper understanding of the landscape of the overweight-obesity pandemic. This is particularly important within Argentina's socio-economic context, which has experienced progressive deterioration due to successive financial crises, seriously affecting food access and choices among the most vulnerable sectors [10]. The patterns observed in this country may reflect broader dynamics common to many low- and middle-income countries in the Global South, including the Asia-Pacific region.

While prior Argentine studies have described overall obesity prevalence and its socioeconomic distribution, little is known about how the age trajectory of BMI, specifically the timing and magnitude of peak BMI differs across sex, socioeconomic strata, and chronic disease status. Moreover, no study has examined whether these trajectories have shifted over time in a middle-income Latin American country undergoing rapid nutritional transition. This study addresses both gaps [6,11].

We hypothesized that the maximum BMI values reached across the lifespan would be higher and attained at younger ages in groups with lower socioeconomic status, in men compared with women, and in individuals with hypertension or type 2 diabetes relative to their healthier counterparts. Furthermore, we expected these disparities to widen across successive survey waves (2005–2018), reflecting an increasing burden of obesity concentrated in the most disadvantaged segments of the population.

Therefore, the aim of this study was to describe age-related BMI trajectories at national level, compare them according to sex, SES, and the presence of overweight/obesity-related chronic diseases, and examine changes in these patterns over time among Argentinian adults, (2005–2018, with complementary local data from the city of Córdoba up to 2022). Beyond describing nutritional status, this approach may offer additional insight into health disparities across population subgroups defined by socioeconomic conditions, sex, and chronic disease status.

Method

Study Design

Between 2005 and 2022, a sample of 126,590 people from Argentinean population-based studies using a repeated cross-sectional (RCS) design was analyzed. The principal data source was the National Risk Factors Survey (NRFS), which employed a multistage probabilistic sampling design. The NRFS is an Argentinean survey that collects information on NCD-related risk factors. The NRFS was conducted in 2005 (n = 37,205), 2009 (n = 31,912), 2013 (n = 29,674), and 2018 (n = 27,799) (12). This survey provides estimates, at the national level and for administrative divisions among adults of both sexes living in urban areas (localities with 5,000 or more inhabitants). The NRFS uses a stratified probabilistic sampling design, with four selection stages: departments, areas, dwellings, and persons [12]. In the first stage, the sample selection was based on the Argentine Master Urban Sample of Dwellings. For the final sample of dwellings in the NRFS, a systematic selection of segments of five contiguous dwellings was applied. At the time of the survey, the interviewer selected one adult participant using a random algorithm. Individuals who could not respond to the survey themselves were excluded [13–16].

The initial sample was 194,046 dwellings, 21,663 (11.16%) were non-eligible dwellings, 23,475 (12,09%) were nonresponding dwellings and 11,115 (5.72%) participants did not meet the inclusion criteria. A total of 137,793 individuals were included, of which 11,203 (8.13%) were excluded due to data inconsistencies. Thus, 126,590 participants constituted the final analytical sample. The study flowchart is presented in Figure 1.

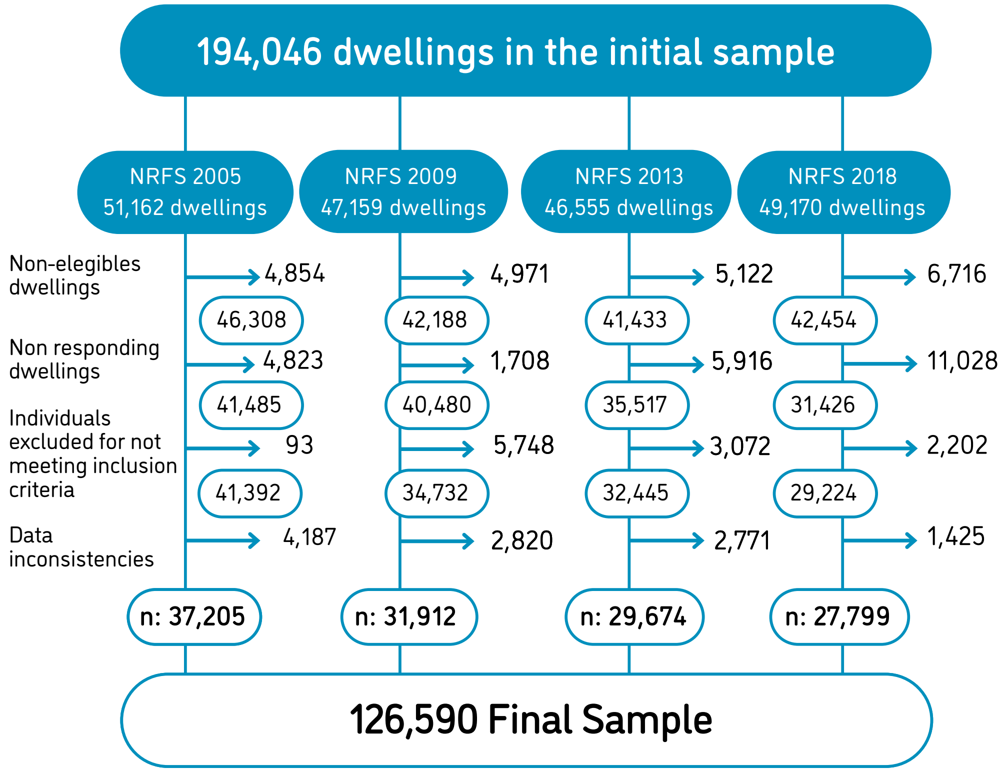

Figure 1. Flow chart of the NRFS subject selection.

Note. NRFS: National Risk Factors Surveys.

To compare national and local results, we included data from the CODIES studies. CODIES I (n = 4232) and II (n = 1447) included participants aged 18-85 years and were conducted in the city of Córdoba (Argentina) in 2005-2009 and 2020-2022, respectively. Details of these studies have been published elsewhere [10]. Briefly, they were probabilistic samples that followed a sampling scheme similar to that of the NRFS. The aim of this inclusion was not only to compare national and local results but also to compare self-reported and measured BMI. The results of these studies are shown in Supplementary Data.

Data Collection

The NFRS collected information through trained interviewers who conducted face-to-face surveys and collected two types of data: household and individual information. Both sections encompassed household characteristics and individual details, including employment status, health status, and non-communicable disease risk factors.

Measurements

BMI was calculated using self-reported weight and height. Additionally, in the 2018 NRFS, height and weight were measured in a sub-sample for validation purposes. Participants with BMI below the first percentile or above the 99th percentile were excluded to minimize the influence of extreme values. For descriptive prevalence analyses, nutritional status was categorized according to the World Health Organization (WHO) criteria [17].

Age, sex, obesity-related chronic diseases (T2DM and HTA), and socioeconomic status (SES) were also included. SES was constructed using a composite indicator that combined income quintiles and occupation, following the methodology of the National Institute of Statistics and Census [12]. Income ranges were first linked to occupational activity and then grouped by type of occupation and educational level to derive social class categories. These were subsequently stratified into three levels: low, medium, and high.

Statistical Analyses

In this study, only information on BMI, age (analyzed as both a continuous and a categorical variable), sex, T2DM, HTA, educational level, and SES was considered. General characteristics of the population were described using means (±SD) for continuous variables and frequencies (%) for categorical variables, and group differences were assessed using ANOVA or the chi-square test, as appropriate. For descriptive purposes, age was categorized as young (<31 years), adults (31–60 years), and older adults (>60 years); educational level, SES (low, middle, and high), and BMI were categorized according to WHO criteria. To evaluate the validity of self-reported BMI in the NRFS, BMI estimates based on self-reported height and weight were compared with BMI values obtained from CODIES and from an NRFS subsample (2018 edition) with directly measured anthropometric data. Mean BMI differences were assessed using a t-test.

We described BMI trends using a three-age moving median to smooth age-related BMI variations. To examine BMI trends across the lifespan, BMI scatterplots by age were created. Subsequently, quadratic polynomial curves were fitted to obtain, both overall and stratified by sex and SES, the age at which BMI reached its maximum value. Quadratic models were fitted using least-squares regression. The second-degree polynomial specification was selected because smoothed BMI-age trajectories consistently exhibited a concave pattern across survey waves and subgroups, and the model provided an adequate and parsimonious approximation of the observed trends.

This value was called maximum BMI (maxBMI). We considered the age range from 18 to 85 years old to reduce variability. Further details regarding the step-by-step function analytical procedures and computational procedures are provided in the Supplementary Methods file. Results were displayed in tables and graphs by using Python 3.11.4 (Python Software Foundation) and Stata 17 (StataCorp, 4905 Lakeway Drive, College Station, Texas 77845 USA).

Ethical statement

All procedures adhered to ethical standards, with approval from the institutional research committee (Hospital Nacional de Clínicas, Universidad Nacional de Córdoba; PV-2020-0077606-UNC-SCT#FCM) and Ethical Committee approval for the CODIES II Study (REPIS no. 4060, August 8th, 2020), following the 1964 Helsinki declaration and its amendments [18]. All participants signed a written informed consent.

Results

A total of 126,590 individuals were included in the analysis from 2005 to 2018. About 45% of participants were men, except in the 2009 edition, when 66% were men. A higher proportion of participants were aged between 30 and 60 years old. A similar demographic distribution was observed across editions (Table 1). Most participants possessed an intermediate level of education. The proportion of lower levels of education decreased by nearly 8% between 2005 and 2018 (Table 1).

Table 1. Main bio-social and health characteristics of the studied populations. NRFS (2005, 2009, 2013, 2018).

	NRFS 2005	**NRFS 2009**	**NRFS 2013**	**NRFS 2018**
	n = 37,205	n = 31,912	n = 29,674	n = 27,799
Gender n (%)				
Men	16,745 (45.0)	21,070 (66.0)	13,405 (45.2)	12,158 (43.7)
Women	20,460 (55.0)	10,842 (34.0)	16,269 (54.8)	15,641 (56.3)
Age mean (SD)	43.6 (17.3)	50.0 (16.2)	44.5 (17.6)	46.4 (18.0)
Age categories n (%)				
Young (18-30)	9,499 (25.5)	3,386 (10.6)	7,035 (23.7)	5,799 (20.9)
Adults (31-60)	20,137 (54.1)	19,254 (60.3)	15,895 (53.6)	14,638 (52.7)
Older (>60)	7,569 (20.3)	9,272 (29.1)	6,744 (22.7)	7,362 (26.5)
Educational level n (%)				
Low	13,073 (35.1)	10,814 (33.9)	9,151 (30.8)	7,566 (27.2)
Medium	13,836 (37.2)	12,514 (39.2)	12,124 (40.9)	11,537 (41.5)
High	10,296 (27.7)	8,584 (26.9)	8,399 (28.3)	8,696 (31.3)
Socioeconomic status n (%)				
Low	16,243 (47.2)	14,150 (48.0)	7,525 (25.4)	12,078 (43.5)
Medium	12,936 (37.6)	11,293 (38.3)	14, 732 (49.6)	10,186 (36.6)
High	5,239 (15.2)	4,047 (13.7)	7,417 (25.0)	5,535 (19.9)
BMI mean (SD)*	25.6 (4.3)	26.1 (4.4)	26.5 (4.5)	27.4 (4.9)
Nutritional status n (%) **				
Underweight and Normal	18,250 (49.0)	14,322 (44.9)	12,167 (41.0)	9,670 (34.8)
Overweight	13,171 (35.4)	11, 781 (36.9)	11,336 (38.2)	10,333 (37.2)
Obesity	5,784 (15.6)	5,809 (18.2)	6,171 (20.8)	7,796 (28.0)
Type II DM n (%) **				
Yes	3,252 (8.8)	3,303 (10.4)	3,034 (10.3)	3,662 (13.2)
No	33,802 (91.2)	28,609 (89.6)	26,525 (89.7)	24,015 (86.8)
HTA n (%)**				
Yes	12, 026 (32.3)	10,192 (35.6)	9,272 (35.3)	9,582 (37.3)
No	25,179 (67.7)	18,452 (64.4)	17,022 (64.7)	16,123 (62.7)

Note. *NRFS. National Risk Factors Survey; BMI: Body mass index (kg/m^2). Type II DM: Type II Diabetes Mellitus; HTA: Arterial Hypertension; SD: Standard Deviation.* * p<0,001 (ANOVA test) across service ** p<0,001 (Chi Square test) across service

Before conducting the trend analyses, supplementary tests were performed to evaluate the validity of self-reported BMI. No significant differences were observed between BMI estimates derived from self-reported data in the NRFS and those obtained from CODIES ($p=0.2968$) or from the NRFS subsample with directly measured anthropometric data ($p=0.8569$), supporting the reliability of the self-reported BMI estimates.

In the 2005 NRFS edition, the obesity prevalence was 15.6%, and rose steadily across subsequent editions to reach 28.0% in 2018 ($p<0.001$). This aligns with the overall trend in BMI across the NRFS surveys, which increased from mean of 25.6 (±4.6) in 2005 to 27.4 (±4.9) in 2018 ($p<0.001$) (Table 1). The prevalence of T2DM and HTA increased from the first to the last edition from 8.8% to 13.2% ($p<0.001$) and from 32.3% in 2005 to 37.3% in the most recent edition, respectively.

Results for BMI-age trends by survey edition are graphically displayed in Figure 2. The maxBMI rose slightly through the NRFS editions, and was observed between 58.9 and 62.8 years old (Figure 2).

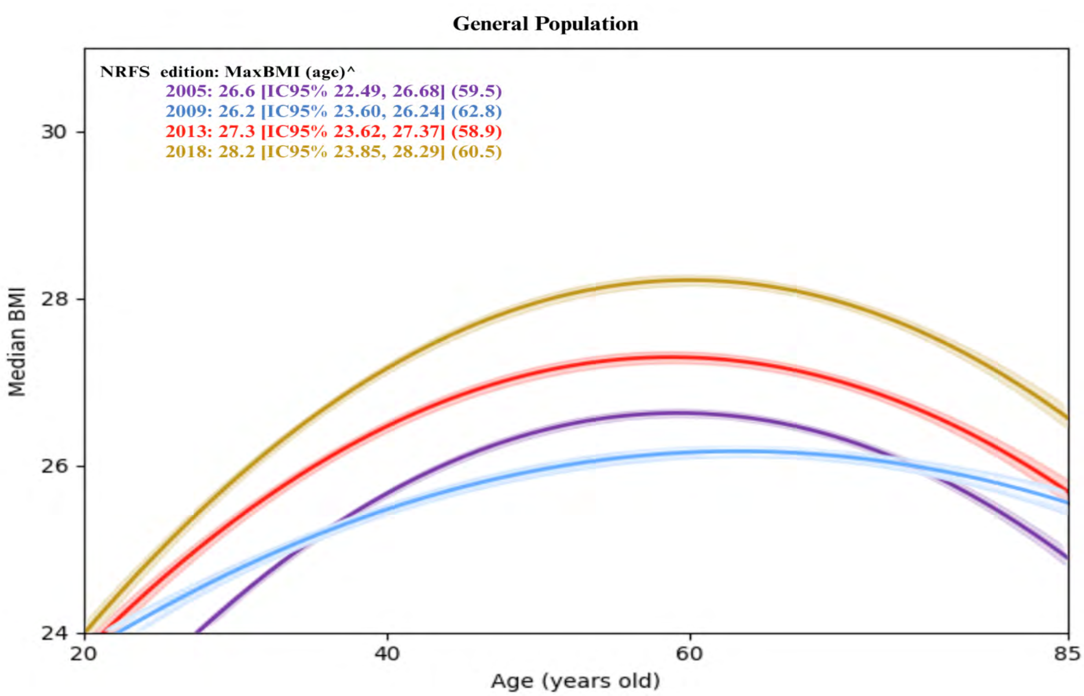

Figure 2. Age-related Body Mass Index trends by age across NRFS editions (2005–2018), Córdoba, Argentina.

Note. Quadratic polynomial fits are displayed with 95% confidence bands. *Numbers show the maximum median BMI (value) and the age (years) at which it is reached, formatted as maxBMI (age). NRFS = National Risk Factors Survey (ENFR).

Trends in BMI by age according to sex showed that in men, the maxBMI ranged from 26.4 to 28.5 kg/m^2 reached between 56.0 and 60.6 years of age, while in women, the maxBMI ranged from 25.9 to 28.0, reaching between 64.0 and 70.7 years (Figure 3).

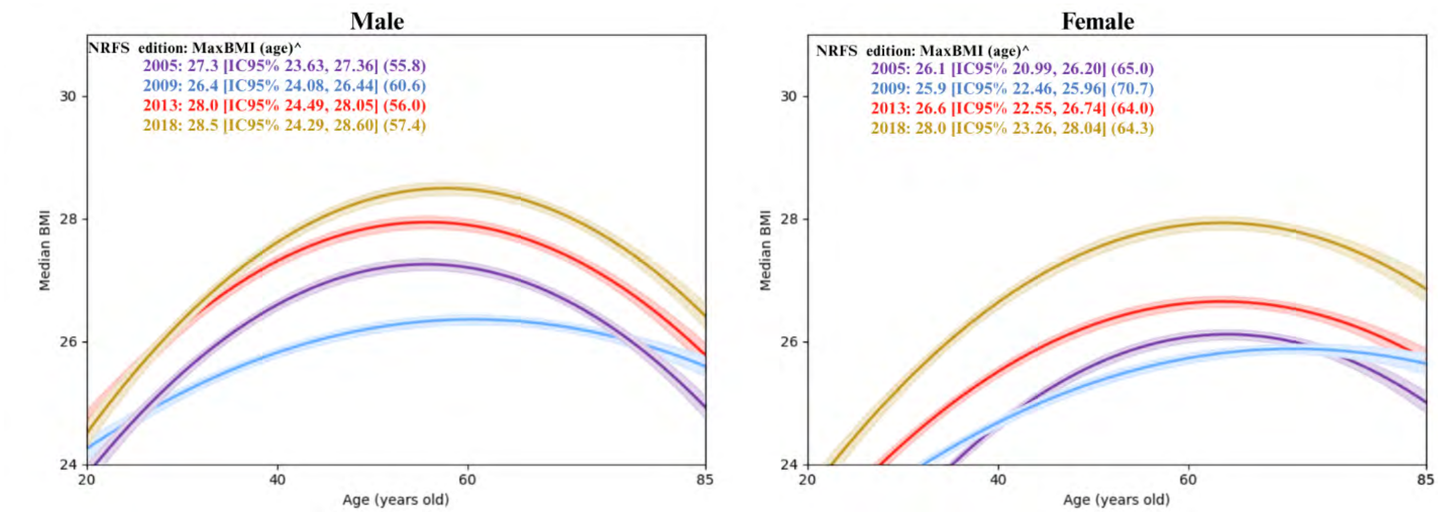

Figure 3. Age-related Body Mass Index trends by age and sex across NRFS editions (2005–2018), Córdoba, Argentina.

Note. Quadratic polynomial fits are displayed with 95% confidence bands. *Numbers show the maximum median BMI (value) and the age (years) at which it is reached, formatted as maxBMI (age). NRFS = National Risk Factors Survey (ENFR).

Participants in the low-SES group exhibited a maxBMI ranging from 26.3 to 28.5 kg/m^2, reaching between 57.8 to 61.0 years old. It was observed that higher maxBMI values were associated with more recent survey editions. Furthermore, the age at which the maximum was reached was clearly lower across editions (Figure 4).

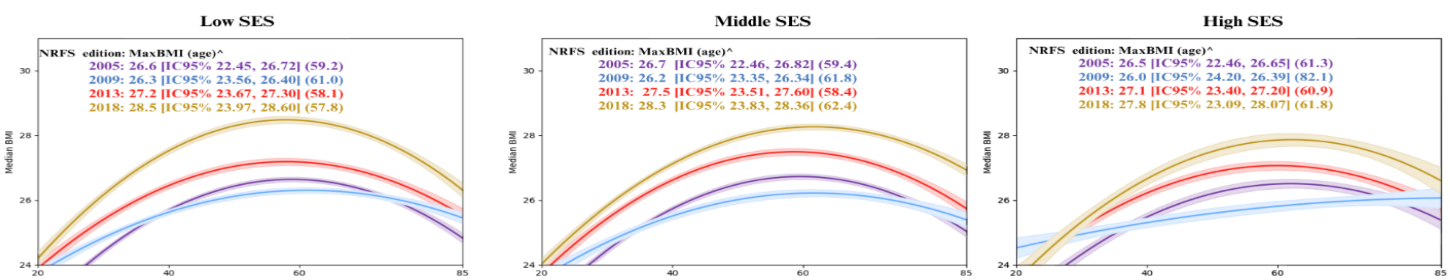

Figure 4. Age-related BMI trends by age and SES across NRFS editions (2005–2018), Córdoba, Argentina.

Note. Quadratic polynomial fits are displayed with 95% confidence bands. *Numbers show the maximum median BMI (value) and the age (years) at which it is reached, formatted as maxBMI (age); SES: Socioeconomic Status; NRFS: National Risk Factors Survey (ENFR).

The maxBMI curves in middle SES showed a consistent and gradual increase over the years, reaching values of approximately 26.2 (95% CI: 23.35-26.34) and 28.3 kg/m² (95% CI: 23.83-28.36) in the initial and final editions, respectively. In high SES groups, the maxBMI were from 26.0 in 2009 (95% CI: 24.20-26.39) to 27.8 kg/m² in 2018 (95% CI: 23.09-28.07), and they were reached at older ages (60.9 to 82.1 years) (Figure 4).

When BMI was analysed by sex and SES, in the low and middle SES categories, the same trends previously observed were evident. Among those in the highest SES category, men had a higher maxBMI than women, and the maximum was also reached at older ages in women than in men (Figure 5).

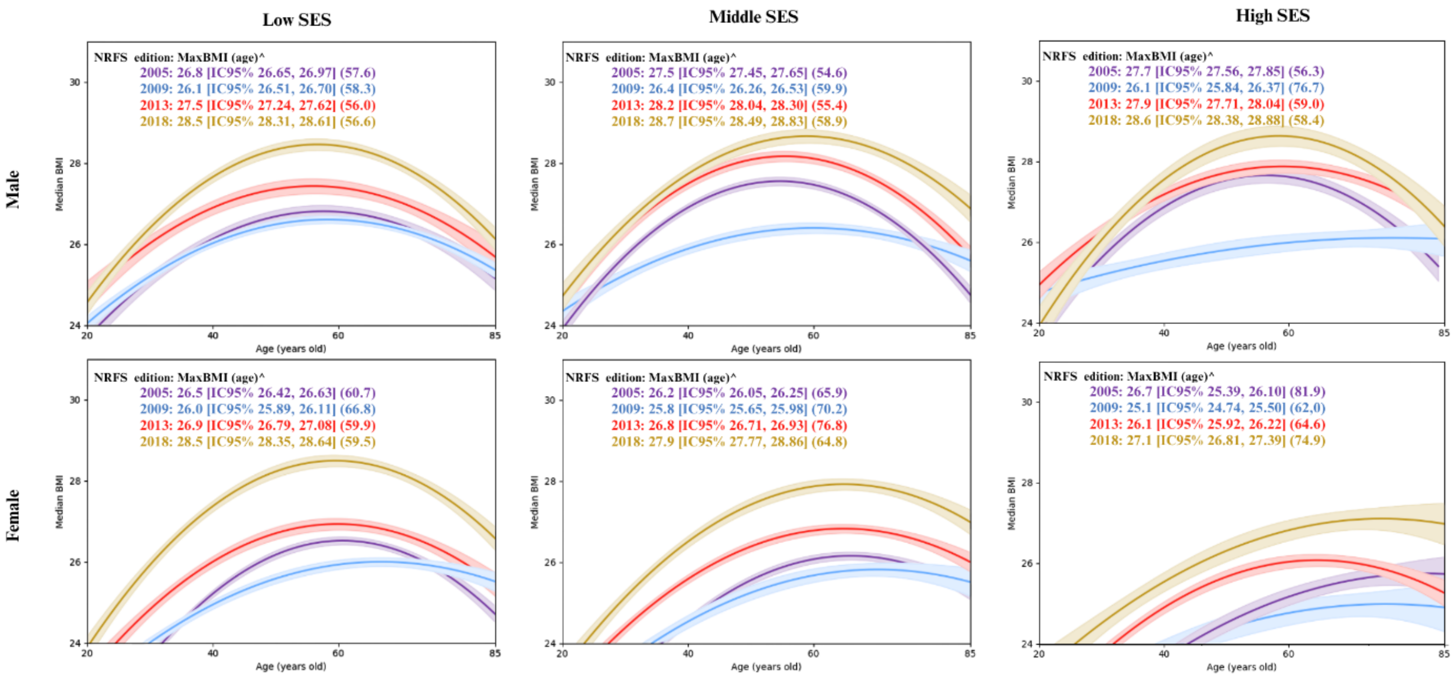

Figure 5. Age-related BMI trends by age, sex and SES across NRFS editions (2005–2018), Córdoba, Argentina.

Note. Left panel: men; right panel: women. Quadratic polynomial fits are displayed with 95% confidence bands. *Numbers show the maximum median BMI (value) and the age (years) at which it is reached, formatted as maxBMI (age); SES: Socioeconomic Status; NRFS: National Risk Factors Survey (ENFR).

Subsequently, we examined the association between BMI and chronic conditions. The shape of the BMI trends by age was similar between participants with and without HTA. However, participants with HTA exhibited a higher maxBMI, ranging from 27.5 kg/m² (95% CI: 27.47–27.65) to 29.5 kg/m² (95% CI: 29.37–29.59), compared with participants without HTA, whose maxBMI ranged from 25.4 kg/m² (95% CI: 25.36–25.51) to 27.3 kg/m² (95% CI: 27.25–27.41). In addition, the peak BMI occurred at younger ages among participants with HTA (54.1–55.6 years) than among those without HTA (57.9–64.3 years) (Figure 6 and Supplementary Data: Table D1, D2, E1, E2).

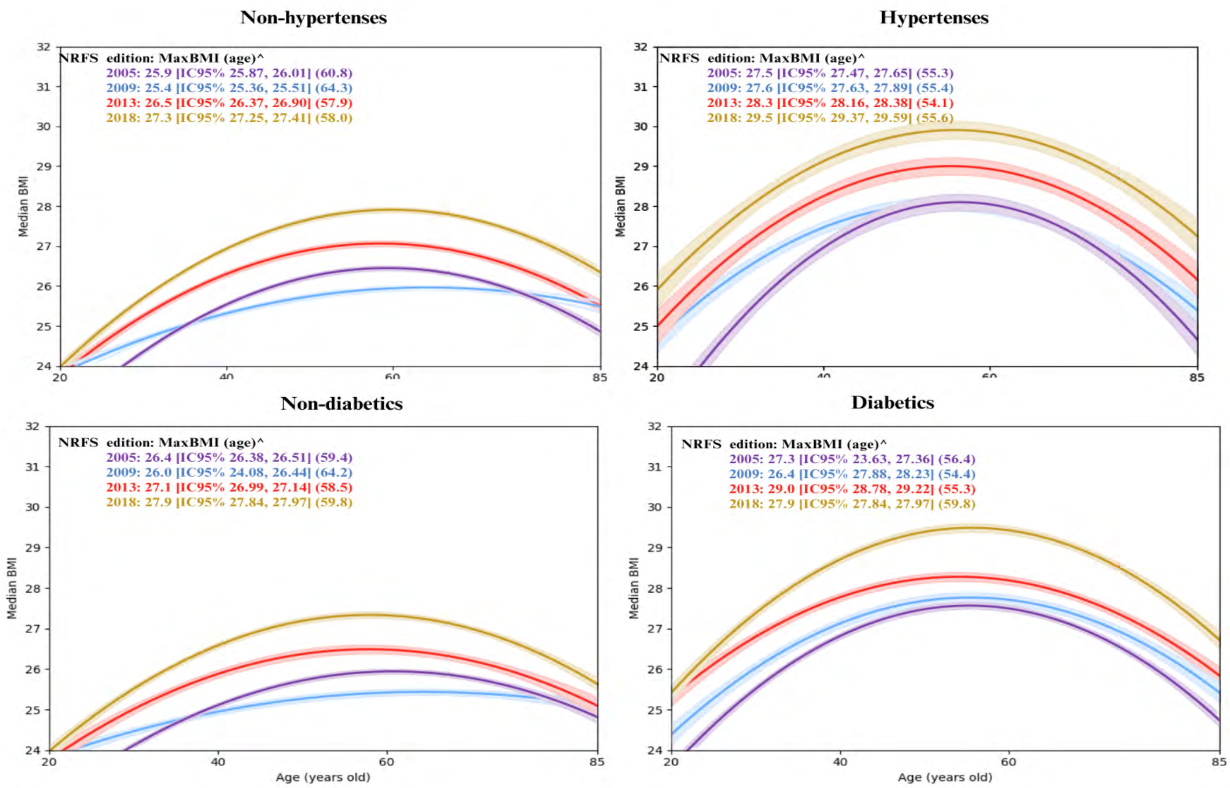

Figure 6. Age-related Body Mass Index trends by Study according to T2DM and hypertension prevalence, Córdoba, Argentina.

Note. Quadratic polynomial fits are displayed with 95% confidence bands. *Numbers show the maximum median BMI (value) and the age (years) at which it is reached, formatted as maxBMI (age). NRFS = National Risk Factors Survey (ENFR).

A similar pattern was observed in T2DM. The magnitude of maxBMI was higher in T2DM participants in all studies, reaching from 26.4 (95% CI: 23.26-27.36) to 29.0 (95% CI: 28.78-29.22) in T2DM, vs. 26.0 (95% CI: 24.08-26.44) to 27.9 (95% CI: 27.84-27.97) in non-T2DM. Furthermore, maxBMI was reached at younger ages among participants with T2DM (54.4–59.9 years) than among those without T2DM (58.5–64.2 years) (Figure 6).

The results obtained at the local level (CODIES I and II) showed similar temporal patterns to those obtained at the national level, either in general or stratified by sex, SES, and chronic conditions (See Supplementary Data, Figures G-I). Additional technical details about NFRS and CODIES can be found in the Supplementary Data.

Discussion

This study examined age-specific BMI trajectories among over 126,590 adults in Argentina using four population-based studies at different time points spanning 13 years. Across all survey waves, more than half of the participants were classified as having overweight or obesity. Our results showed Across all survey waves, more than half of the participants were classified as having overweight or obesity. Overall, the maxBMI was around 27 kg/m^2 and occurred between 58 and 62 years of age, even though women reached the maxBMI at higher ages than men. In high SES groups, the maxBMI was attained later in life and differed in magnitude compared with lower-SES groups across all survey waves. In addition, individuals with T2DM and HTA reached higher maxBMI values at earlier ages.

Regarding sex differences, this study showed two noteworthy findings: women reached a lower maxBMI and at later ages than men. This pattern may partly reflect sex-related differences in social, behavioral, and biological factors across adulthood. The higher and earlier peak BMI observed among men may be related to differences in health-related behaviors, including dietary patterns, alcohol consumption, lower engagement with preventive health care, and occupational or leisure-time physical activity patterns, which have been described as gendered health behaviors in previous literature [19,20]. However, these factors may not apply equally across all social groups. Research on gender and social conditions, based on the cumulative advantage/disadvantage framework, has shown that lower-SES women are significantly more likely to experience weight gain over the life course compared to higher-SES women and men [11]. Consistent with this evidence, in our study, women of low SES reached their maximum BMI at earlier ages than those of higher SES.

Several studies have documented a marked increase in overweight and obesity prevalence in low- and middle-income countries, conditions that were once considered characteristic of more economically developed societies [21]. Moreover, even in many of the poorest nations, obesity prevalence is high, with overweight/underweight ratios exceeding >1 [6]. The complex relationships between economic status and health throughout the ageing process have been extensively documented [22]. In this study, low SES individuals showed a higher maxBMI than their middle and high SES counterparts, and reached it at an earlier age, as previously highlighted [23]. This finding is consistent with previous evidence from Latin America and other low- and middle-income countries showing that the burden of obesity is increasingly concentrated among socioeconomically disadvantaged groups, although the direction and magnitude of this association may vary by sex, educational level, and stage of nutritional transition [24,25]. Several factors contribute to this situation, including limited access to nutritious food due to its high cost, and fewer opportunities for physical activity, such as lack of leisure time and insufficient safe spaces, in addition to the stress associated with job and economic insecurity from an early age [22]. Earlier exposure to elevated BMI may result in a longer cumulative burden of overweight and obesity and their associated health consequences [26].

The social determinants of health are those conditions in which "people are born, grow, work, live, and age, and the set of forces and systems shaping the conditions of daily life" [27]. Several theoretical frameworks, including fundamental cause theory, health lifestyle theory, and cultural capital theory, have been proposed to explain how socioeconomic inequalities influence health outcomes [27]. According to these perspectives, differences in SES and lifestyles have a significant influence on weight gain. However, social determinants cannot fully explain the multifactorial etiology of obesity, although they are key variables acting independently or together with biological causes [28,29]. Recently, biomarkers have been used in sociological studies of weight gain, as social variables are used in gene–environment studies, to provide more thorough assessments of the causes of obesity [26,30].

In addition to the effect of poverty on obesity development, there is a widely recognised negative impact of high BMI on both physical and mental health. There is evidence that obesity is associated with impaired social functioning and reduced health-related quality of life [5]. Consequently, this can lead to limitations on family economic development as well as negative public health implications. The multidimensional nature of poverty is explicitly recognized in the United Nations 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs) [8,31]. Therefore, incorporating this approach into research on population health is consistent with worldwide strategic directives [7,30].

According to scientific literature, individuals with low socio-economic status face an increased probability of developing obesity and other diseases and consequently have a worse prognosis as they are less likely to comply effectively with treatment [3,23]. Measuring BMI trends by age, considering different SES, provides insight into the potential impact on their health in terms of the risk of developing NCDs [22]. From a public health perspective, this life-course approach may help identify critical periods for intervention and support the design of targeted, multidimensional prevention strategies.

Age-related increase in BMI poses a risk for several chronic conditions. Since total body fat, reflected by waist or BMI, increases with age, it is sometimes difficult to separate the consequences of ageing from those of weight gain. Factors which contribute to increased body fat, commonly also contribute directly or independently to conditions caused or aggravated by obesity, such as diabetes and other NCDs. In fact, in our study, individuals with the highest maxBMI values, reached at younger ages, were part of the groups with the poorest health status (diabetes and/or hypertension). In individuals with overweight and obesity, inflammation—normally the body's response to tissue injury—becomes chronic. And over time, inflammatory processes contribute to vascular damage, triggering other severe chronic diseases and metabolic conditions [32]. These pose a serious threat to the health and well-being of the population, especially the most disadvantaged.

There is overwhelming, consistent evidence that higher BMI values, particularly those over 30, are strongly associated with the risk of developing chronic diseases such as T2DM and HTA [33]. Obesity increases the impact of genetic susceptibility and environmental factors on DM as they share features in their pathogenesis [34]. The expansion of adipose tissue and excessive accumulation of certain nutrients and metabolites disrupt the metabolic balance via insulin resistance, dysfunctional autophagy, and microbiome-gut-brain axis [34]. The accumulation of "visceral" adipose tissue, which accompanies the aging process, leads to several cardio-metabolic consequences: from increased blood pressure to overt HTA, from insulin-resistance to overt T2DM, dyslipidemia, chronic kidney disease, and obstructive sleep apnea [35]. Then, more attention should be paid to the prevention of obesity, given that weight loss improves risk factors for cardiometabolic disease and quality of life [36].

Some methodological issues need to be considered. The repeated cross-sectional (RCS) design allowed to include new participants at each survey wave rather than following the same individuals over time, and was useful in terms of economy and feasibility. Furthermore, if sufficient new participants were included, this could compensate for the loss of statistical power when using an RCS design [37]. However, this RCS design allowed us only to describe BMI temporal trends according to sex, SES and age, but not to establish any causal relationship, as other analytical designs are needed. In addition, in the NRFS studies, BMI was calculated using self-reported weight and height. This could have introduced a misclassification bias among the participants, as research shows that individuals often give socially desirable responses [26]. Therefore, we compared self-reported BMI estimates from the NRFS with BMI values obtained from measured anthropometric data in both CODIES and a measured NRFS subsample. No significant differences were observed between sources, supporting the reliability of the self-reported BMI data and suggesting minimal, if any, non-differential bias.

On the other hand, the sizable sample size stands as one of the strengths of this research, enabling reliable and precise statistical analyses. Moreover, the sampling and data collection methodologies employed in each edition of the surveys ensured the representativeness of the study populations.

The shape of BMI trajectories across age is complex, and relying solely on a quadratic function may impose a simplified functional form. However, more flexible modelling approaches, such as LOWESS and GAMLSS, yielded results consistent with those obtained using the quadratic specification. Therefore, the quadratic function was retained because of its parsimony, interpretability, reproducibility, and its ability to identify an epidemiologically meaningful peak, corresponding to the age at which median BMI reaches its maximum value. Multivariable modelling was not performed because the objective of this study was not to estimate independent associations or causal effects, but rather to describe age-related BMI trajectories at the national level, compare them according to sex, SES, and the presence of overweight/obesity-related chronic diseases, and examine changes in these patterns over time among adults aged 18–85 years in Argentina. Although a classic sensitivity analysis based on alternative causal scenarios did not apply to this descriptive design, the consistency of the findings with previous literature [11,38] and prior analyses using the same data sources [10,12] supports the robustness and reliability of the observed patterns.

BMI is a proxy indicator of adiposity rather than a direct measure of body fat, and its correlation with total fat varies by age, sex and race/ethnicity. Alternative measures—such as waist circumference or direct body-composition assessment by DEXA—provide more specific information on fat distribution and adiposity but are rarely available in large, population-based surveys. Despite its limitations, BMI remains valuable for population surveillance because it is standardized, simple to measure, and correlates with cardiometabolic risk at the population level. For example, recent evidence found that obesity prevalence defined by BMI was broadly similar to prevalence confirmed by direct adiposity measures in comparable samples [39]. Therefore, in this study, we interpret BMI as a population-level indicator of weight status, not as a diagnostic measure of excess adiposity at the individual level. Finally, future studies could complement BMI-based analyses with additional anthropometric and nutritional status indicators, including waist circumference, waist-to-height ratio, body fat percentage, and, when available, metabolic biomarkers. These measures would allow a more complete characterization of adiposity, fat distribution, and cardiometabolic risk than BMI alone.

Conclusions

In conclusion, this repeated cross-sectional study of approximately 126,590 adults in Argentina showed that median BMI followed a non-linear age-related pattern, reaching a maximum value of approximately 27 kg/m^2 between 58 and 62 years of age. The age and magnitude of maxBMI differed across population groups. Women reached a lower maxBMI and at later ages than men, whereas individuals with low SES reached maxBMI earlier and at a different magnitude than those with higher SES. Participants with hypertension and type 2 diabetes also showed distinct BMI-age patterns, suggesting that maxBMI may provide a useful population-level indicator for characterizing differences in BMI trajectories across cardiometabolic risk groups.

These findings highlight relevant inequalities in BMI-age patterns according to sex, socioeconomic status, and the presence of obesity-related chronic diseases. Rather than indicating causal relationships, the observed earlier attainment of higher BMI levels in socially disadvantaged groups may reflect differential exposure to obesogenic conditions across adulthood.

Therefore, these results support the importance of considering age, sex, and socioeconomic context when designing population-level strategies for obesity and chronic disease prevention.

These findings should be interpreted in light of the inherent limitations of repeated cross-sectional designs and the use of self-reported anthropometric data. Future longitudinal and analytical studies incorporating measured anthropometry and additional indicators of nutritional status are needed to better understand the pathways linking socioeconomic disadvantage, BMI trajectories, and cardiometabolic outcomes.

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