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Nutritional status in school-age children in Veracruz

Estado de nutrición en niños de edad escolar de Veracruz

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ABSTRACT

Child malnutrition is a silent pandemic that undermines the growth and development of children aged between 5 and 19. Nearly 160 million of these children are affected by obesity, which increases the risk of developing respiratory and cardiovascular diseases, type 2 diabetes, and even disability. Mexico ranks first worldwide in childhood obesity; however, few studies focus on early diagnosis within this population. Therefore, this study evaluated nutritional status using the body mass index-for-age anthropometric indicator, through a quantitative, exploratory, and cross-sectional study involving 315 children aged 6 to 13 years enrolled in an urban primary school in Banderilla, Veracruz. Results showed that 18 % of the students were overweight, while 24 % were classified as obese. The prevalence of overweight was higher among girls (57.1 %), whereas obesity was more frequent among boys (55.8 %). Combined, the prevalence of overweight and obesity reached an alarming 42 %, surpassing the 2022 national estimates for Mexico, and indicating a heightened risk of health complications in the school-aged population.

KEY WORDS: Malnutrition, Overweight, Obesity, Childhood obesity, Schoolchildren.

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A B S T R A C T

La malnutrición infantil es una pandemia silenciosa que vulnera el crecimiento y desarrollo de niñas/os de entre 5 a 19 años. Cerca de 160 millones de estos presentan obesidad, lo que incrementa su riesgo de padecer enfermedades respiratorias, cardiovasculares, diabetes tipo 2 e incluso discapacidad. México ocupa el primer lugar mundial en obesidad infantil; sin embargo, son pocos los estudios que se realizan para el diagnóstico temprano en esta población. Por ello, esta investigación evaluó el estado nutricional a través del indicador antropométrico índice de masa corporal para la edad, mediante un estudio cuantitativo, exploratorio y transversal aplicado a 315 niñas y niños de entre 6 a 13 años pertenecientes a una escuela primaria urbana en Banderilla, Veracruz. Los resultados revelaron que el 18 % de los escolares presentaron sobrepeso, mientras que el 24 % fueron clasificados como obesos. La prevalencia del sobrepeso fue mayor en el sexo femenino (57,1 %), mientras que la obesidad predominó en el sexo masculino (55,8 %). En conjunto, las prevalencias de sobrepeso y obesidad alcanzaron un alarmante 42 %, superando las estimaciones para México en 2022, lo que supone un riesgo mayor en los escolares de padecer complicaciones de salud.

K E Y W O R D S : Malnutrición, Sobrepeso, Obesidad, Obesidad infantil, Escolares.

Introduction

Malnutrition is a state of deviation from optimal nutrition, occurring when the body does not receive the appropriate amount of nutrients necessary for proper function. This condition is associated both with insufficient food intake and with the excessive consumption of nutritionally poor foods, leading to adverse health outcomes. Malnutrition is not limited to undernutrition, where weight is inadequate for height due to nutrient deficiencies, but also includes excess weight, resulting in overweight and obesity, contributing to a complex global nutritional reality (Jiménez *et al.,* 2021).

Although society has promoted a favorable decline in the prevalence of undernutrition, it remains essential to address this nutritional spectrum, as individuals with low weight/height and/or low body mass index for age are at risk of nutritional deficiencies. These deficiencies can lead to pathological conditions of varying severity and metabolic stress, which over time may irreversibly impair both physical and mental development (Rivera *et al.,* 2024).

This nutritional disorder arises from two principal causes. Exogenous causes are linked to limited access to food, while endogenous ones result from macro- and micronutrient deficiencies

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due to inadequate food intake or impairments in nutrient absorption and metabolism (Martínez & Cortés, 2023).

In recent decades, concern has grown over overweight and obesity, as they are chronic diseases characterized by abnormal or excessive accumulation of body fat. These conditions arise from an imbalance between energy intake, caloric expenditure, and lifestyle habits, and have become a global public health threat (Pérez & Cruz, 2019; UNICEF, 2024).

The child population is a particularly vulnerable group. Global malnutrition trends threaten the survival, growth, and development of this demographic, as both undernutrition and obesity are not only consequences but also causes of poverty and social deprivation. Most of the children suffering from visible forms of malnutrition, such as wasting and undernutrition, are found in Africa and Asia; however, nearly all countries are affected by one or more forms of malnutrition (UNICEF, 2019).

The figures for overweight (OW) and obesity (OB) are particularly alarming at the global level. Studies conducted in 2022 revealed that 390 million children and adolescents aged 5 to 19 exhibit overweight, with 160 million of them living with obesity. In addition, another 190 million children had a body mass index (BMI) more than two standard deviations above the mean, indicating significantly higher weight for their age, sex, and height (WHO, 2024 [b]).

These figures imply serious and lasting consequences for families, communities, and nations, which must contend with the economic burden of treating obesity-related conditions, such as respiratory and cardiovascular diseases, insulin resistance, type 2 diabetes, and disability, projected to cost around $4 trillion by 2035. This amount would represent approximately 3 % of the global gross domestic product (WOF, 2024). Furthermore, each year more than 20 % of healthy life years are lost due to these preventable chronic diseases, further straining public health systems (Calderon *et al.,* 2023).

According to Pardos *et al.* (2021), multiple factors are associated with OW and OB in school-aged children. Among these, unhealthy eating behaviors and sedentary lifestyles stand out, interacting with individuals' genetic traits to increase the prevalence of these conditions in many countries. However, the most significant rise in cases over the last decade has been observed in developing nations (Calderón *et al.,* 2023).

According to WHO, the global ranking for obesity in children aged 5 to 19 is led by Chile (27.5 %), followed by the United States (20.6 %), Egypt (20.4 %), Argentina (20.3 %), Saudi Arabia (18.1 %), Mexico (17.7 %), Australia (15.8 %), and China (11.9 %). These are countries where public health promotion and prevention strategies have not been entirely effective in curbing the rise in cases, despite coordinated efforts (WHO, 2024[a]). Furthermore, WOF (2024) warns that without significant public policy interventions, the combined prevalence of overweight and obesity will continue to rise between 2025 and 2035, potentially affecting over one million children and adolescents during that period (Figure 1).

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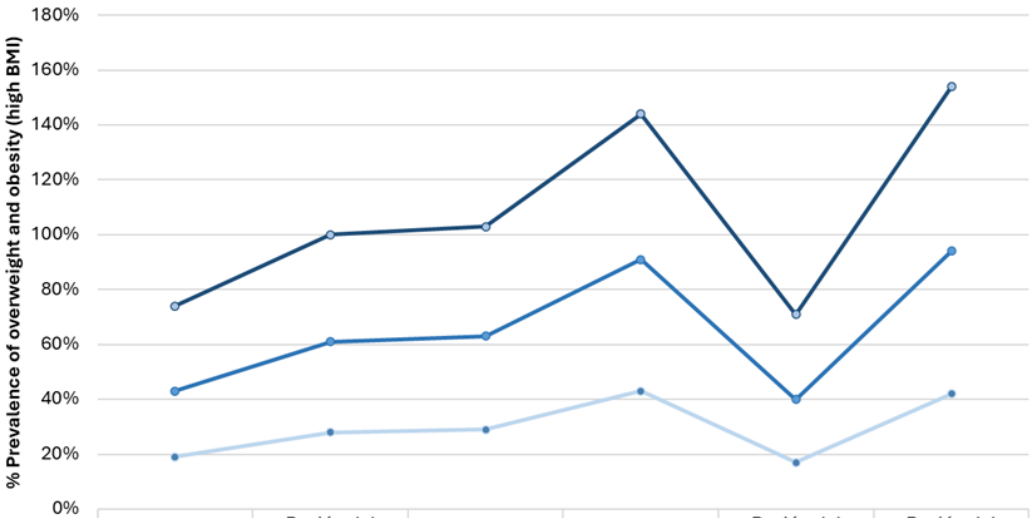
In the Latin America and Caribbean (LAC) region, overweight is a widespread issue affecting nearly every country. Moreover, the number of children impacted continues to rise steadily. In Mexico, the current prevalence of overweight exceeds the global average of 6.2 %, reaching up to 7.5 %. This means that three out of every ten children and adolescents are overweight (UNICEF, 2022).

The outlook for malnutrition is also not encouraging. It is estimated that this condition affects 45 % of children worldwide, contributing to the deaths of 8,500 children daily (Jiménez *et al.,* 2021). Despite concerted efforts, undernutrition has yet to be eradicated in the LAC region. Growth stunting affects approximately 11.5 % of children, an estimated 5.7 million cases (Rivera *et al.,* 2024).

According to UNICEF (2022), the figures for OW remain troubling, even as strategies aligned with the 2030 Agenda for Sustainable Development aim to end all forms of malnutrition. At least eight countries in the region report overweight prevalence above 30 % among children and adolescents aged 5 to 19: Argentina (36.4 %), Chile (35.5 %), Mexico (35.5 %), Venezuela (34 %), Uruguay (33.5 %), Dominica (32.6 %), Costa Rica (31.7 %), and El Salvador (30.7 %).



	Región de África (AFRO)	Región del Mediterráneo Oriental (EMRO)	Región de Europa (EURO)	Región de las Américas (OPS)	Región del Sudeste Asiático (SEARO)	Región del Pacífico Occidental (WPRO)
2035	31%	39%	40%	53%	31%	60%
2030	24%	33%	34%	48%	23%	52%
2025	19%	28%	29%	43%	17%	42%

Figure 1. Childhood overweight and obesity 2025-2035, WHO regions.

Source. Prepared by the authors based on WOF (2024).

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The WHO continues to classify Mexico as a predominantly malnourished country, with steadily increasing figures over the past 30 years. Currently, Mexico holds the alarming distinction of having the highest childhood obesity rate worldwide, with 25 % of children under 10 and 24.7 % of children under 9 suffering from obesity and overweight, respectively (García *et al.,* 2020; Shamah *et al.,* 2020[a]; Shamah *et al.,* 2022, Shamah *et al.,* 2023[a])

Addressing other forms of malnutrition, it is known that the prevalence of underweight is 3.9 %, as well as 13.9 % for short stature for age. In the case of wasting, which is the most severe and visible form of malnutrition, the prevalence is 1.2 % in the child population. International organizations are warning of the consequences, as one in eight children in Mexico is affected by chronic malnutrition in early childhood (Bonvecchico *et al.,* 2020; Rivera *et al.,* 2024).

According to Cuevas *et al.* (2023), Mexico is undergoing an epidemiological transition because access to healthy foods for this age group has not been fully resolved, coupled with the existence of environments and lifestyles that encourage this population to consume highly processed foods with low nutritional value. This creates the ideal conditions for the prevalence of poor child nutrition (Mendoza *et al.,* 2023; Shamah *et al.,* 2023[b]).

This trend is particularly concerning given that childhood OW and OB have been identified as predictors of severe metabolic complications in adulthood Vázquez & Cruz, (2024). These include premature death due to cardiovascular events, cancer, lipid metabolism disorders, hypertension with ventricular hypertrophy, insulin resistance, metabolic syndrome, fatty liver disease, type 2 diabetes, and even psychological disorders (García & Castell, 2023; Herrera & Lurbe, 2024; López *et al.,* 2022).

To address these alarming statistics, Mexico has implemented a variety of strategies, including intersectoral approaches involving key policy stakeholders. One of such measures is a tax policy, introduced in 2014, that led to a 7.4 % reduction in the purchase of unhealthy foods by imposing a 10 % tax on sugary and carbonated beverages and an 8 % tax on energy-dense foods such as snacks, confectionery, and chocolate, many of which are popular among children (Ríos *et al.,* 2022).

Another important measure was the implementation of front-of-package warning labels. This initiative required the food industry to inform consumers about the nutritional content of their products. These user-friendly labels help consumers in making informed decisions about foods high in critical nutrients such as sugar, sodium, and saturated fats, which are known to contribute to hypertension, hyperglycemia, OB, and OW (PAHO, 2020; SE, 2020).

Despite these interventions, the persistence of childhood OW and OB across the country underscores the need for cross-cutting approaches and greater intersectoral collaboration to address this public health crisis. Prevalence varies by region, with the highest rates in the North Pacific (33.4 %), followed by Mexico City (32.5 %), the Peninsula (32.1 %), Central Pacific (31.4 %), and South Pacific (30.2 %). Other regions, such as the State of Mexico (29.4 %), Central-

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North (29.1 %), and Central (27.3 %), also report elevated rates. The Northern Border region shows the lowest combined prevalence of OW + OB, at 25.7 % (Shamah *et al.,* 2022).

The 2021 Continuous National Health and Nutrition Survey (ENSANUT-México) assessed the nutritional status of the child population and found that 7.8 % of children under age 5 were OW or OB. Moreover, 87 % of these children regularly consumed sugary drinks, and 53 % consumed snacks. Among school-aged children (5–11 years), the figures were even higher: 92.9 % consumed sweetened beverages and 50 % consumed snacks (Shamah *et al.,* 2022).

Particularly, Veracruz state, located in the Peninsula region of Mexico, had approximately 1.361 million children and adolescents aged 5 to 14 as of 2020 (INEGI, 2024); In this state, overweight prevalence among schoolchildren was 18.4 % for girls and 17.7 % for boys, while obesity prevalence reached 15.0 % in girls and 20.1 % in boys (Shamah *et al.,* 2020[b]).

Diagnostic evaluation of nutritional status

The assessment of physical growth and development is a key component of pediatric primary health care, as it contributes to comprehensive child evaluation and enables the early detection of health conditions within specific population groups. This facilitates the development of preventive and timely care programs (Bastida et al., 2021).

Regular anthropometric measurements provide a non-invasive, low-cost diagnostic method for evaluating body composition, thus allowing for the identification of children at nutritional risk due to deficiencies or excesses. Furthermore, the standardized graphical representation of these results allows for comparison across various contexts (Aguirre *et al.,* 2021; Rosell *et al.,* 2023).

The three most important anthropometric measures are body weight-for-age, body length-for-age, and head circumference; height is a linear measurement reflecting lean body mass growth, while body weight is a global indicator of both lean and fat mass (Bastida *et al.,* 2021).

According to Aguirre et al. (2021), several indicators are available to assess nutritional status; however, the most commonly used ones are weight and height. The combination of these measures adds significant value, allowing for the calculation of weight-for-height or Body Mass Index (BMI).

BMI, in this context, serves as a reliable indicator for suitable correlations with body fat and health risk. It is a valuable tool for defining, classifying, and diagnosing underweight, overweight, and obesity in pediatric patients due to its accuracy and ability to identify excess fat. Moreover, BMI values can be compared to international reference standards, such as the WHO percentile/Z-score curves (Bauce, 2021; Moreno & Garrido, 2023).

In specific cases where anamnesis and anthropometric assessment suggest deviations from normal parameters, it is necessary to conduct complementary tests, such as complete blood

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counts, iron metabolism studies, or blood biochemistry, to identify health risks and potential growth delays (Martínez & Cortés, 2023).

Addressing the key factors of child malnutrition, including undernutrition, OW, and OB, should be a priority for any health system aiming to improve public health outcomes. In this context, it is crucial to design and implement cross-cutting, intersectoral strategies that increase the likelihood of achieving global objectives in the fight against these conditions.

Hence, the present study is highly valuable, as it allows for the collection of weight, height, and BMI data, with further comparison analysis including percentile (Z-score) curves, among the most effective methods for diagnosing deviations from optimal nutrition in schoolchildren aged 6 to 13 years. This approach facilitates early detection of nutritional alterations and supports the development of effective public policies for prevention and treatment at the regional level.

Material and Methods

A quantitative, exploratory, and cross-sectional study was conducted involving 315 schoolchildren aged 6 to 13 years enrolled in an urban primary school in Banderilla, Veracruz. The objective was to determine the nutritional status of this population by assessing the prevalence of severe undernutrition, moderate undernutrition, overweight, and obesity using BMI.

Data collected included age (in years and months), weight, measured with a scale accurate to ±100 g, and height, measured using a portable stadiometer with ±1 mm precision. Body Mass Index (BMI) was calculated using Quetelet's formula, and Z-scores were determined by age. The results were classified according to the criteria proposed by the WHO (2007 cited in FANTA, 2013) for children aged 5 to 18 years.

Table 1 shows BMI-for-age classification criteria by sex, which were used to determine the nutritional status of the study participants.

Table 1. Classification criteria for BMI-for-age, for Girls and Boys from 5 to 18 years

Age	Severe malnutrition	Moderate malnutrition	Normal	Overweight	Obesity
(years: months)	< –3 SD (BMI)	≥ –3 to < –2 SD (BMI)	≥ –2 to ≤ +1 SD (BMI)	> +1 to ≤ +2 SD (BMI)	> +2 SD (BMI)

Source: Food and Nutrition Technical Assistance (FANTA, 2013).

The obtained data were analyzed using descriptive statistics, including frequencies, percentages, and standard deviation, through the Statistical Package for the Social Sciences (SPSS), version 25 for Windows.

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Results

A total of 315 schoolchildren aged 6 to 13 years were evaluated, of whom 48.9 % were female and 51.1 % male. The average age was 8 ± 1.8 years (SD).

The diagnostic evaluation of nutritional status, performed using BMI adjusted for sex and age (Figure 2), revealed a combined prevalence of OW + OB of 42 % in the study population.

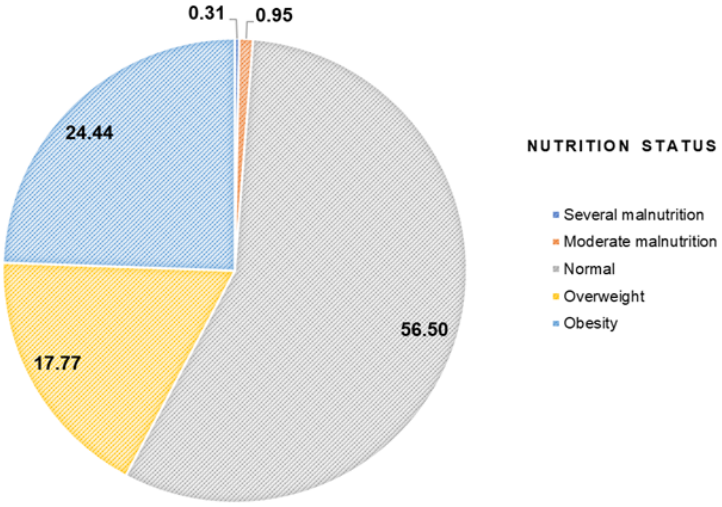

Figure 2. Diagnostic assessment of nutritional status through BMI by sex and age.

Source: Prepared by the authors in 2024.

Most students exhibit normal nutritional status (n = 178). Regarding malnutrition due to deficiency, four cases were recorded (1.2 %): one case of severe undernutrition in a girl and three cases of moderate undernutrition in boys. Obesity was more prevalent among boys (n = 43) compared to girls (n = 34), whereas overweight was slightly more frequent among girls (n = 29) than boys (Table 2).

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Table 2. Nutrition status by sex

		Severe malnutrition	Moderate malnutrition	Normal	Overweight	Obesity	
Sex	Female	1 (.31 %)	0	90 (28.57 %)	29 (9.20 %)	34 (10.79 %)	154 (48.88 %)
	Male	0	3 (.95 %)	88 (27.93 %)	27 (8.57 %)	43 (13.65 %)	161 (51.11 %)
Total		1(.31 %)	3 (.95 %)	178 (56.50 %)	56 (17.77 %)	77 (24.44 %)	315 (100 %)

Source: Prepared by the authors in 2024.

The grouped bar chart illustrates nutritional status by age. The highest number of children with normal weight (n = 40) was observed at age 9. In contrast, obesity was especially prevalent among children aged 6, 9, 10, and 11. Overweight was more common at ages 9, 10, and 11 (Figure 3).

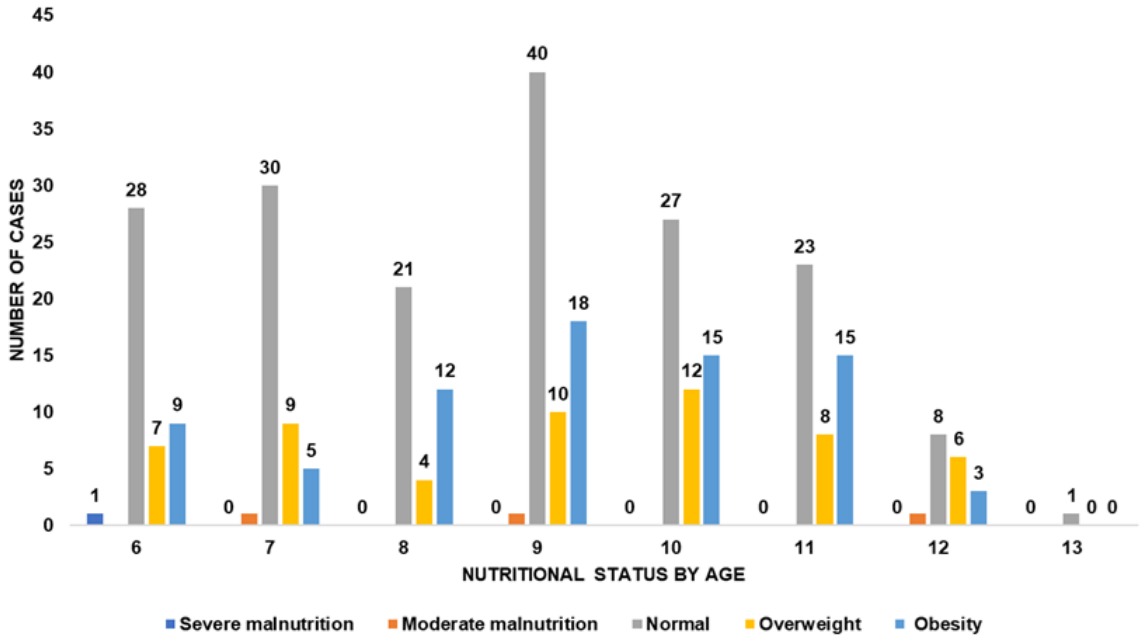

Figure 3. Nutritional status by age.

Source: Prepared by the authors, 2024.

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Table 3 presents the average Body Mass Index (BMI) ± standard deviation (SD) by age and sex. Among girls, the average BMI increased from 17.18 at age 6 to 19.6 at age 12. Among boys, it rose from 16.78 at age 6 to 20.21 at age 12. Considerable variability in BMI was observed within each age group. However, the average BMI consistently exceeded +1 SD, suggesting a population-wide trend toward overweight.

Table 3. Mean and standard deviation of the Body Mass Index (BMI) by age and sex.

	Age	6	7	8	9
Sex	Female	17.18 ± 4.06	17.17 ± 3.10	17.84 ± 3.05	19.28 ± 5.79
	Male	16.78 ± 2.46	17.06 ± 3.73	20.12 ± 5.77	18.39 ± 3.57

	Age	10	11	12	13
Sex	Female	18.83 ± 3.68	20.27 ± 4.18	19.66 ± 3.90	-
	Male	20.07 ± 4.17	20.71 ± 3.92	20.21 ± 4.94	19.90

Source: Prepared by the authors in 2024.

The trend in BMI by age and sex shows a continuous increase. In both sexes, the average BMI rises with age, as expected in the general population. At age six, girls exhibited a higher mean BMI (17.18), possibly due to an earlier onset of growth. However, this trend reversed after age eight, with boys showing higher mean values (Figure 4).

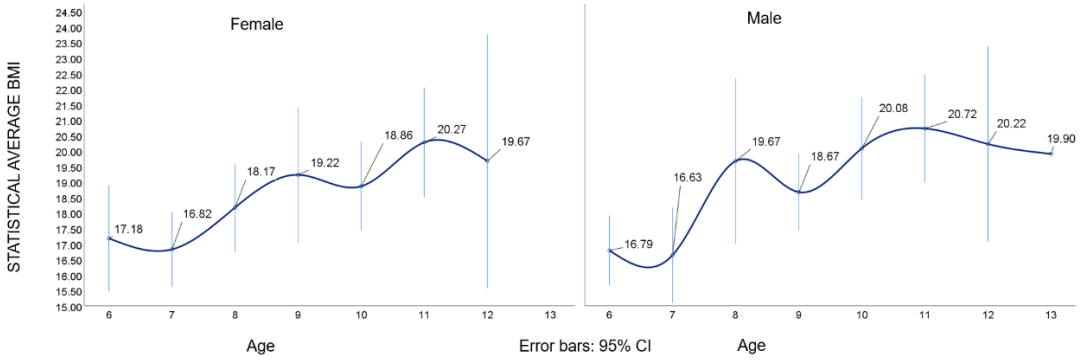

Figure 4. BMI trend by age and sex.

Source: Prepared by the authors, 2024.

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Discussion

The results are consistent with the national epidemiological context. According to ENSANUT data, 25 % of children under 10 suffer from obesity, and 24.7 % are overweight. In the peninsular region, which includes the Veracruz state, the combined prevalence of OW + OB is 32.1 %, slightly lower than the 42 % observed in this study (Shamah *et al.*, 2023[a]).

Specifically, for school-aged children in Veracruz, the reported prevalence of overweight is 18.4 % in girls and 17.7 % in boys. Obesity prevalence is 15 % in girls and 20.1 % in boys (Shamah *et al.,* 2020[b]).

Regarding the distribution of OW and OB by sex, the findings align with those of Shamah *et al.* (2020[a]), who also reported higher overweight prevalence in girls (18.4 %) and greater obesity prevalence in boys (20.1 %). These differences highlight an opportunity to further explore the biological, social, and cultural causes behind this disparity, as gender awareness and its impact on lifestyle and eating habits leading to obesity have often been overlooked (Tinat & Núñez, 2022).

Furthermore, the proportion of overweight among children under 10 years of age was 16.8 %, while the obesity rate reached 23.6 %. These results are in line with García *et al.* (2020), who reported that 25 % of children under 10 nationwide suffered from obesity, and 24.7 % of children under 9 were overweight.

As for undernutrition, a prevalence of 1.2 % was observed, which is lower than the national average (Bonvecchico *et al.,* 2020; Rivera *et al.,* 2024). This may be attributed to local improvements in access to basic nutrition and food security reforms, although the sample size may also play a role.

Internationally, data from UNICEF (2022) and WHO (2024[a]) indicate that Mexico exceeds the global average for overweight (6.2 %) and ranks among countries with a combined OW + OB prevalence greater than 30 % in children aged 5 to 19. In this study, the combined prevalence surpassed 42 %, higher than in countries like the United States (20.6 %) and Argentina (20.3 %), and approaching the levels observed in Chile (27.5 %).

Finally, the findings reflect the epidemiological transition described by Cuevas *et al.* (2023), in which the environment allows for the coexistence of a wide nutritional spectrum, representing a significant risk factor for the development of chronic noncommunicable diseases in adulthood. This positions the issue as a public health priority.

Conclusions

The combined analysis of BMI by age and sex, along with SD, revealed a general trend toward overweight and obesity. For girls, a BMI range between 12.7 and 17.3 is expected at age

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six, according to FANTA (2013); however, the mean value was 17.18 ± 4.06, indicating that a significant portion of the group exceeded +1 SD, and a notable proportion exceeded +2 SD, based on data dispersion. This points to a high number of overweight and obesity cases within the study population.

Similarly, boys of the same age had a mean BMI of 16.78 ± 2.46, placing them above the upper limit of the normal range (13.0-17.0) (FANTA, 2013).

A similar pattern was observed at 12 years of age, with both girls and boys having an average BMI within the expected range according to international reference values. In girls, the BMI was 19.66 ± 3.90, within the reference range of 14.4-21.8. In boys, the average value was 20.21 ± 4.94, also within the reference range of 14.5-20.8, although in this case, there was greater dispersion.

The wide standard deviation across all results suggests that a significant proportion of the population may fall above +2 SD, reflecting a concerning trend toward overweight and obesity.

In terms of nutritional status, the findings confirm a concerning scenario of malnutrition in all its forms among the school population. Although most students fell within normal reference parameters, over 40 % were living with overweight or obesity. Additionally, moderate and severe undernutrition was identified in 1.2 % of cases, underscoring the importance of maintaining comprehensive screening strategies. These would help better quantify the problem and support the development of timely interventions for the detection, prevention, and treatment of malnutrition in its various forms.

This study focused solely on the evaluation of nutritional status through physical examination and BMI calculation, which presents limitations, particularly in individuals with unusually high or low lean mass, even though BMI cut-off points are internationally accepted.

For individuals identified with any form of malnutrition, it is important to complement the assessment with specialized tests, including cardiovascular risk profiling, body fat distribution analysis, and biochemical evaluations.

To comprehensively address malnutrition, future research should incorporate a gender perspective, recognizing that eating habits, physical activity, and body image are shaped by social norms and gender-based expectations.

Regarding the strengthening of public policies, it is recommended to continue following the guidelines established by international organizations. These include ongoing screening that promotes early diagnosis and multidisciplinary treatment, as well as measures to ensure food accessibility and security, and to create opportunities for physical activity, recreation, and leisure.

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Author contributions

Work conceptualization: SSLA, NGNG; Methodology development: SSLA, NGNG, JRAS; Software handling: SSLA, NGNG; Experimental validation: SSLA, NGNG, JRAS; Data analysis: SSLA, NGNG, JRAS; Data management: SSLA, NGNG, JRAS; Writing, original draft preparation: SSLA, NGNG, JRAS; Writing, review and editing: SSLA, NGNG, JRAS; Project administration: SSLA, NGNG, JRAS.

All authors have read and agreed to the published version of the manuscript.

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Ethical declarations

The authors declare that this research was conducted responsibly and ethically, in compliance with relevant research codes and applicable legislation. This study was approved by the Research Ethics Committee of the University Clinic for Reproductive and Sexual Health (CE-CUSRS/02/2024) at Universidad Veracruzana.

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

Conflict of interest

The authors declare no conflict of interest.

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