Journal of Biosocial Science (2024), 56: 4, 683–692
doi:10.1017/S0021932024000142

CAMBRIDGE UNIVERSITY PRESS

RESEARCH ARTICLE

Nutritional status of schoolchildren before and after confinement by COVID-19 (2019–2021) in Jujuy, Argentina

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(Received 26 September 2023; revised 28 February 2024; accepted 5 March 2024; first published online 15 April 2024)

Abstract

An increase in the prevalence of obesity due to lockdown and confinement linked to COVID-19 is observed. Variations in the nutritional status of schoolchildren from Jujuy are analyzed in relation to confinement due to COVID-19 (2019–2021) and its relationship with socio-demographic variables and the school environment. This is an observational, descriptive study. Data from 56,695 schoolchildren aged 6–18 years old is analyzed based on two temporary cuts (2019 pre-confinement and 2021 post-confinement). The nutritional status of schoolchildren (underweight, overweight, and obese) was established using the IOTF (International Obesity Task Force) criterion. The prevalence of each nutritional phenotype was estimated by sex and age group, considering the following independent variables: setting (rural/urban), school management system (public/private), geographic altitude, and percentage of households with unmet basic needs (UBN) in the place where they attend school. Multiple proportions contrast was performed using Fisher's test, a transition matrix ws produced and a statistical model of proportional odds was fitted. It was observed that between 2019 and 2021, the prevalence of underweight decreased and the prevalence of overweight and obesity increased significantly. In 2021, 67% of schoolchildren maintained the same nutritional category that they had in 2019, 21% gained weight and 12% lost weight. The model explains about 52% of the total variability observed. The factors that are significantly correlated in the model are school cycle, age, geographic altitude, school setting, and % of households with UBN. The results indicate that during the COVID-19 pandemic, there was a shift to the right in the distribution of the nutritional status categories of the schoolchildren population in Jujuy, with a decrease in the prevalence of underweight and an increase in the prevalence of overweight and obesity with variations related to age, school location, geographic altitude, and socioeconomic characteristics of the households in the place where the children attended school.

Keywords: COVID-19; transition; obesity

Introduction

The prevalence of obesity has been increasing in recent decades, reaching pandemic levels in all age groups in all countries and constituting a health challenge for both developed and developing

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countries (Blüher, 2019). Studies on the prevalence, geospatial distribution, and secular trend of obesity carried out in schoolchildren from Jujuy indicate a dramatic increase and a differential regional distribution according to altitudinal level, with a higher prevalence in the lowlands of Jujuy (Bejarano *et al.*, 2005; Bustamante *et al.*, 2021; Meyer *et al.*, 2013).

The coronavirus disease 2019 (COVID-19) pandemic was declared by the World Health Organization (WHO) on 11 March 2020 (WHO, 2020). The first confirmed case of COVID-19 in Jujuy was registered on 17 March 2020. In order to mitigate the spread of the virus and reduce the pressure on the healthcare system in Argentina, preventive and mandatory social confinement (ASPO, *Aislamiento Social Preventivo y Obligatorio*) was decreed on 19 March 2020 (Gobierno de la República Argentina, 2020). This situation entailed health, social, and economic implications. Rundle *et al.* (2020) consider that school closures due to COVID-19 may exacerbate the epidemic of childhood obesity and increase disparities in obesity risk. Moreover, previous studies show that schoolchildren tend to gain more weight when they do not attend school, which raised further concerns in this context (Pietrobelli *et al.*, 2020; Rundle *et al.*, 2020). Unhealthy weight gain in this stage is a long-term concern because multiple studies show that obesity experienced in childhood is associated with higher weight in adulthood (Rundle *et al.*, 2020).

Obesity, especially severe and visceral obesity, has been recognised as a strong determinant of severe disease from COVID-19, increasing the risk of hospitalisation, intensive care, need for mechanical ventilation, and death, both in adults and in child and adolescent populations (Brambilla *et al.*, 2022; Stefan *et al.*, 2021). Thus, there is a link and interconnection between the COVID-19 pandemic and the obesity pandemic (Guarisco and Leonetti, 2021; Stefan *et al.*, 2021).

As a result of ASPO, there were changes in the lifestyles of individuals, especially in terms of diet and physical activity (Ruiz-Roso *et al.*, 2020; Stavridou *et al.*, 2021). Different study designs have analysed the relationship between the two epidemics in terms of changes in physical activity, eating behaviour, and body weight (Stavridou *et al.*, 2021). Longitudinal studies with a before and after pandemic model focus mainly on changes in physical activity and eating habits (Enriquez-Martinez *et al.*, 2021; Stavridou *et al.*, 2021). Those that emphasise changes in weight or other indicators of obesity based on anthropometry are scarce and, in general, only consider self-reported weight and height (Dunton *et al.*, 2020; Lange *et al.*, 2021; Pietrobelli *et al.*, 2020; Yang *et al.*, 2020).

As in other countries, the studies published in relation to the changes that occurred in the lifestyle and health of the population after the COVID-19 pandemic and ASPO in Argentina focused on changes in eating habits and physical activity and not on the impact on the prevalence of malnutrition including first-hand longitudinal data (Intelangelo *et al.*, 2021). In this study, the authors analyse the modification of the prevalence of different nutritional phenotypes, due to both excess and lack of weight, in schoolchildren from Jujuy in relation to ASPO as a result of the COVID-19 pandemic and its relationship with other socio-demographic variables using the anthropometric data provided by the Sistema Integral de Información Digital Educativa (SInIDE).

Methods

Study design

In this pre- and peri-lockdown observational study, the authors analyse data from schoolchildren from primary and secondary levels of the province of Jujuy registered in SInIDE for two time periods, the year before (2019) and the year after (2021) the lockdown, with anthropometric measurements reported in both school years and taken by trained personnel.

The SInIDE of the Ministry of Education of the Argentine Republic (https://sinide.educacion.gob.ar/) is a nominal information system that collects information on different variables in all educational establishments of the country. In the province of Jujuy, anthropometric data of students surveyed during the school year is added to the original data provided by SInIDE. The anthropometric data collection (weight and height) was conducted at the school and carried out

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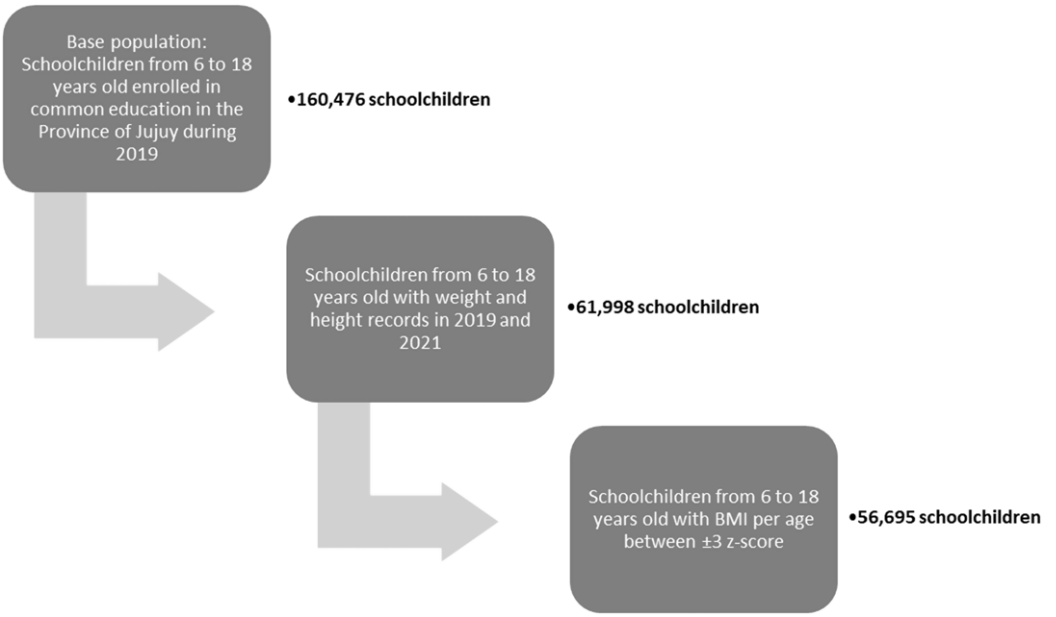

Figure 1. Flow Chart Showing the Database Depuration Process.

by physical education teachers with the assistance of grade-level teachers, using the instruments available in the institution, following the protocol established by the Secretaría de Equidad Educativa, Plan de Contingencia y Comedores Escolares of the Ministry of Education (Circular No. 05-SEE/21). The teacher in charge of the measurements may have varied from one measurement to another, as there are changes in the personnel responsible for taking them from one year to another.

The province of Jujuy is located in the northwest of Argentina, and due to its location on the Andean massif, it presents an altitudinal cline (500–4000 masl) that allows the delimitation of two clearly defined altitudinal levels: highlands (H) (>2000 masl) and lowlands (L) (<2000 masl).

For this study, in order to show variations in nutritional status during the study period, only those schoolchildren between 6 and 18 years of age who were recorded in both time periods were considered. In addition, the authors excluded those schoolchildren whose age in 2021 was less than or equal to that of 2019, whose height in 2021 was less than that of 2019, and whose age was less than 6 years or more than 18 years old. In the second stage, the body mass index (BMI, weight/height^2) was calculated based on the data of weight (kg) and height (m), and the extreme values of the z score (±3) of the BMI were eliminated by age and sex, generated by AnthroPlus (Figure 1).

Based on BMI for age and sex, the nutritional phenotype of each individual was determined, considering the cut-off points proposed by the International Obesity Task Force which are equivalent to those proposed for adults: (a) underweight ($\leq$18.5 kg/m^2), (b) overweight ($\geq$24.9 and <30 kg/m^2) and (c) obesity ($\geq$30 kg/m^2) (Cole *et al.*, 2000, 2007).

The independent variables were (a) sex: female or male; (b) age divided into three groups of 6–9, 10–14, and 15–18 years old; (c) geographic altitude deduced from the geographic coordinates of the school and grouped in highlands or lowlands; (d) school management system: state or private; (e) school setting: urban or rural; and (f) percentage of households with unmet basic needs (%hUBN), a direct indicator of poverty developed by INDEC (Instituto Nacional de Estadística y Censos) which is related to four areas of people's basic needs (housing, sanitation, basic education, and minimum income) recorded in population and housing censuses (Feres and Mancero, 2001). The %hNBI was inferred from the UBN of the census radius where the school was located.

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The data were divided into two groups: (a) data recorded in SInIDE in 2019 – pre-ASPO by COVID-19 pandemic and (b) data recorded in 2021 – post-ASPO by COVID-19.

Statistical analysis

The prevalence of each nutritional phenotype was calculated using different grouping criteria for the 2019 and 2021 school cycles. To compare the prevalence of the different nutritional phenotypes before and after the COVID pandemic, the authors used multiple proportions contrast through Fisher's exact test at the provincial level disaggregated by the independent variables.

Given that the data for 2019 and 2021 correspond to the same individuals, a transition matrix analysis was carried out between nutritional status categories during the period analysed to show whether there was an increase or decrease in weight among schoolchildren during the ASPO.

To examine associations between nutritional status and the independent variables, a proportional odds model was fitted for ordinal polytomous variables. The coefficients of β were estimated for the independent variables. The model was fitted with the vglm() function of the VGAM library of the R software. Fisher's exact test of contrasts of proportions was performed using the fisher.test() function of R. Data manipulation and analysis were performed with the functions of the Tidyverse libraries of R.

Bioethical considerations

The use and dissemination of SInIDE information safeguard the identity of individuals and educational institutions in agreement with the provisions of National Education Law No. 2606 and Personal Data Protection Law No. 25326. For the analysis, the data were anonymized. This study follows the bioethical guidelines proposed by the Ministry of Health of Argentina (2011), which exempts epidemiological studies that use public or publicly available records or information from obtaining informed consent.

Results

The sample consisted of 56,695 schoolchildren, and the distribution by variables is shown in Table 1.

The prevalence of underweight decreased and that of excess weight increased significantly between 2019 and 2021. This pattern is also found when analysing the change according to the independent variables, except for the 15–18 age group and the type of private school system (Table 2).

Table 3 shows that in 2021, 67% of schoolchildren maintained the same nutritional category they had in 2019, 21% gained weight, and 12% lost weight. Approximately 17.5% of schoolchildren who were lean, normal weight, or overweight in 2019 moved to an overweight or obese category in 2021.

The adjusted multinomial model explained about 52% of the total variability observed (Table 4). The factors that were significantly correlated in the model were school cycle, age, school setting, geographic altitude, and %UBN. Regarding the school cycle, it was observed that the possibility of presenting an 'overweight' nutritional category was significantly higher in 2021 with respect to 2019. In turn, in the age group from 10 to 14 years of age, there was a higher chance in the direction of excess weight, in opposition to the age group from 15 to 18 years of age, where it was in the direction of underweight, in relation to schoolchildren aged 6–9 years. Regarding school setting and geographic altitude, urban and lowland schoolchildren were more likely to present a nutritional category in the direction of excess weight, compared with rural and highland schoolchildren, respectively. Finally, when considering the %hUBN of the place where they

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Table 1. Schoolchildren Distribution According to Sex, Age Group, Geographic Altitude, Setting, and School Management System for the Year 2021 in Jujuy (Argentina)

	N 2021	% 2021
Sex		
Male	29,536	52.1
Female	27,159	47.9
Age		
6–9 years	19,805	34.9
10–14 years	34,873	61.5
15–18 years	2,017	3.6
Geographic altitude		
Highlands	6,507	11.5
Lowlands	50,188	88.5
Setting		
Rural	6,063	10.7
Urban	50,632	89.3
School management system		
Public	49,182	86.7
Private	7,513	13.3
Total	56,695	

attended school, it was observed that the higher the value, the greater the chance of presenting a nutritional situation in the direction of underweight, which confirms what was previously evidenced in the bivariate analysis.

Discussion

This research is in agreement with several previous studies that show that after the social confinement caused by the COVID-19 pandemic, the prevalence of malnutrition has changed (Chaabane *et al.*, 2021; Dunton *et al.*, 2020; Hu *et al.*, 2021; Lange *et al.*, 2021; Pietrobelli *et al.*, 2020; Wen *et al.*, 2021; Yang *et al.*, 2020). In this particular case, the sample analysed is representative of the Jujuy school population and comes from information collected from 607 schools distributed in an altitudinal gradient that characterises the orography of the province of Jujuy. The results show that the prevalence of underweight among Jujuy schoolchildren decreased by 1.15 percentage points, while the prevalence of overweight and obesity increased by 4.25 and 2.3 percentage points, respectively. These variations in weight and nutritional status may be due to various factors linked to confinement, including decreased physical activity, changes in eating habits, and family context, among others. Pietrobelli *et al.* (2020) found that aspects related to diet, activity, and sleep behaviours changed in an unfavourable direction in children and adolescents with obesity three weeks into confinement during the lockdown. In addition, several studies reported variations in weight in the direction of excess weight during summer vacations, so it is to be expected that children and adolescents who spend more time at home during these seasons will gain weight, such as in confinement (Rundle *et al.*, 2020; von Hippel and Workman, 2016).

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Table 2. Distribution of Schoolchildren According to Malnutrition Category (Underweight, Overweight, Obesity) by Sex, Age Group, School Setting, School Management System, Geographic Altitude, and %hUBN Where the School Is Located for 2019 and 2021 (Jujuy, Argentina)

		Underweight			Excess weight					
					Overweight			Obesity		
		2019	2021		2019	2021		2019	2021	
Category		%		p.v[a]	%		p.v[a]	%		p.v[a]
Total		5.6 (5.4; 5.8)	4.5 (4.3; 4.7)	***	24.5 (24.1; 24.9)	28.7 (28.3; 29.1)	***	8.4 (8.2; 8.6)	10.7 (10.4; 11)	***
Sex	Female	6.1 (5.8; 6.4)	5 (4.8; 5.2)	***	24.2 (23.7; 24.7)	27.9 (27.4; 28.4)	***	9.4 (9.1; 9.7)	10.9 (10.5; 11.3)	***
	Male	5 (4.7; 5.3)	3.9 (3.7; 4.1)	***	24.8 (24.3; 25.3)	29.7 (29.2; 30.2)	***	7.3 (7; 7.6)	10.5 (10.1; 10.9)	***
Age	6–9	6 (5.8; 6.2)	4.5 (4.2; 4.8)	***	23.1 (22.7; 23.5)	28.3 (27.7; 28.9)	***	8 (7.7; 8.3)	12.2 (11.7; 12.7)	***
	10–14	4.8 (4.5; 5.1)	4.2 (4; 4.4)	**	27.4 (26.8; 28)	29.4 (28.9; 29.9)	***	9.3 (8.9; 9.7)	10.1 (9.8; 10.4)	**
	15–18	7.1 (5.3; 8.9)	7.4 (6.3; 8.5)		21.2 (18.3; 24.1)	20.4 (18.6; 22.2)		4.4 (2.9; 5.9)	5.7 (4.7; 6.7)	
Setting	Rural	5.2 (4.6; 5.8)	3.5 (3; 4)	***	20.7 (19.7; 21.7)	27 (25.9; 28.1)	***	7.2 (6.6; 7.8)	9.7 (9; 10.4)	***
	Urban	5.7 (5.5; 5.9)	4.6 (4.4; 4.8)	***	25 (24.6; 25.4)	28.9 (28.5; 29.3)	***	8.5 (8.3; 8.7)	10.8 (10.5; 11.1)	***
School management system	Public	5.7 (5.5; 5.9)	4.4 (4.2; 4.6)	***	24.2 (23.8; 24.6)	28.7 (28.3; 29.1)	***	8.3 (8.1; 8.5)	10.9 (10.6; 11.2)	***
	Private	5 (4.5; 5.5)	4.8 (4.3; 5.3)		26.7 (25.7; 27.7)	29.2 (28.2; 30.2)	***	9.1 (8.4; 9.8)	9.5 (8.8; 10.2)	
Geographic altitude	Lowlands	6.9 (6.3; 7.5)	5.6 (5; 6.2)	**	18.6 (17.7; 19.5)	24.6 (23.6; 25.6)	***	5.4 (4.9; 5.9)	7.2 (6.6; 7.8)	***
	Highlands	5.4 (5.2; 5.6)	4.3 (4.1; 4.5)	***	25.2 (24.8; 25.6)	29.3 (28.9; 29.7)	***	8.8 (8.6; 9)	11.1 (10.8; 11.4)	***
%hUBN[b]	<7%	5.8 (5.5; 6.1)	4.5 (4.2; 4.8)	***	25.6 (25; 26.2)	29.3 (28.7; 29.9)	***	8.7 (8.3; 9.1)	10.8 (10.4; 11.2)	***
	7–15%	5.2 (4.9; 5.5)	4.5 (4.2; 4.8)	**	24.7 (24; 25.4)	29 (28.3; 29.7)	***	8.5 (8.1; 8.9)	10.7 (10.2; 11.2)	***
	>15%	5.7 (5.4; 6)	4.3 (4; 4.6)	***	23.2 (22.6; 23.8)	27.9 (27.3; 28.5)	***	8 (7.6; 8.4)	10.5 (10.1; 10.9)	***

[a]*P*.value of Fisher's exact test: ***$p.v < 0.001$, **$0.001 \leq p.v < 0.01$,
Empty cells indicate non-significant differences.
[b]The cut-off values correspond to the 1/3 and 2/3 quantiles of the complete series.

Table 3. Distribution of Jujuy Schoolchildren According to Their Transition Between Nutritional Status Categories from 2019 to 2021 According to IOTF Criteria

	Underweight	Normal	Overweight	Obesity	Total
2019/2021	N (%)	N (%)	N (%)	N (%)	N (%)
Underweight	1,058 (33.3)	1,931 (60.7)	158 (5.0)	34 (1.1)	3,181 (100)
Normal	1,383 (4.0)	26,355 (75.6)	6,443 (18.5)	700 (2.0)	34,881 (100)
Overweight	73 (0.52)	3,259 (23.5)	7,973 (57.4)	2,576 (18.6)	13,881 (100)
Obesity	12 (0.25)	279 (5.9)	1,716 (36.1)	2,745 (57.8)	4,752 (100)
Total	2,526	31,824	16,290	6055	56,695

Table 4. Coefficients of the Cumulative Model for Ordinal Polytomous Data and P-Values of the Deviance χ^2 Test Associated with Each Factor

FV	β	Std. error	Degrees of freedom	*P*
School cycle			1	0.0000***
2021	−0.2637	0.0123		
Sex			1	0.6107
Age			2	0.0000***
10–14	−0.0876	0.0124		
15–18	0.5278	0.0413		
School management system			1	0.2429
Setting			1	0.0000***
Urban	−0.0785	0.0201		
Geographic altitude			1	0.0000***
Lowlands	−0.3864	0.0196		
% UBN			2	0.0096***
7% < UBN < 15%	−0.0270	0.0148		
UBN > 15%	0.0194	0.0148		

***p.v < 0.001.

Bivariate analysis indicated that the only cases where the prevalence of malnutrition did not vary significantly between periods were in the 15–18 age group and in those attending a private school. Previous studies indicate that the younger the age group, the greater the increase in BMI and the higher the prevalence of overweight and obesity (Stavridou *et al.*, 2021; Yang *et al.*, 2020). These age differences can probably be attributed to the possibility of maintaining pre-pandemic lifestyles, particularly those related to physical activity. In the USA, older versus younger children were more likely to participate in team sports training sessions or practices via remote or streaming services (Stavridou *et al.*, 2021).

In state-run schools, the increase in the prevalence of overweight and obesity was 4.51 percentage points and 2.56 percentage points, respectively, while in private schools, the prevalence was 2.62 and 0.37 percentage points, respectively. In Argentina, there is a significant socio-economic gap between public and private schools according to family socio-economic level (goods and services in the home and parental education) (Dari *et al.*, 2022). Although information on the

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socio-economic characteristics of school populations examined in relation to changes in eating behaviours and physical activity imposed by confinement is scarce (Stavridou *et al.*, 2021), it is possible to deduce that families with better socio-economic status would have greater advantages in obtaining healthier foods and more adequate spaces to foster the continuity of their children's physical activity at home.

As shown by other studies, the prevalence of overweight and obesity pre- and post-COVID-19 confinement in the school population of Jujuy was higher in males than in females (Knebusch *et al.*, 2021; Qiu *et al.*, 2021; Yang *et al.*, 2020). The energy balance between energy intake (food and beverages) and energy expenditure (physical activity and sedentary behaviour) is an immediate determinant of childhood obesity and is influenced by sex and gender (Knebusch *et al.*, 2021). During the pandemic, differences were observed between males and females in diet type and physical activity. Females increased their consumption of fruits and vegetables, while males increased the number of meals and were more prone to engage in physical activity (Stavridou *et al.*, 2021).

Besides, in this study, other factors that could have had a differential effect on the variations observed in the prevalence of obesity were the setting where the school was located (rural/urban) and geographic altitude. Along these lines, a higher prevalence of overweight and obesity was observed in urban schoolchildren compared with rural schoolchildren, which may be related to the fact that urban children are probably more affected by social distancing and its consequences on dietary practices and, above all, physical activity. On the other hand, there are previous studies that reported that schoolchildren in the highlands present a higher prevalence of underweight and lower average height values and average BMI than those of the lowlands (Meyer *et al.*, 2013), which coincides with what was observed in this study where the prevalence of excess weight is lower in the highlands.

The socio-economic conditions of the environment where children attend school play a key role in the variations observed in the prevalence of these phenomena. In this case, it was observed that as the %hUBN increases, the prevalence of overweight and obesity decreases, in contrast to the information presented by Clemmensen *et al.* (2020), who describe a relationship between socio-economic status and obesity risk, in which an increase in social inequality driven by ASPO would translate into an increase in the prevalence of obesity and metabolic diseases in groups with lower socio-economic status.

Compared to other similar studies where the information came from online questionnaires, the strength of this study lies in the fact that the data, especially the anthropometric data, were collected in the schools without the specific purpose of being used to evaluate the effect of the ASPO on the nutritional status of schoolchildren. The main limitation of this study lies in the fact that it was not possible to use the totality of the SInIDE data due to the asynchrony between the load of the anthropometric data and the remaining variables in the system.

Furthermore, another limitation is the potential bias resulting from variations in measurement instruments, techniques, and personnel responsible for carrying it out between one measurement and another (2019 and 2021).

Finally, this study shows that measures such as the social confinement imposed by the COVID-19 pandemic would foster an unfavourable environment for the development and maintenance of a healthy lifestyle, especially in children and adolescents. Considering this, future measures should be rethought for contexts similar to the present in order to protect the integral health of these groups.

Conclusions

The use of anthropometric indicators of under- and overnutrition indicates there was a shift in the nutritional status of schoolchildren and adolescents in Jujuy during the COVID-19 pandemic, with a decrease in the prevalence of underweight and an increase in the prevalence of overweight and obesity with variations according to age, school location, geographic altitude, and socio-economic characteristics of the households.

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Funding statement. This research received no specific grant from any funding agency, commercial entity, or not-for-profit organisation.

Competing interests. The authors have no conflicts of interest to declare.

Ethical standard. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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Cite this article: Bustamante MJ, Solis JM, Tabera CM, Maraz N, Gutiérrez GBR, and Dipierri JE (2024). Nutritional status of schoolchildren before and after confinement by COVID-19 (2019–2021) in Jujuy, Argentina. *Journal of Biosocial Science* **56**, 683–692. https://doi.org/10.1017/S0021932024000142

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