Obesity and Severe Obesity in Youth Before and During COVID-19

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abstract

BACKGROUND AND OBJECTIVES: Childhood obesity has remained persistently high in the United States. This study aimed to (1) assess changes in obesity prevalence and (2) examine the associations of ultra-processed food (UPF) intake and physical activity (PA) patterns with obesity, by obesity severity, before and during the COVID-19 pandemic among US 2- to 19-year-olds.

METHODS: A serial cross-sectional analysis using the National Health and Nutrition Examination Survey compared data from before (2017 to March 2020) and during (August 2021 to August 2023) the COVID-19 pandemic. Obesity was determined using body-mass-index-for-age percentiles: class I obesity (≥95th percentile to <120% of the 95th percentile), class II (≥120% to <140%), and class III (≥140% of the 95th percentile). UPF intake was assessed via 24-hour dietary recalls. Participants self-reported the number of days/week they engaged in moderate to vigorous PA. Survey logistic regression models assessed the odds of increasing obesity severity by UPF intake and PA, age, sex, race, ethnicity, and household income.

RESULTS: Analysis included 4756 participants in the pre-pandemic period and 2501 in the pandemic period. Obesity prevalence was 21.2% pre-pandemic (N = 1072) and 22.6% during the pandemic (N = 694; $P = .30$). Mean %UPF intake decreased from 66.0% to 62.7% ($P < .01$). Before the pandemic, adjusted analysis showed youth with higher PA days had lower odds of class II obesity (odds ratio [OR] = 0.86, 95% CI: 0.76–0.97) and overall obesity (OR = 0.91, 95% CI: 0.85–0.97), with a protective effect across class I and III that did not reach significance. During the pandemic, meeting PA guidelines was also protective against overall obesity (OR = 0.86, 95% CI: 0.76–0.99). Although no significant predictors of obesity by class emerged during the pandemic, protective nonsignificant effects of PA were also observed.

CONCLUSIONS: Obesity prevalence trended up from before to during the pandemic, and PA was associated with obesity, whereas no distinct associations of UPF and increasing obesity severity emerged.

WHAT'S KNOWN ON THIS SUBJECT: Childhood obesity in the United States has remained high for decades due to environmental, behavioral, genetic variability, and biologic factors. The COVID-19 pandemic exacerbated these trends, especially among younger children and those with preexisting obesity.

WHAT THIS STUDY ADDS: Obesity prevalence was 21.2% before the COVID-19 pandemic and 22.6% during the pandemic. Physical activity was generally protective of increasing obesity severity. No clear patterns of ultra-processed food intake as predictors of increasing obesity severity emerged either before or during the pandemic.

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INTRODUCTION

In the United States, childhood obesity has remained persistently high, with the sharpest increase observed in the prevalence of severe obesity (body mass index [BMI] ≥ 120% of the 95th percentile for age and sex).[1] The prevalence of obesity among US children and adolescents aged 2 to 19 years increased from 5.2% in 1971–1974 to 19.3% in 2017–2018, while severe obesity rose from 1.0% in 1971–1974 to 6.1% in 2017–2018.[1,2] The COVID-19 pandemic intensified these trends, especially among young children,[3] disadvantaged groups, racial and ethnic minorities, and those with preexisting overweight or obesity.[3,4]

Childhood obesity is a major clinical and public health challenge associated with type 2 diabetes, metabolic dysfunction–associated steatotic liver disease, hypertension, cardiomyopathy, kidney disease, sleep apnea, polycystic ovarian syndrome, and certain cancers.[5–9] It is also associated with psychological distress, reduced quality of life, internalized weight bias, and a high likelihood of persisting into adulthood.[5,10,11] Although genetic predisposition plays a role in obesity risk,[12] the persistent rise in obesity rates over recent decades points to environmental and lifestyle exposures, particularly dietary patterns, including the widespread availability and consumption of ultra-processed foods (UPFs, industrial formulations typically made with little or no whole foods that often contain additives such as flavors, colors, emulsifiers, or preservatives that are not commonly used in home cooking), as well as physical activity (PA) as key contributors.[13]

Total dietary energy intake among US 2- to 18-year-olds increased significantly between 1989 and 2004 before declining through 2010,[14] although some reports noted an increase in caloric intake in 2009–2010.[15] In the United States, dietary composition has shifted considerably with declining fat intake and rising carbohydrate consumption, particularly from high-glycemic-index sources.[16] From 1999 to 2018, the proportion of total energy from UPFs increased from 61.4% to 67.0%, reflecting a shift toward more calorie-dense diets.[17] Diets high in refined carbohydrates may promote excessive weight gain through mechanisms including postprandial hyperinsulinemia.[16,18] Among adults, diets low in UPFs are associated with lower obesity prevalence.[19,20] However, although international evidence of these associations in youth is growing,[21–26] it remains limited in the United States.[27,28]

Physical inactivity further compounds the impact of low-quality diet on obesity risk.[29,30] Sedentary behaviors, including excessive screen time and reduced opportunities for structured PA, have become increasingly prevalent among US youth.[30] The COVID-19 pandemic exacerbated these trends, as school closures and mandatory lockdowns restricted access to recreational spaces and physical education programs.[31,32] One review reported that daily PA decreased by 20% during the pandemic while high-intensity activities declined by 32%, resulting in a 17-minute reduction in daily moderate to vigorous PA.[32]

This study aimed to (1) provide updated COVID-19 pandemic prevalence estimates of obesity and severe obesity among US youth compared with pre-pandemic estimates and (2) examine the association between UPF consumption and PA patterns with obesity, by class and severity in both periods. We hypothesized that higher UPF consumption and lower PA levels would be associated with increased severity of obesity among US youth and that these associations may differ between the pre-pandemic and pandemic periods.

METHODS

Study Design, Participant Recruitment, and Data Collection Procedures

A serial cross-sectional analysis of pre-pandemic (2017–2020) and pandemic (2021–2023) data from the National Health and Nutrition Examination Survey (NHANES) was conducted to assess prevalence of obesity and severe obesity, UPF intake, and PA patterns among US youth (aged 2 to 19 years). NHANES suspended data collection in March 2020 due to the COVID-19 pandemic and resumed in August 2021 with protocol adjustments. As a result, the transition period (March 2020 to July 2021) was excluded from analysis due to the absence of available data. NHANES employed a multistage, nationally representative sampling approach, selecting primary and secondary sampling units, followed by household and individual recruitment for comprehensive health examinations and interviews.[33,34]

NHANES obtained written parental consent for participants aged 2 to 17 years, with additional assent from those aged 7 to 17 years. Written informed consent was obtained directly from participants aged 18 to 19 years. NHANES protocols were approved by the National Center for Health Statistics research ethics review board. The University of Texas Southwestern Medical Center Institutional Review Board exempted this study from review because it involved a retrospective analysis of public, anonymized datasets. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.[35]

Assessment of Obesity (Primary Outcome)

NHANES personnel recorded participant height and weight measurements during physical examinations in mobile examination centers. These measurements were converted to standardized BMI percentiles. Obesity was categorized into 3 classes based on standardized BMI percentiles for age and sex[36]; class I obesity: BMI greater than or equal to 95th percentile and less than 120% of the 95th percentile; class II obesity: BMI between 120% and 140% of the 95th percentile; and class III obesity: BMI greater than or equal to 140% of the 95th percentile.[26] Severe obesity was defined as BMI greater than or equal to 120% of the 95th percentile.[36]

Assessment of Primary Exposures

Dietary Assessment

Dietary data were obtained from two 24-hour food intake recalls collected in both NHANES cycles—the first conducted in person during the mobile examination center visit and the second by telephone 3 to 10 days later.[37] Participants aged 12 to 19 years completed the dietary recall independently, whereas proxy-assisted interviews were conducted for those aged 6 to 11 years. For children aged 5 years and younger, a proxy familiar with their dietary intake provided responses. The US Department of Agriculture (USDA) Automated Multiple-Pass Method was used to improve accuracy and completeness of data while minimizing respondent burden.[38] Participants who did not provide a valid recall (n = 1505) were excluded.

UPF Intake

Ultra-processed and unprocessed foods and beverages were categorized based on the Nova classification system: unprocessed or minimally processed foods (group 1), processed culinary ingredients (group 2), processed foods (group 3), and UPF (group 4).[39] The Nova system defines UPF as industrial formulations composed primarily of processed food substances not commonly used in home cooking such as hydrolyzed proteins, high-fructose corn syrup, and hydrogenated oil—along with cosmetic additives like colorings, flavor enhancers, and emulsifiers. These products often undergo multiple processing stages.[40]

Nova group and subgroup assignments were determined by evaluating the food descriptions and ingredient lists associated with each NHANES food code. For potentially handmade mixed dishes, the classification was applied to the underlying ingredients obtained from cycle-specific USDA Food and Nutrition Database for Dietary Studies (FNDDS) to improve accuracy. The energy and nutrient contents of each Nova food group and subgroup were further estimated using the cycle-specific USDA FNDDS, the USDA National Nutrient Database for Standard Reference (NNDSR).[41–44] For this analysis, the primary exposure was the percentage of total energy consumed from UPF (%UPF).

Physical Activity

PA was assessed among 2- to 17-year-olds using the NHANES-adapted Youth Physical Activity Questionnaire.[45] Participants aged 18 to 19 years were excluded (from PA analysis only) because they were asked about PA over the past 30 days, which was not comparable to the assessment used for younger participants. Trained NHANES interviewers used a computerized system to conduct surveys for participants aged 2 to 11 years and 16 to 17 years. Those aged 12 to 15 years completed the questionnaire at the mobile examination centers using an audio-assisted, self-interviewing computer program designed for privacy and ease of use. The questionnaire asked about the number of days in the past week the participant engaged in at least 60 minutes of moderate to vigorous PA. The mean days per week of self-reported moderate to vigorous PA were analyzed. These age-specific assessment methods were harmonized by focusing on the common metric of days per week with at least 60 minutes of PA, aligned with the US Department of Health and Human Services recommendations for children and adolescents aged 6 to 17 years.[46]

Covariates

Based on prior literature,[1,2] self-reported age, sex (male, female), race (non-Hispanic white, non-Hispanic Black, other/multi-race), ethnicity (Hispanic), and family monthly poverty level (categorized as ≤1.30, 1.30–1.85, or >1.85 times above the federal poverty level)[47] were included as covariates.

Statistical Analysis

All statistical analyses accommodated the complex sampling plan (strata, cluster, and weight) provided by NHANES. Categorical variables were reported as weighted prevalence with 95% CIs and continuous variables were reported as weighted means and SEs. Chi-square tests compared participant demographics before and during the pandemic, whereas 2-sample *t* tests compared continuous variables between the 2 periods. Comparison of prevalence estimates of class I, II, III, severe, and overall obesity before and during the pandemic was conducted using generalized linear models (GLMs) with a quasibinomial distribution and logit link function and incorporating the complex sampling plan[48,49] (logistic regression). Each obesity class was entered as the dependent variable and survey cycle was included as the independent variable.

Separate multivariable logistic regression analysis generated the adjusted odds ratios (ORs) of overall obesity, severe obesity, and class I, II, and III obesity for each period, respectively, controlling for age, sex, race, ethnicity, household income, UPF consumption (quartiles), and PA. This GLM uses a quasibinomial family to mimic a multinomial regression by fitting separate logistic regressions applying survey weights. In logistic regression, the reference category for each obesity class is healthy/normal weight, whereas the reference class for obesity and severe obesity are those not falling into those categories, respectively. %UPF was categorized into quartiles to facilitate comparisons across the intake spectrum and align with prior studies using the Nova classification,[50] although we recognize this approach may reduce power or introduce interpretative complexity. Statistical analyses were performed using NHANES sampling weights in R (version 4.4.2) using "survey" package. The GLM was fit using the svygml function.

Two-sided $P \leq .05$ was considered significant. To assess the robustness of this approach, we also conducted multinomial logistic regression as sensitivity analyses modeling %UPF as a continuous variable and modeled PA using restricted cubic splines with 3 knots, with the default placement at the 10th, 50th, and 90th percentiles, to account for potential nonlinear associations. Both sensitivity analyses were performed using STATA version 18.5 (College Station, Texas).

RESULTS

Descriptive Characteristics

This study included participants from the pre-pandemic (N = 4756) and pandemic years (N = 2501). Demographic characteristics did not differ by cycle. PA levels remained stable at 4.77 days/week from before to during the pandemic (Table 1). Mean %UPF decreased from 66.0% vs 62.7% ($P < .01$), and obesity remained relatively similar from before (21.2%, N = 1072) to during (22.6%, N = 694) the pandemic (1.4% increase, $P = .30$). The prevalence of all obesity classes also remained similar from before to during the pandemic: class I (13.7% to 14.7%), class II (5.0% to 5.3%), and class III (2.5% to 2.7%) ($P = .57$). (Figure 1).

TABLE 1. Descriptive Characteristics, NHANES 2017–2020 (Pre-Pandemic) and 2021–2023 (Pandemic) Participants, (N = 7257)

	Pre-Pandemic 2017–2020 (N = 4756)	Pandemic 2021–2023 (N = 2501)	P Value[a]
	Number of Participants (Prevalence) or Mean (SE)		
Demographic characteristics			
Sex, n (%)			
Male	2414 (50.6)	1257 (51.4)	.59
Female	2342 (49.4)	1244 (48.6)	
Age group, years, n (%)			
2–5	1154 (21.1)	515 (19.7)	.43
6–11	1770 (33.3)	864 (33.3)	
12–19	1832 (45.6)	1122 (47.0)	
Race and ethnicity, n (%)			
Hispanic	1145 (25.0)	741 (25.2)	.30
White	1475 (50.2)	995 (46.1)	
Black	1270 (13.3)	366 (12.0)	
Asian	421 (5.0)	173 (8.3)	
Other	445 (6.5)	226 (8.4)	
Socioeconomic factors			
Family monthly poverty level category, n (%)			
≤1.30	1996 (36.0)	840 (32.6)	.27
1.30–1.85	618 (13.4)	418 (16.9)	
>1.85	1681 (50.6)	986 (50.5)	
Don't know	149	41	
Refused	32	6	
Missing	280	210	
Lifestyle behaviors			
UPF percentage			
Mean (SE)	66.0 (0.4)	62.7 (0.7)	<.01
Missing, n	738	767	
Days physically active at least 60 minutes per week			
Mean (SE)	4.77 (0.08)	4.78 (0.07)	.91
Missing, n	798	338	
BMI characteristics, n (%)			
BMI category[b]			
Underweight	141 (3.1)	75 (3.5)	.57
Normal weight	2739 (58.2)	1438 (58.2)	
Overweight	804 (17.5)	384 (15.7)	
Class I obesity	676 (13.7)	372 (14.7)	
Class II obesity	255 (5.0)	150 (5.3)	
Class III obesity	141 (2.5)	82 (2.7)	

(Continued on next column)

Abbreviations: BMI, body mass index; NHANES, National Health and Nutrition Examination Survey.
All prevalence estimates/analyses were weighted appropriately to account for the sampling technique.
[a] Design-based *t* test for numeric variables; design-based chi-square test for categorical variables.
[b] Underweight = below the 5th percentile, normal weight = 5th to less than the 85th percentile, class I obesity = BMI of 95th percentile to 120% of 95th percentile, class II obesity = BMI between 120% and 140% of 95th percentile, class III obesity = BMI greater than or equal to 140% of 95th percentile for age and sex.

Unadjusted Results

Before the pandemic, the prevalence of class III obesity varied by age group, from 0.6% among 2- to 5-year-olds to 3.5% among 12- to 19-year-olds ($P < .001$). During the pandemic, a similar age gradient was observed, with class III obesity prevalence highest among adolescents aged 12 to 19 years (3.7%), followed by 6- to 11-year-olds (2.5%) and 2- to 5-year-olds (0.7%) ($P = .048$). Days of PA per week was highest among those with class I obesity (4.43 [0.17] days), followed by those with class III obesity (4.09 [0.33] days) and Class II obesity (3.88 [0.17] days), respectively ($P = .033$) (Table 2). Children from the lowest-income households (≤130% of the federal poverty level) had the highest prevalence of class III obesity (3.6%), compared with 2.3% in the 130% to 185% family monthly poverty

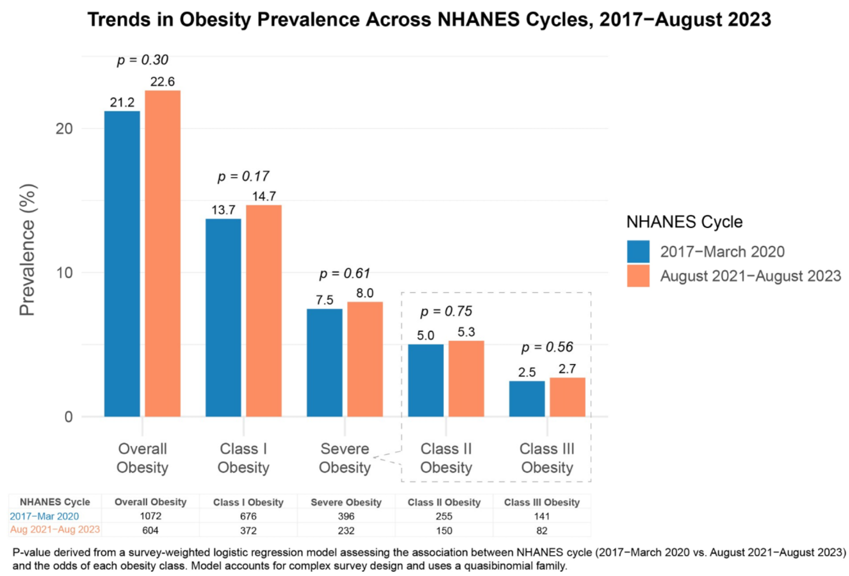

FIGURE 1.
Prevalence of overall obesity, class I, class II, class III, and severe obesity (II+III) among US children and adolescents, NHANES 2017–2020 (pre-pandemic) and March 2021 to 2023 (pandemic).
Abbreviation: NHANES, National Health and Nutrition Examination Survey.

level (FPL) group and 2.5% among those with income greater than 185% FPL ($P = .026$) (Table 3).

Adjusted Models

Before the pandemic, adjusted models showed that compared with children aged 2 to 5 years (reference group), those aged 6 to 11 years had significantly higher odds of overall obesity (OR = 1.63, 95% CI: 1.18–2.24), severe obesity (OR = 3.31, 95% CI: 1.55–7.09), class II obesity (vs normal weight) (OR = 3.67, 95% CI: 1.67–8.06), and in particular, class III obesity (vs normal weight) (OR = 3.93, 95% CI: 1.35–11.45). Similarly, adolescents aged 12 to 19 years had greater odds of severe obesity (OR = 2.83, 95% CI: 1.29–6.18), including almost 8 times the odds of class III obesity (OR = 7.75, 95% CI: 2.17–27.60), compared with 2- to 5-year-olds.

Compared with white children, Black children had almost twice the odds of severe obesity (OR = 1.87, 95% CI: 1.15–3.04) and more than 3 times the odds of class III obesity (OR = 3.32, 95% CI: 1.52–7.24), whereas Asian children had half the odds of obesity (OR = 0.49, 95% CI: 0.33–0.74) and 66% lower odds (OR = 0.34, 95% CI: 0.16–0.73) of severe obesity. Compared with those with family income at 130% to 185% FPL, children from higher-income households (>185% FPL) had lower odds of overall obesity (OR = 0.56, 95% CI: 0.38–0.83). Children meeting the PA guideline of at least 60 minutes daily had lower odds of overall obesity and class II obesity, compared with those who did not (OR = 0.91, 95% CI: 0.85–0.97 and OR = 0.86, 95% CI: 0.76–0.97, respectively), with the direction of the effect for class I and III substantiating this finding, without reaching significance (Table 4). There was no difference in obesity categories by UPF quartile.

During the pandemic, meeting the PA guideline of at least 60 minutes daily is the only significant protective factor for overall obesity (OR = 0.86, 95% CI: 0.76–0.99). No other significant associations were observed between obesity classes, severity, and chosen predictors (Table 5).

Sensitivity analyses modeling %UPF as a continuous variable yielded results consistent with the main analyses: no significant associations between UPF intake and obesity severity emerged, while PA remained protective in some categories (Supplemental Tables 1–4). These findings suggest that our conclusions are robust to alternative specifications of UPF intake.

DISCUSSION

Results presented here from the most recent NHANES data revealed several key findings. First, the prevalence of all obesity classes rose modestly from before to during the COVID-19 pandemic. The overall 1.4% rise in obesity prevalence among US youth from before to during the pandemic translates to more than 1 million additional children at risk for obesity-related comorbidities.[51] Although not statistically significant compared with the prior NHANES cycle's data, this uptrend is clinically meaningful given its potential implications for population health, especially in terms of the absolute number of children at risk for cardiometabolic complications and long-term health burdens. Second, UPF accounted for a large proportion of daily energy intake, declining slightly from 66.0% before the

TABLE 2. Descriptive Characteristics, UPF Energy Intake, and Physical Activity by Obesity Class Among Children and Adolescents, NHANES 2017 to March 2020 (N = 4756)

	Overall Sample		Class I Obesity		Class II Obesity		Class III Obesity		
	(N = 4756)		(N = 676)		(N = 255)		(N = 141)		
	Number of Participants[a]	Prevalence (95% CI)[b] or Mean (SE)[c]	Number of Participants[a]	Prevalence (95% CI)[b] or Mean (SE)[c]	Number of Participants[a]	Prevalence (95% CI)[b] or Mean (SE)[c]	Number of Participants[a]	Prevalence (95% CI)[b] or Mean (SE)[c]	*P* Value[d]
Overall sample	4756		676	13.7 (12.8, 14.6)	255	5.0 (4.1, 5.9)	141	2.5 (1.9, 3.0)	
Sex									.466
Male	2414	50.6 (48.2, 53.0)	340	14.4 (13.2, 15.6)	135	5.7 (4.5, 7.0)	68	2.5 (1.8, 3.2)	
Female	2342	49.4 (47.0, 51.8)	336	13.0 (11.5, 14.6)	120	4.3 (3.1, 5.4)	73	2.4 (1.7, 3.2)	
Age group, years									<.001
2–5	1154	21.1 (19.5, 22.6)	123	10.9 (8.8, 13.1)	19	1.7 (0.9, 2.5)	8	0.6 (0.1, 1.2)	
6–11	1770	33.3 (31.7, 34.9)	273	14.7 (13.0, 16.4)	117	6.3 (4.1, 8.5)	47	2.1 (1.5, 2.8)	
12–19	1832	45.6 (43.3, 47.9)	280	14.3 (12.6, 15.9)	119	5.6 (4.3, 6.9)	86	3.5 (2.6, 4.5)	
Race and ethnicity									
Hispanic	1145	25.0 (20.1, 29.9)	217	19.0 (16.9, 21.2)	86	6.8 (5.4, 8.2)	30	2.5 (1.4, 3.5)	NE[e]
White	1475	50.2 (44.2, 56.1)	193	11.7 (10.0, 13.4)	64	4.3 (2.9, 5.7)	33	1.7 (0.7, 2.6)	
Black	1270	13.3 (9.7, 17.0)	179	14.6 (12.2, 16.9)	75	6.1 (4.4, 7.9)	64	5.7 (4.3, 7.2)	
Asian	421	5.0 (3.0, 6.9)	33	7.9 (5.6, 10.2)	9	2.0 (0.5, 3.6)	0	0.0 (0.0, 0.0)	
Other	445	6.5 (5.4, 7.7)	54	11.5 (7.4, 15.7)	21	3.4 (1.2, 5.5)	14	3.8 (0.8, 6.9)	
Family monthly poverty level category									.080
≤1.30	1996	36.0 (33.1, 38.9)	315	17.3 (15.1, 19.6)	105	5.0 (3.8, 6.1)	71	3.5 (2.7, 4.4)	
1.30–1.85	618	13.4 (11.2, 15.6)	92	14.2 (11.1, 17.3)	46	6.6 (4.4, 8.9)	18	3.5 (1.5, 5.6)	
>1.85	1681	50.6 (46.6, 54.6)	197	10.5 (8.9, 12.2)	70	4.1 (2.7, 5.6)	36	1.4 (0.8, 2.4)	
UPF percentage (%) of daily energy intake									
Mean (SE)	4018	66.0 (0.4)	575	67.03 (0.59)	218	68.97 (1.35)	128	65.32 (1.87)	.263
Days physically active at least 60 minutes per week									
Mean (SE)	4296	4.77 (±0.08)	676	4.43 (0.17)	255	3.88 (0.17)	141	4.09 (0.33)	.033

Abbreviations: NHANES, National Health and Nutrition Examination Survey; UPF, ultra-processed food.
All prevalence estimates/analyses were weighted appropriately to account for the sampling technique; prevalence estimates reported as percentages.
[a] Unweighted sample size reported.
[b] Weighted prevalence (weighted CI) reported.
[c] Weighted mean (weighted SE) reported.
[d] Design-based one-way analysis of variance for numeric variables; design-based chi-square test for categorical variables.
[e] NE = not estimable due to zero frequency in Asian group.

TABLE 3. Descriptive Characteristics, UPF Energy Intake, and Physical Activity by Obesity Class Among Children and Adolescents, NHANES 2021–2023 (N = 2501)

	Overall Sample (N = 2501)		Class I Obesity (N = 372)		Class II Obesity (N = 150)		Class III Obesity (N = 82)		
	Number of Participants[a]	Prevalence (95% CI)[b] or Mean (SE)[c]	Number of Participants[a]	Prevalence (95% CI)[b] or Mean (SE)[c]	Number of Participants[a]	Prevalence (95% CI)[b] or Mean (SE)[c]	Number of Participants[a]	Prevalence (95% CI)[b] or Mean (SE)[c]	*P* Value[d]
Overall sample	2501		372	14.7 (13.7, 15.7)	150	5.3 (4.0, 6.5)	82	2.7 (2.1, 3.3)	
Sex									.228
Male	1257	51.4 (49.7, 53.2)	196	16.0 (14.7, 17.3)	74	5.2 (3.6, 6.9)	51	3.5 (2.2, 4.7)	
Female	1244	48.6 (46.8, 50.3)	176	13.3 (11.2, 15.4)	76	5.3 (3.7, 6.8)	31	1.9 (1.1, 2.7)	
Age group, years									.048
2–5	515	19.7 (18.1, 21.3)	63	12.3 (9.1, 15.6)	15	2.6 (1.2, 4.0)	4	0.7 (0.1, 1.5)	
6–11	864	33.3 (31.3, 35.2)	143	16.7 (14.5, 19.0)	57	5.4 (3.1, 7.8)	29	2.5 (1.4, 3.5)	
12–19	1122	47.0 (44.9, 49.2)	166	14.2 (12.0, 16.4)	78	6.2 (4.7, 7.8)	49	3.7 (2.5, 4.8)	
Race and ethnicity									NE[e]
Hispanic	741	25.2 (18.9, 31.6)	131	17.8 (14.3, 21.3)	58	7.0 (4.6, 9.4)	31	4.1 (2.1, 6.0)	
White	995	46.1 (40.9, 51.3)	118	12.5 (10.9, 14.1)	47	4.1 (2.9, 5.4)	20	1.7 (0.8, 2.7)	
Black	366	12.0 (9.2, 14.7)	74	20.9 (14.0, 27.8)	35	10.1 (5.3, 14.9)	20	5.0 (1.8, 8.3)	
Asian	173	8.3 (4.5, 12.1)	17	8.6 (3.4, 13.7)	4	1.9 (0.1, 3.8)	0	0.0 (0.0, 0.0)	
Other	226	8.4 (7.0, 9.7)	32	14.3 (10.6, 18.0)	6	2.8 (0.3, 5.2)	11	3.3 (1.4, 5.3)	
Family monthly poverty level category									.026
≤1.30	840	32.6 (26.9, 38.3)	137	15.5 (13.6, 17.5)	63	7.5 (5.4, 9.7)	37	3.6 (2.7, 4.6)	
1.30–1.85	418	16.9 (14.5, 19.3)	71	15.7 (11.5, 19.8)	30	6.4 (3.7, 9.0)	12	2.3 (1.0, 3.6)	
>1.85	986	50.5 (43.3, 57.7)	128	13.8 (11.8, 15.8)	37	3.0 (1.8, 4.2)	27	2.5 (1.5, 3.5)	
UPF percentage (%) of daily energy intake									
Mean (SE)	1734	62.7 (0.7)	260	63.13 (1.50)	101	63.34 (2.94)	59	65.31 (3.21)	.835
Days physically active at least 60 minutes per week									
Mean (SE)	2163	4.78 (0.07)	372	4.37 (0.13)	150	3.97 (0.26)	82	3.75 (0.32)	.240

Abbreviations: NHANES, National Health and Nutrition Examination Survey; UPF, ultra-processed food.
All prevalence estimates/analyses were weighted appropriately to account for the sampling technique; prevalence estimates reported as percentages.
[a] Unweighted sample size reported.
[b] Weighted prevalence (weighted CI) reported.
[c] Weighted mean (weighted SE) reported.
[d] Design-based one-way analysis of variance for numeric variables; design-based chi-square test for categorical variable.
[e] NE = not estimable due to zero frequency in Asian group.

TABLE 4. Logistic Regression to Estimate Odds of Obesity (Overall and Severity) by UPF Intake, and Physical Activity, 2017 to March 2020 (N = 4756)					
	Overall Obesity OR (95% CI)	Class I Obesity OR (95% CI)	Severe Obesity OR (95% CI)	Class II Obesity OR (95% CI)	Class III Obesity OR (95% CI)
Sex					
Male	Reference	Reference	Reference	Reference	Reference
Female	0.80 (0.67, 0.97)[a]	0.89 (0.69, 1.15)	0.68 (0.5, 0.9)[a]	0.56 (0.38, 0.82)[b]	1.06 (0.55, 2.05)
Age group, years					
2–5	Reference	Reference	Reference	Reference	Reference
6–11	1.63 (1.18, 2.24)[b]	1.38 (0.94, 2.02)	3.31 (1.55, 7.09)[b]	3.67 (1.67, 8.06)[b]	3.93 (1.35, 11.45)[a]
12–19	1.62 (1.09, 2.4)[a]	1.30 (0.80, 2.11)	3.51 (1.7, 7.23)[b]	2.83 (1.29, 6.18)[a]	7.75 (2.17, 27.60)[b]
Race and ethnicity					
White	Reference	Reference	Reference	Reference	Reference
Hispanic	1.37 (0.97, 1.94)	1.33 (0.92, 1.92)	1.45 (0.85, 2.5)	1.70 (0.99, 2.92)	1.40 (0.50, 3.90)
Black	1.27 (0.91, 1.78)	1.02 (0.71, 1.45)	1.87 (1.15, 3.04)[a]	1.18 (0.64, 2.17)	3.32 (1.52, 7.24)[b]
Asian	0.49 (0.33, 0.74)[b]	0.52 (0.32, 0.87)[b]	0.34 (0.16, 0.73)[b]	0.42 (0.19, 0.97)[a]	NE[c]
Other	1.14 (0.69, 1.9)	1.12 (0.66, 1.90)	1.16 (0.58, 2.33)	0.89 (0.41, 1.96)	2.06 (0.46, 9.17)
FPL category (FPL ratio)					
≤1.30	Reference	Reference	Reference	Reference	Reference
1.30–1.85	0.98 (0.69, 1.37)	0.77 (0.51, 1.16)	1.52 (0.86, 2.67)	1.87 (1.13, 3.09)[a]	1.08 (0.36, 3.25)
>1.85	0.56 (0.38, 0.83)[b]	0.50 (0.32, 0.77)[b]	0.84 (0.55, 1.29)	1.11 (0.61, 2.03)	0.40 (0.23, 0.70)[b]
UPF percentage quartiles					
Q1 (lowest)	Reference	Reference	Reference	Reference	Reference
Q2	1 (0.72, 1.39)	1.02 (0.70, 1.50)	0.88 (0.51, 1.54)	0.92 (0.44, 1.89)	0.73 (0.31, 1.71)
Q3	0.97 (0.73, 1.3)	0.98 (0.72, 1.33)	0.93 (0.56, 1.53)	1.05 (0.57, 1.93)	0.70 (0.31, 1.58)
Q4 (highest)	1.14 (0.84, 1.54)	1.12 (0.79, 1.59)	0.99 (0.54, 1.81)	1.17 (0.49, 2.82)	0.63 (0.26, 1.54)
Physical activity					
≥60 min days in a week	0.91 (0.85, 0.97)[b]	0.92 (0.85, 1.00)[a]	0.88 (0.82, 0.96)[b]	0.86 (0.76, 0.97)[a]	0.92 (0.82, 1.04)

Abbreviations: FPL, family monthly poverty level; OR, odds ratio; UPF, ultra-processed food.
Logistic correction controlling for age, sex, race, ethnicity, household income, UPF consumption (quartiles), and physical activity (continuous).
[a] $P < .05$.
[b] $P < .01$.
[c] NE = not estimable due to complete separation (no cases in group); not interpretable as statistical significance.

pandemic to 62.7% during the pandemic. Third, overall PA remained unchanged between the 2 periods, averaging 4.77 days/week, well below national recommendations[46] and was protective against overall obesity both before and during the pandemic and class I/II obesity before the pandemic. Lastly, pre-pandemic obesity prevalence was higher among older, Black, and male youth compared with their respective counterparts, which is consistent with previous studies during the pandemic.[3,4] Although some of the associations did not reach statistical significance or diverged from our initial hypotheses, these findings are nonetheless important. The absence of consistent associations, particularly during the pandemic period, underscores the complexity of behavioral responses during a time of widespread disruption to routines, access, and environments. Rather than signaling a lack of impact, these null or inverse findings may point to variability in how youth adapted to this pandemic's conditions, with some experiencing worsened health behaviors while others may have benefited from increased family meals or reduced access to UPFs. These results highlight the limits of a one-size-fits-all interpretation of obesity risk during public health emergencies and emphasize the need for more nuanced, context-aware interventions to decrease the risk of developing future symptomatic cardiometabolic diseases.

Results showed a modest 3.3% decline in %UPF consumption from before to during the pandemic, likely reflecting pandemic-related shifts such as increased home-cooked meals, reduced restaurant access, financial constraints, and changing food preferences. Social trends (eg, cooking shows, social media recipes) and safety concerns about restaurant-prepared foods may also have contributed.[52] Despite this decline, UPFs still accounted for more than 60% of daily caloric intake among US youth,

TABLE 5. Logistic Regression to Estimate Odds of Obesity (Overall and Severity) by UPF Intake, and Physical Activity, NHANES 2021–2023 (N = 2501)

	Overall Obesity OR (95% CI)	Class I Obesity OR (95% CI)	Severe Obesity OR (95% CI)	Class II Obesity OR (95% CI)	Class III Obesity OR (95% CI)
Sex					
Male	Reference	Reference	Reference	Reference	Reference
Female	0.64 (0.25, 1.66)	0.66 (0.20, 2.18)	0.71 (0.27, 1.88)	0.86 (0.28, 2.62)	0.49 (0.10, 2.31)
Age group, years					
2–5	Reference	Reference	Reference	Reference	Reference
6–11	1.4 (0.61, 3.19)	1.38 (0.42, 4.47)	2.2 (0.36, 13.51)	2.68 (0.39, 18.27)	3.14 (0.20, 49.43)
12–19	1.22 (0.43, 3.45)	1.09 (0.38, 3.11)	2.5 (0.31, 20.26)	2.99 (0.47, 19.17)	3.81 (0.16, 90.27)
Race and ethnicity					
White	Reference	Reference	Reference	Reference	Reference
Hispanic	1.66 (0.55, 4.99)	1.67 (0.45, 6.27)	1.62 (0.55, 4.8)	1.60 (0.38, 6.64)	2.32 (0.46, 11.60)
Black	1.76 (0.65, 4.78)	1.75 (0.48, 6.41)	1.44 (0.33, 6.34)	1.71 (0.18, 16.59)	0.98 (0.05, 18.02)
Asian	0.24 (0.03, 1.8)	0.33 (0.04, 2.51)	NE[a]	NE[a]	NE[a]
Other	1.04 (0.26, 4.21)	1.18 (0.22, 6.42)	0.73 (0.08, 6.51)	0.36 (0.00, 41.01)	1.47 (0.11, 19.34)
FPL category (FPL ratio)					
≤1.30	Reference	Reference	Reference	Reference	Reference
1.30–1.85	0.99 (0.42, 2.35)	1.12 (0.31, 4.08)	0.76 (0.36, 1.6)	0.83 (0.25, 2.76)	0.55 (0.05, 6.26)
>1.85	0.71 (0.36, 1.42)	0.96 (0.41, 2.22)	0.35 (0.09, 1.38)	0.25 (0.05, 1.16)	0.45 (0.06, 3.45)
UPF percentage quartiles					
Q1 (lowest)	Reference	Reference	Reference	Reference	Reference
Q2	0.9 (0.41, 1.97)	0.78 (0.32, 1.89)	1.23 (0.31, 4.96)	0.97 (0.11, 8.25)	1.54 (0.30, 7.95)
Q3	0.86 (0.31, 2.43)	0.72 (0.15, 3.41)	1.46 (0.32, 6.6)	1.32 (0.35, 4.95)	1.67 (0.13, 21.35)
Q4 (highest)	1.09 (0.52, 2.26)	1.04 (0.34, 3.18)	1.11 (0.31, 4.07)	0.89 (0.18, 4.41)	1.50 (0.12, 18.63)
Physical activity					
≥60 min days in a week	0.86 (0.76, 0.99)[b]	0.87 (0.71, 1.07)	0.87 (0.63, 1.19)	0.85 (0.61, 1.18)	0.83 (0.56, 1.24)

Abbreviations: FPL, family monthly poverty level; NHANES, National Health and Nutrition Examination Survey; OR, odds ratio; UPF, ultra-processed food.
Logistic regression controlling for age, sex, race, ethnicity, household income, UPF consumption (quartiles), and physical activity (continuous).
[a] NE = not estimable due to complete separation (no cases in group); not interpretable as statistical significance.
[b] $P < .05$.

a level that remains concerning for long-term cardiometabolic health.[53]

Unexpectedly, youth in the highest quartile of %UPF consumption before the pandemic had an inverse association with class III obesity, although this association was not statistically significant. This inverse trend may reflect reverse causality (ie, youth with severe obesity already receiving dietary interventions), underreporting due to social desirability bias, or greater awareness of dietary guidance. Importantly, the lack of statistical significance warrants caution against overinterpretation. These findings contrast with prior research: a review of 17 observational studies reported that high UPF intake was associated with nearly a 3-fold greater likelihood of obesity and a 19% higher risk of obesity in young children.[21–26,52–57] However, no prior work has examined UPF consumption stratified by obesity class, making this study the first to explore associations by obesity severity. Mechanistic studies highlight UPFs' high palatability, large portion sizes, ease of consumption, and aggressive marketing, all of which encourage frequent snacking, rapid eating, and disrupted satiety signaling, contributing to obesity risk that often persists into adulthood.[5–9,55]

The absence of clear associations between UPF intake and obesity severity during the pandemic may reflect several factors: (1) reporting and recall bias, potentially exacerbated by disrupted routines; (2) pandemic-driven increases in home-prepared meals that temporarily reduced UPF exposure[52]; (3) temporal misalignment between short-term dietary recalls and long-term weight changes; (4) behavioral confounding, as families reducing UPF intake may have also adopted other protective habits (eg, more family meals, improved sleep); and (5) uniformly high UPF intake across groups, which may dilute between-group differences. Taken together, these findings underscore the difficulty of interpreting dietary exposures during periods of societal disruption. Although UPF consumption remains alarmingly high among US youth,[53] further research is needed to clarify its relationship with obesity severity, particularly during times of rapid environmental and behavioral change such as the pandemic.

A key finding was that overall, PA remained unchanged between the 2 study periods, averaging 4.77 days per week, and was protective of overall, class I/II, and severe obesity before the pandemic and overall obesity only during the pandemic. Indeed, studies have consistently shown that increased PA is associated with lower odds of obesity.[32] Several social and behavioral factors influence PA, including screen time and access to outdoor spaces or equipment. During the pandemic, studies reported that US children experienced a significant increase in screen time[59,60] and a simultaneous reduction in PA due to social distancing, lockdowns, and cancellation of school and community recreational events.[31,32] Pandemic-related job loss may have further reduced families' ability to afford gym memberships, activity fees, and sports equipment. A recent study showed that students were significantly less likely to achieve healthy cardiorespiratory and musculoskeletal fitness zones during the pandemic vs before the pandemic.[61] These changes in daily structure and routine also contributed to marked increases in sedentary behavior, with screen time displacing opportunities for movement and potentially increasing exposure to food cues and snacking, further compounding obesity risk.[59,60] Additionally, PA may have become more variable across subgroups, influenced by disparities in access to safe outdoor spaces, structured activities, and school-based programs.[31,32] Conversely, some youth may have substituted unstructured or household PA for formal exercise, which might not have been fully captured by the survey instrument. Importantly, population-level stability may mask heterogeneity across subgroups, with some youth experiencing significant reductions in PA while others maintained or even increased their activity. Moreover, increases in sedentary time and screen use may have offset the protective effects of PA that were shown before the pandemic, obscuring associations with weight status. These complexities underscore the need for more detailed and objective measurement methods to better capture youth PA patterns in future surveillance efforts.

Potential mechanisms linking UPF intake and PA to varying degrees of obesity severity may differ by both metabolic and behavioral pathways. UPFs are typically energy-dense, low in fiber and protein, and high in refined carbohydrates and additives that impair satiety signaling, promote hyperpalatable eating, and increase glycemic load, all factors that contribute to excess caloric intake and weight gain in early obesity stages (class I).[16,17,55] As obesity severity increases, physiological adaptations such as leptin and insulin resistance, alterations in gut microbiota, and chronic low-grade inflammation may diminish the effectiveness of behavioral changes alone.[6–8,55] These changes can lead to a biological defense of a higher set point weight, making it more difficult for youth with class II or III obesity to respond to reductions in UPF intake or modest increases in PA. Moreover, although PA is protective against weight gain and can improve metabolic markers, its impact on weight loss is typically modest and may be insufficient for youth with severe obesity without concurrent dietary or clinical interventions.[29,30,32] Together, these mechanisms may help explain why associations between UPF or PA and obesity risk appear more detectable in lower obesity classes.

Finally, pre-pandemic results showing significantly higher obesity prevalence among older youth, Black youth, and youth from lower-income backgrounds, compared with their respective counterparts, are consistent with prior NHANES data.[61–66] These observed disparities echo a troubling and well-documented pattern and underscore the entrenched nature of US obesity inequities, shaped by intersecting social, structural, and environmental exposures. That these disparities persist more than 2 to 3 decades into national obesity prevention efforts speaks to the urgent need for more equity-driven, culturally responsive initiatives.

Addressing pediatric obesity requires bold and specific public health strategies while acknowledging that current policies have not been effective. For example, concrete next steps could include integrating Nova classifications into national dietary guidelines to help consumers identify and limit UPFs, revising front-of-package labeling to clearly indicate processing levels, and updating school food procurement standards to prioritize minimally processed options. An integrated approach linking labeling reform, procurement policy, and dietary guidance could help translate research insights into effective strategies to promote healthier pediatric outcomes. This approach moves away from traditional American dietary policy that has traditionally focused on US Dietary guidelines food groups, nutrient consumption analysis (eg, National School Lunch nutrition standards[67]) and other legal mechanisms like labeling and consumer protection laws—policies that are largely siloed. The challenge for policymakers should focus on synthesizing the different interventions noted above into a coherent and effective strategy to reduce pediatric obesity.[68] For example, this novel population-level analysis provides an example of how to do that because it examines a novel approach by examining Nova food classifications rather than traditional USDA 5 food groups or eating patterns. This alternate strategy, from food groups by nutrient profile to production methods, allows new insights into which strategy, or combination of strategies, yields the most effective approach to creating new policy for healthy pediatric outcomes.[69] This innovative approach is just the start of where an integrated study of labeling law, production classifications, nutrient classifications, food as medicine, exercise promotion, and effective consumer information transmission (label content and marking techniques) in the context of public health data can forge new solutions.[70,71]

A key limitation of this study is its cross-sectional design, which precludes causal inference between the pandemic and changes in obesity trends and limits the ability to rule out reverse causality as a potential explanation for the inverse association between UPF intake and class III obesity. Additionally, self-reported data on dietary intake and PA may introduce recall and social desirability bias. The increased proportion of missing data for some variables also impacted the robustness of the findings. The absence of NHANES data from March 2020 to July 2021 limits our ability to assess short-term changes in obesity risk and related behaviors immediately following the onset of the COVID-19 pandemic. Additionally, differences in sample sizes between the pre- and during-pandemic samples may limit generalizability, as disruptions to NHANES data collection during the pandemic could have resulted in underrepresentation of more vulnerable populations. Finally, although the Nova classification system is widely used to categorize foods by degree of processing, an important limitation of our study is the lack of sufficient detail in the NHANES dietary data to precisely characterize food processing levels. For example, limited information on preparation methods, brand names, or ingredient details in mixed dishes and composite foods may lead to misclassification of some items as ultra-processed or not. Such misclassification could result in under- or overestimation of UPF intake. Importantly, any resulting misclassification is likely nondifferential with respect to obesity outcomes, potentially biasing our associations toward the null.

However, the study's strengths include the use of the most currently available nationally representative NHANES data, providing insights into trends across diverse demographic groups representative of the US Dietary guidelines that adopt the Nova classification that can empower individuals to make informed choices, while also supporting educational, clinical, and policy interventions to improve population health.

CONCLUSION

This population-level analysis reveals concerning trends in dietary patterns and the prevalence of obesity among US youth; obesity prevalence was 21.2% before the COVID-19 pandemic and 22.6% during the pandemic, with no clear patterns of associations between increasing obesity severity and UPF intake and PA habits. These findings suggest a complex relationship between diet, PA, and obesity severity. Furthermore, these findings highlight the urgent need for testable, targeted interventions that move beyond siloed policies toward integrated, innovative strategies, linking food classification, labeling, access, and activity to reduce pediatric obesity and prevent cardiometabolic disease across the life course.

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ABBREVIATIONS

BMI: body mass index
FNDDS: USDA Food and Nutrition Database for Dietary Studies
FPL: family monthly poverty level
GLM: generalized linear model
NHANES: National Health and Nutrition Examination Survey
OR: odds ratio
PA: physical activity
UPF: ultra-processed food
USDA: United States Department of Agriculture

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Dr Messiah conceptualized and designed the study, curated and analyzed the data, and drafted the initial manuscript. Ms Guo and Dr Xie conducted the analyses. Dr DeSantis reviewed all analyses, weighting, and code. Drs Steele and Neri assisted with the food coding according to Nova, all dietary analyses, and reviewing and revising the manuscript. Dr McCabe assisted with drafting the policy recommendations and with reviewing and revising the manuscript. Ms Ernest carried out the initial analyses and assisted with drafting the initial manuscript. Dr Cartwright critically reviewed and revised the manuscript. Dr Barlow critically reviewed and revised the manuscript. Dr Lipshultz critically reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects.

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