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Disparities in weight changes during the COVID-19 pandemic-related lockdown in youths

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Abstract

Objective: This study evaluates whether changes in weight among school-aged youth in California due to the COVID-19 lockdown vary by social constructs of race/ethnicity and associated social factors.

Methods: Including 160,472 youth aged 5 to 17 years enrolled at Kaiser Permanente Southern California, mixed effects models stratified by age group were fitted to estimate changes in distance from the median BMI-for-age from March 2020 to January 2021 (lockdown) compared with the same period before the pandemic.

Results: Excess pandemic weight gain was higher among Black and Hispanic youth aged 5 to 17 years than among White and Asian youth; this difference was most pronounced in those aged 5 to 11 years. In youth aged 5 to 11 years, the distance from the median BMI-for-age increased by 1.72 kg/m^2 (95% CI: 1.61-1.84) in Hispanic and 1.70 kg/m^2 (95% CI: 1.47-1.94) in Black youth during the lockdown compared with 1.16 kg/m^2 (95% CI: 1.02-1.29) in non-Hispanic White youth. The excess weight gain was also higher in youth with fewer neighborhood parks and those with state-subsidized health insurance.

Conclusions: The COVID-19 pandemic lockdown led to a gain of excess body weight, particularly for Black and Hispanic youth; this weight gain varied by social factors associated with race and ethnicity.

INTRODUCTION

The COVID-19 pandemic has dramatically altered many aspects of life across all population sectors, including children and adolescents [1]. During the pandemic-related lockdown, schools were intermittently closed, learning was moved online, recreational activities were curtailed, social activities were restricted, and the food supply was impacted [2, 3]. These changes, combined with the emotional and financial stress caused by the pandemic, may affect energy balance and, consequently, body weight [4]. We recently reported that the pandemic contributed to accelerated weight gain among Southern California children and led to an almost 5.1% increase in the prevalence of obesity, the same increase observed nationally over the past nearly two decades combined [5, 6].

In the United States, childhood obesity (≥95th percentile of body mass index [BMI]-for-age) disproportionately affects Hispanic and Black youth compared with non-Hispanic White youth (25.8% and 22.0% vs. 14.1%, respectively) and children from families with low income [7, 8]. Although the COVID-19 pandemic has affected the country as a whole, Hispanic people, non-Hispanic

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Black people, and populations with low income and socioeconomic status have shouldered the burden of higher case rates, hospitalizations, and deaths [9, 10]. The same populations may also experience a higher burden of weight gain during the pandemic.

The present study investigates disparities in weight changes among youths 5 to 17 years of age of different racial/ethnic and social groups among members of a Kaiser Permanente health plan in Southern California. Early in the pandemic, California had one of the world's highest per capita rates of COVID-19 infection, followed by one of the most prolonged and strict lockdown orders in the United States, lasting from March 19, 2020, to January 25, 2021.

Study Importance

What is already known?

- The pandemic contributed to excess weight gain among Southern California children.
- Overall childhood obesity during this period increased by almost 5.1%.

What does this study add?

- We observed significant racial and social disparities in weight gain during the COVID-19 pandemic lockdown.
- Black and Hispanic youth gained more body weight than their White counterparts.
- Youth from low-income families and those with limited access to neighborhood parks also gained more weight.

How might these results change the direction of research or the focus of clinical practice?

- Programs that promote healthy eating and physical activity should be developed that account for the unique stressors and lifestyle changes during the COVID-19 pandemic lockdown that will likely persist in ways we currently do not understand.

METHODS

Study design and setting

To compare BMI in youth before and during the COVID-19 pandemic-related lockdown (including the stay-home period) in California, we conducted a retrospective cohort study among pediatric health plan members of Kaiser Permanente Southern California (KPSC), an integrated managed health care system that serves approximately 4.7 million members in Southern California (~19.5% of the Southern California population). We compared electronic health record data during the lockdown (March 1, 2020, through January 31, 2021) with data from the same youth before the lockdown (March 1, 2019, through January 31, 2020) as the comparison period. KPSC members receive care in medical offices and hospitals owned by KPSC throughout the nine-county region. The membership is diverse and similar in socioeconomic characteristics to the region's census demographics [11]. The KPSC Institutional Review Board approved the study and granted a waiver for informed consent.

Study population

We identified school-aged youth between 5 and 17 years enrolled at KPSC on March 16, 2020 ($n = 701{,}082$; Figure 1) [12]. To be eligible for the present study, youth were required to have a continuous health plan membership between January 1, 2020, and December 31, 2020, and in the 24 months prior to March 16, 2020 (allowing a 90-day gap in coverage), and to be free of any pediatric complex chronic conditions such as cerebral palsy and congenital and chromosomal abnormalities [13, 14]. Eligible youth ($n = 569{,}350$) were required to have one or more valid BMI measurements between June 16, 2020 (i.e., about 3 months after the start of the lockdown in California), and the end of the study period, January 31, 2021 ($n = 197{,}707$). We excluded youth without a BMI measurement during the comparison period (March 2019 to January 2020 = 37,235, 3.2%). The final analytical cohort comprised 160,472 youth (667,554 BMI measurements).

Body weight and height

Weight and height measurements, routinely obtained at clinic visits by trained medical staff, were extracted from the EMR; BMI was calculated as weight (kilograms) divided by the square of the height (meters). Well-child visits during the pandemic were conducted as in-person or phone/video visits with follow-up in a nurse clinic where weight and height were measured (mainly to update vaccination). In July 2020, in-person visits with weight and height measurements were at 76.4% of the pre-pandemic in-person visit numbers (Supporting Information Table S1). BMI percentiles are based on sex-specific BMI-for-age according to growth charts developed by the Centers for Disease Control and Prevention (Supporting Information Table S2) [15–18].

Our primary measure of increased adiposity was the absolute difference in the distance from the median BMI-for-age and sex [16]. This metric is a more reliable measure of change in adiposity, particularly for individuals in the upper end of the BMI distribution, compared with other methods such as BMI z score. It does not have an upper limit (as has BMI-for-age percentile) and can be used to assess adiposity across the entire BMI spectrum. In addition, we also provide data on change in body weight adjusted for height and the prevalence of overweight and obesity because these measures of weight status are more commonly used by clinicians [15, 19].

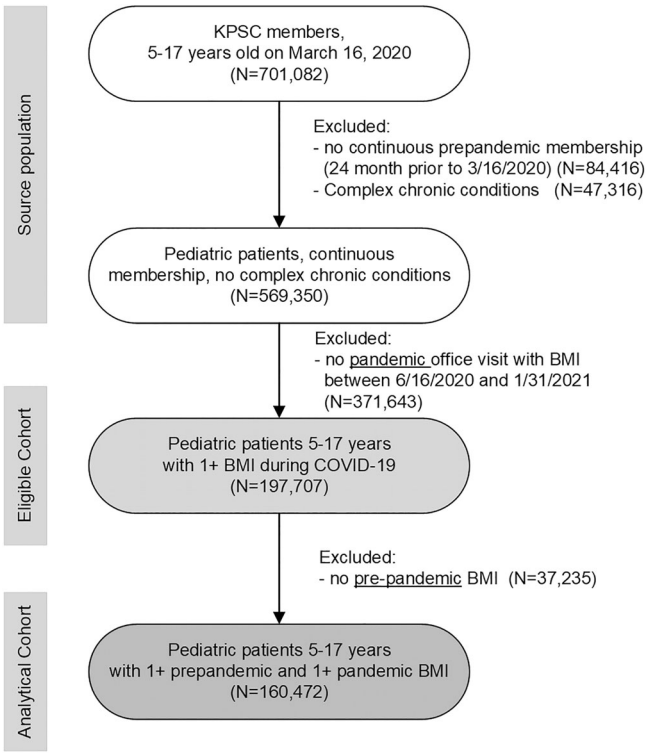


FIGURE 1 Study flowchart. KPSC, Kaiser Permanente Southern California

Main exposures and covariates

All covariates are defined in Supporting Information Table S2 [20]. We categorized self-reported race/ethnicity from various sources such as registration records, clinical visit records, and birth certificates as non-Hispanic White (hereafter, White), Hispanic or Latino (regardless of race, hereafter, Hispanic), Black or African American (hereafter, Black), Asian or Pacific Islander (API), and other or unknown race/ethnicity. Data for this study included US adults who self-reported as non-Hispanic Black (hereafter, Black), Hispanic or Latino, and non-Hispanic White (hereafter, White) individuals. Health insurance coverage through government health care assistance programs such as Medicaid (Yes/No) was used as a proxy for socioeconomic status. Neighborhood education and income were derived from geocoding patients' address information and were based on the 2010 US census block group and annual American Community Survey information. Neighborhood park information was derived using ArcGIS software (Version 10.1, ESRI, Redlands, California), Claritas LLC (Cincinnati, Ohio), and the ESRI USA 2019 parks layer package.

Statistical analysis

Standardized mean differences (SMD) were used to compare the KPSC source cohort with the analytical cohort; SMD values ≤ 0.2 were considered small [21]. We fit mixed-effect linear models for distance from the median BMI-for-age and body weight; Poisson regression was used for overweight and obesity. All models accounted for repeated measures within each child, using an autoregressive correlation structure and maximum likelihood estimation of covariance parameters to assess each outcome during the 11-month COVID-19 pandemic lockdown (March 2020 to January 2021) compared with the same children in the same calendar months before COVID-19 (March 2019 to January 2020). Similar to an interrupted time series design, we included a binary indicator representing the periods before or during the pandemic plus a calendar month by period interaction term. Additional details on the model development are described in the Supporting Information Methods. All final models included three three-way interactions for a pandemic by time by race/ethnicity, parks, and state-subsidized health insurance, as well as their main effects and two-way interactions and adjusted for sex, neighborhood education, and income. BMI and body weight models were also adjusted for BMI-for-age group at baseline, and the model for body weight was additionally adjusted for height. All analyses were performed with $\alpha = 0.05$ for two-sided tests using SAS version 9.4 (SAS Institute, Inc., Cary, North Carolina).

RESULTS

The analytical cohort was racially/ethnically diverse (50.7% Hispanic, 25.2% non-Hispanic White, 6.9% non-Hispanic Black, 10.4% Asian/Pacific Islander) and comparable to the overall KPSC pediatric population regarding sex, age, race/ethnicity, and socioeconomic factors (Supporting Information Table S3 and Table 1). Before the pandemic, 39.2% of children in the analytic cohort lived with overweight, obesity, or severe obesity compared with 39.4% of children in the KPSC source population.

The COVID-19 pandemic lockdown was associated with a higher distance from the median BMI-for-age compared with the prepandemic period, which varied by race/ethnicity, socioeconomic status, and number of neighborhood parks (Table 2). Excess weight gain compared with the same period before the pandemic lockdown was most pronounced among Hispanic and Black youth with an excess increase in the distance from the median BMI-for-age by 1.72 kg/m^2 (95% CI: 1.61-1.84) and 1.70 (95% CI: 1.47-1.94), respectively, during the pandemic compared with 1.16 (95% CI: 1.02-1.29) in non-Hispanic White youth (p for lockdown × time × race/ethnicity: $p < 0.001$ for 5- to 11-year-olds, $p < 0.001$ for 12- to 15-year-olds, and $p = 0.004$ for 16- to 17-year-olds, respectively). Although the excess weight gain overall was lower in youth aged 12 to 15 years and 16 to 17 years, Hispanic and Black youth consistently gained more than non-Hispanic White youth (Table 2).

Youth with state-subsidized health insurance gained more body weight than those with other insurance types (p for lockdown × time × state-subsidized insurance: $p < 0.001$ for 5- to 11-year-olds, $p = 0.02$ for 12- to 15-year-olds, and $p = 0.39$ for 16- to 17-year-olds, respectively). Among 5- to 11-year-olds, youth with state-subsidized health insurance increased their distance from the median BMI-for-age by 1.39 (95% CI: 1.21-1.56) compared with 1.16

TABLE 1 Characteristics of the analytical cohort by age group

		Age at baseline[b,c] (y)		
	Analytical cohort	5-11	12-15	16-17
n	160,472	84,762	51,635	24,075
Age at baseline				
Mean (SD)	11.5 (3.8)	8.4 (2.2)	14.1 (1.2)	16.9 (0.6)
Sex				
Girls	79,496 (49.5)	40,895 (48.2)	25,620 (49.6)	12,981 (53.9)
Boys	80,976 (50.5)	43,867 (51.8)	26,015 (50.4)	11,094 (46.1)
Race/ethnicity				
Non-Hispanic White	40,487 (25.2)	21,324 (25.2)	13,029 (25.2)	6134 (25.5)
Non-Hispanic Black	11,052 (6.9)	5546 (6.5)	3699 (7.2)	1807 (7.5)
Hispanic	81,421 (50.7)	42,524 (50.2)	26,504 (51.3)	12,393 (51.5)
Asian/Pacific Islanders	16,740 (10.4)	9454 (11.2)	5131 (9.9)	2155 (9.0)
Other/Unknown	10,772 (6.7)	5914 (7.0)	3272 (6.3)	1586 (6.6)
State-subsidized health insurance				
No	126,118 (78.6)	65,883 (77.7)	40,998 (79.4)	19,237 (79.9)
Yes	34,354 (21.4)	18,879 (22.3)	10,637 (20.6)	4838 (20.1)
Neighborhood education				
Less than high school	31,364 (19.5)	16,853 (19.9)	9898 (19.2)	4613 (19.2)
High school	35,961 (22.4)	19,085 (22.5)	11,499 (22.3)	5376 (22.3)
Some college or higher	93,147 (58.0)	48,824 (57.6)	30,237 (58.6)	14,086 (58.5)
Neighborhood income ($)				
<$35,000	36,034 (22.5)	19,303 (22.8)	11,409 (22.1)	5322 (22.1)
$35,000-$49,999	17,973 (11.2)	9599 (11.3)	5707 (11.1)	2667 (11.1)
$50,000-$74,999	25,971 (16.2)	13,810 (16.3)	8292 (16.1)	3869 (16.1)
$75,000-$99,999	21,225 (13.2)	11,215 (13.2)	6828 (13.2)	3182 (13.2)
$100,000-$149,999	29,194 (18.2)	15,320 (18.1)	9465 (18.3)	4408 (18.3)
$150,000 or more	30,075 (18.7)	15,514 (18.3)	9933 (19.2)	4628 (19.2)
Parks				
0	55,545 (34.6)	29,866 (35.2)	17,540 (34.0)	8139 (33.8)
1 (includes missing)	57,825 (36.0)	30,472 (36.0)	18,643 (36.1)	8710 (36.2)
2+	47,102 (29.4)	24,424 (28.8)	15,452 (29.9)	7226 (30.0)
BMI before March 2020				
n	160,472	84,762	51,635	24,075
Mean (SD)	20.8 (5.4)	18.4 (4.0)	22.9 (5.3)	24.9 (5.7)
% BMI distance to median				
Mean (SD)	19.3 (28.2)	18.2 (28.4)	20.8 (27.8)	20.2 (27.9)
BMI distance to median				
Mean (SD)	4.3 (6.3)	4.1 (6.4)	4.6 (6.2)	4.5 (6.2)
BMI-for-age[a]				
Underweight	3228 (2.0)	2013 (2.4)	852 (1.7)	363 (1.5)
Normal	94,419 (58.8)	50,804 (59.9)	29,552 (57.2)	14,063 (58.4)
Overweight	29,702 (18.5)	14,772 (17.4)	10,138 (19.6)	4792 (19.9)
Obesity	22,386 (14.0)	12,132 (14.3)	7203 (13.9)	3051 (12.7)
Severe obesity	10,737 (6.7)	5041 (5.9)	3890 (7.5)	1806 (7.5)
Missing	0	0	0	0

[a]Youth BMI-for-age was categorized at baseline as underweight (BMI-for-age < 5th percentile), normal weight (BMI-for-age ≥ 5th to <85th percentile), overweight (BMI-for-age ≥ 85th to <95th percentile), moderate obesity (BMI-for age ≥ 95th to <1.2 × 95th percentile), and severe obesity (BMI-for age ≥1.2 × 95th percentile).
[b]Baseline: March 1, 2020.
[c]Standardized mean differences (SMD) were tested for each variable between two Kaiser Permanente Southern California source populations. All SMD values were smaller then 0.2, suggesting no difference between the two groups.

TABLE 2 Predicted means and change in the distance from the median BMI-for-age in youth before and during the pandemic by race/ethnicity and socioeconomic factors

	Pre-pandemic (March 2019 to January 2020)			Pandemic (March 2020 to January 2021)			
Characteristic	Start, mean (SD)	End, mean (SD)	Change 1 (Δ1, 95% CI)	Start, mean (SD)	End, mean (SD)	Change 2 (Δ2, 95% CI)	Δ2-Δ1 (95% CI)
Age 5-11 years							
Race/ethnicity							
NH White	0.35 (0.03)	0.39 (0.03)	0.04 (−0.03 to 0.12)	0.43 (0.04)	1.64 (0.04)	1.20 (1.09 to 1.32)	1.16 (1.02 to 1.29)
Hispanic	0.52 (0.03)	0.76 (0.03)	0.24 (0.18 to 0.29)	0.78 (0.04)	2.74 (0.03)	1.96 (1.86 to 2.06)	1.72 (1.61 to 1.84)
NH Black	0.44 (0.05)	0.78 (0.05)	0.34 (0.22 to 0.47)	0.68 (0.07)	2.73 (0.06)	2.05 (1.85 to 2.25)	1.70 (1.47 to 1.94)
API	0.00 (0.04)	0.25 (0.04)	0.25 (0.15 to 0.35)	0.07 (0.06)	1.67 (0.05)	1.60 (1.44 to 1.77)	1.36 (1.16 to 1.55)
Other/unknown	0.22 (0.05)	0.47 (0.05)	0.25 (0.13 to 0.38)	0.53 (0.07)	1.86 (0.06)	1.32 (1.12 to 1.52)	1.07 (0.84 to 1.30)
State-subsidized health care							
No	0.42 (0.03)	0.47 (0.03)	0.04 (−0.03 to 0.12)	0.51 (0.04)	1.71 (0.04)	1.20 (1.09 to 1.32)	1.16 (1.02 to 1.29)
Yes	0.56 (0.04)	0.62 (0.04)	0.07 (−0.02 to 0.16)	0.74 (0.06)	2.20 (0.05)	1.46 (1.31 to 1.61)	1.39 (1.21 to 1.56)
Neighborhood parks							
No park	0.39 (0.03)	0.50 (0.03)	0.10 (0.03 to 0.18)	0.59 (0.05)	1.80 (0.04)	1.22 (1.10 to 1.34)	1.11 (0.97 to 1.25)
1 park	0.46 (0.03)	0.50 (0.03)	0.04 (−0.03 to 0.12)	0.54 (0.05)	1.74 (0.04)	1.20 (1.09 to 1.32)	1.16 (1.02 to 1.29)
2 or more parks	0.35 (0.03)	0.42 (0.03)	0.07 (−0.00 to 0.14)	0.55 (0.04)	1.46 (0.04)	0.91 (0.80 to 1.02)	0.84 (0.71 to 0.97)
Age 12-15 years							
Race/ethnicity							
NH White	0.36 (0.04)	0.52 (0.04)	0.16 (0.09 to 0.23)	0.47 (0.05)	1.17 (0.04)	0.70 (0.58 to 0.81)	0.54 (0.40 to 0.67)
Hispanic	0.78 (0.03)	0.76 (0.03)	−0.02 (−0.08 to 0.04)	0.74 (0.04)	1.68 (0.03)	0.93 (0.84 to 1.03)	0.95 (0.84 to 1.07)
NH Black	0.85 (0.06)	0.85 (0.06)	−0.00 (−0.13 to 0.13)	0.89 (0.08)	1.96 (0.06)	1.08 (0.88 to 1.27)	1.08 (0.85 to 1.30)
API	0.28 (0.05)	0.29 (0.05)	0.01 (−0.10 to 0.13)	0.17 (0.07)	0.77 (0.06)	0.60 (0.42 to 0.78)	0.58 (0.37 to 0.80)
Other/unknown	0.60 (0.06)	0.54 (0.06)	−0.06 (−0.20 to 0.07)	0.51 (0.08)	1.31 (0.07)	0.80 (0.60 to 1.01)	0.87 (0.62 to 1.11)
State-subsidized health care							
No	0.42 (0.04)	0.58 (0.04)	0.16 (0.09 to 0.23)	0.54 (0.05)	1.24 (0.04)	0.70 (0.58 to 0.81)	0.54 (0.40 to 0.67)
Yes	0.51 (0.05)	0.71 (0.05)	0.20 (0.11 to 0.30)	0.68 (0.06)	1.57 (0.05)	0.90 (0.75 to 1.05)	0.69 (0.52 to 0.87)
Neighborhood parks							
No park	0.46 (0.04)	0.62 (0.04)	0.16 (0.08 to 0.24)	0.58 (0.05)	1.26 (0.04)	0.68 (0.57 to 0.80)	0.52 (0.38 to 0.66)
1 park	0.45 (0.04)	0.61 (0.04)	0.16 (0.09 to 0.23)	0.56 (0.05)	1.26 (0.04)	0.70 (0.58 to 0.81)	0.54 (0.40 to 0.67)
2 or more parks	0.33 (0.04)	0.50 (0.04)	0.17 (0.09 to 0.24)	0.49 (0.05)	1.02 (0.04)	0.53 (0.42 to 0.65)	0.37 (0.24 to 0.50)
Age 16-17 years							
Race/ethnicity							
NH White	0.42 (0.05)	0.28 (0.05)	−0.14 (−0.24 to −0.03)	0.34 (0.06)	0.40 (0.06)	0.06 (−0.09 to 0.22)	0.20 (0.02 to 0.39)
Hispanic	0.64 (0.05)	0.47 (0.05)	−0.18 (−0.26 to −0.09)	0.46 (0.06)	0.82 (0.05)	0.36 (0.24 to 0.49)	0.54 (0.39 to 0.69)

(Continues)

TABLE 2 (Continued)

Characteristic	Pre-pandemic (March 2019 to January 2020)			Pandemic (March 2020 to January 2021)			
	Start, mean (SD)	End, mean (SD)	Change 1 (Δ1, 95% CI)	Start, mean (SD)	End, mean (SD)	Change 2 (Δ2, 95% CI)	Δ2-Δ1 (95% CI)
NH Black	0.86 (0.08)	0.66 (0.08)	−0.21 (−0.38 to −0.04)	0.72 (0.10)	1.13 (0.09)	0.41 (0.17 to 0.66)	0.62 (0.32 to 0.92)
API	0.28 (0.08)	0.06 (0.08)	−0.23 (−0.40 to −0.05)	−0.06 (0.10)	−0.02 (0.08)	0.04 (−0.21 to 0.30)	0.27 (−0.04 to 0.58)
Other/unknown	0.55 (0.09)	0.24 (0.09)	−0.31 (−0.50 to −0.13)	0.44 (0.11)	0.52 (0.09)	0.08 (−0.18 to 0.35)	0.40 (0.08 to 0.72)
State-subsidized health care							
No	0.47 (0.05)	0.33 (0.05)	−0.14 (−0.24 to −0.03)	0.39 (0.07)	0.45 (0.06)	0.06 (−0.09 to 0.22)	0.20 (0.02 to 0.39)
Yes	0.65 (0.07)	0.42 (0.07)	−0.23 (−0.37 to −0.09)	0.55 (0.09)	0.60 (0.07)	0.05 (−0.15 to 0.25)	0.28 (0.04 to 0.53)
Neighborhood parks							
No park	0.53 (0.06)	0.32 (0.06)	−0.21 (−0.32 to −0.10)	0.39 (0.07)	0.55 (0.06)	0.16 (0.00 to 0.32)	0.37 (0.18 to 0.56)
1 park	0.49 (0.05)	0.35 (0.05)	−0.14 (−0.24 to −0.03)	0.41 (0.07)	0.47 (0.06)	0.06 (−0.09 to 0.22)	0.20 (0.02 to 0.39)
2 or more parks	0.38 (0.05)	0.32 (0.05)	−0.06 (−0.16 to 0.04)	0.32 (0.06)	0.36 (0.06)	0.04 (−0.11 to 0.18)	0.10 (−0.08 to 0.28)

Note: Total BMI measures included in the models were 425,855 from March 2019 to January 2020 (2.65 BMI measures/youth) compared with 241,699 from March 2020 to January 2021 (1.51 BMI measures/youth). After the initial decrease, in-person well-child visits were back to 84% of pre-pandemic visits by June 2020. All models are adjusted for race/ethnicity (Hispanic, non-Hispanic [NH] Black, Asian or Pacific Islander [API], other, reference: NH White), state-subsidized health care (reference: none), parks (no parks, two or more parks, reference: one park), neighborhood education, neighborhood income, and baseline weight class (<5th, 5th to 84th, 85 to 94th, 95 to 97th, ≥97th, reference: 5th to ≤85th). Estimates are shown for the reference group. Interaction terms: pandemic × time × race/ethnicity, $p = 0.001$ for 5- to 11-year-olds, $p < 0.001$ for 12- to 15-year-olds, and $p = 0.004$ for 16- to 17-year-olds; pandemic × time × state-subsidized insurance, $p < 0.001$ for 5- to 11-year-olds, $p = 0.02$ for 12- to 15-year-olds, and $p = 0.39$ for 16- to 17-year-olds; pandemic × time × parks, $p < 0.001$ for 5- to 11-year-olds, $p = 0.03$ for 12- to 15-year-olds, and $p = 0.02$ for 16- to 17-year-olds.

TABLE 3 Youth living with obesity before and during the pandemic

	Pre-pandemic			Pandemic			
Obesity (≥95th percentile)	Start, mean (SD)	End, mean (SD)	Change 1 (Δ1, 95% CI)	Start, mean (SD)	End, mean (SD)	Change 2 (Δ2, 95% CI)	Δ2-Δ1 (95% CI)
Race/ethnicity							
Age 5-11 years							
NH White	14.17 (0.32)	15.15 (0.33)	0.99 (0.27 to 1.70)	15.71 (0.42)	21.95 (0.44)	6.24 (5.04 to 7.44)	5.25 (3.84 to 6.66)
Hispanic	23.53 (0.25)	24.91 (0.26)	1.38 (0.92 to 1.84)	25.37 (0.31)	34.97 (0.34)	9.59 (8.77 to 10.42)	8.21 (7.27 to 9.16)
NH Black	19.66 (0.60)	21.77 (0.64)	2.11 (0.81 to 3.40)	22.32 (0.80)	31.46 (0.84)	9.14 (6.88 to 11.40)	7.03 (4.50 to 9.55)
API	13.38 (0.46)	14.43 (0.46)	1.06 (0.03 to 2.09)	14.02 (0.61)	21.14 (0.64)	7.11 (5.28 to 8.94)	6.06 (3.98 to 8.14)
Other/Unknown	16.43 (0.61)	18.32 (0.65)	1.88 (0.44 to 3.32)	19.04 (0.84)	25.19 (0.80)	6.16 (3.82 to 8.49)	4.28 (1.59 to 6.96)
Age 12-15 years							
NH White	16.27 (0.42)	17.01 (0.43)	0.74 (−0.09 to 1.57)	16.46 (0.51)	21.46 (0.54)	5.00 (3.63 to 6.37)	4.26 (2.64 to 5.88)
Hispanic	24.68 (0.33)	24.39 (0.33)	−0.29 (−0.86 to 0.29)	24.08 (0.40)	29.39 (0.39)	5.31 (4.34 to 6.28)	5.60 (4.45 to 6.74)
NH Black	24.90 (0.79)	24.60 (0.79)	−0.30 (−1.75 to 1.16)	24.53 (1.01)	29.89 (0.99)	5.37 (2.67 to 8.07)	5.67 (2.56 to 8.78)
API	12.77 (0.59)	13.24 (0.64)	0.47 (−0.93 to 1.88)	11.65 (0.75)	16.21 (0.76)	4.56 (2.42 to 6.70)	4.09 (1.55 to 6.63)
Other/Unknown	19.37 (0.83)	18.66 (0.82)	−0.71 (−2.31 to 0.89)	18.75 (1.10)	23.88 (1.06)	5.14 (2.09 to 8.18)	5.85 (2.32 to 9.37)
Age 16-17 years							
NH White	16.72 (0.64)	15.63 (0.60)	−1.09 (−2.26 to 0.08)	16.12 (0.72)	18.43 (0.72)	2.31 (0.54 to 4.09)	3.40 (1.26 to 5.54)
Hispanic	23.38 (0.49)	23.34 (0.48)	−0.04 (−0.89 to 0.82)	23.43 (0.57)	25.87 (0.54)	2.45 (1.14 to 3.76)	2.49 (0.93 to 4.04)
NH Black	22.15 (1.11)	22.67 (1.08)	0.52 (−1.28 to 2.32)	23.16 (1.35)	25.52 (1.22)	2.36 (−0.65 to 5.37)	1.84 (−1.69 to 5.37)
API	12.34 (0.88)	12.01 (0.85)	−0.33 (−2.01 to 1.35)	11.40 (1.24)	12.82 (1.13)	1.42 (−2.16 to 5.00)	1.75 (−2.07 to 5.56)
Other/Unknown	18.34 (1.26)	17.84 (1.18)	−0.50 (−3.08 to 2.08)	19.59 (1.60)	20.14 (1.34)	0.55 (−3.38 to 4.48)	1.05 (−3.47 to 5.57)
State-subsidized health care							
Age 5-11 years							
No	15.96 (0.21)	17.37 (0.22)	1.41 (0.94 to 1.89)	17.81 (0.29)	24.86 (0.29)	7.05 (6.23 to 7.87)	5.64 (4.70 to 6.57)
Yes	18.21 (0.34)	19.72 (0.35)	1.50 (0.81 to 2.20)	19.93 (0.43)	28.07 (0.45)	8.13 (6.92 to 9.34)	6.63 (5.23 to 8.02)
Age 12-15 years							
No	18.29 (0.28)	18.19 (0.29)	−0.10 (−0.69 to 0.50)	17.50 (0.36)	22.22 (0.35)	4.72 (3.72 to 5.73)	4.82 (3.64 to 6.00)
Yes	19.73 (0.45)	19.99 (0.46)	0.26 (−0.60 to 1.13)	19.41 (0.57)	25.04 (0.57)	5.64 (4.13 to 7.14)	5.37 (3.62 to 7.13)
Age 16-17 years							
No	17.07 (0.41)	16.87 (0.40)	−0.20 (−1.00 to 0.60)	17.56 (0.56)	18.70 (0.49)	1.14 (−0.32 to 2.61)	1.34 (−0.30 to 2.98)
Yes	19.26 (0.69)	18.72 (0.66)	−0.54 (−1.77 to 0.69)	18.70 (0.84)	21.24 (0.78)	2.54 (0.45 to 4.62)	3.08 (0.73 to 5.42)
Neighborhood parks							
Age 5-11 years							
No park	17.61 (0.30)	18.86 (0.31)	1.26 (0.62 to 1.89)	19.32 (0.39)	27.03 (0.40)	7.70 (6.61 to 8.79)	6.45 (5.19 to 7.70)

(Continues)

TABLE 3 (Continued)

	Pre-pandemic			Pandemic			
Obesity (≥95th percentile)	**Start, mean (SD)**	**End, mean (SD)**	**Change 1 (Δ1, 95% CI)**	**Start, mean (SD)**	**End, mean (SD)**	**Change 2 (Δ2, 95% CI)**	**Δ2-Δ1 (95% CI)**
1 park	17.42 (0.29)	18.71 (0.30)	1.29 (0.67 to 1.92)	18.69 (0.38)	26.93 (0.40)	8.24 (7.14 to 9.33)	6.94 (5.69 to 8.19)
2 or more parks	16.17 (0.32)	17.97 (0.33)	1.80 (1.11 to 2.50)	18.53 (0.43)	25.33 (0.43)	6.80 (5.61 to 7.99)	5.00 (3.63 to 6.36)
Age 12-15 years							
No park	20.02 (0.41)	19.90 (0.41)	−0.12 (−0.92 to 0.68)	19.19 (0.51)	24.59 (0.51)	5.40 (4.02 to 6.78)	5.52 (3.91 to 7.13)
1 park	19.63 (0.40)	19.67 (0.41)	0.04 (−0.76 to 0.83)	19.13 (0.51)	24.41 (0.50)	5.29 (3.91 to 6.66)	5.25 (3.65 to 6.85)
2 or more parks	17.43 (0.41)	17.71 (0.42)	0.28 (−0.55 to 1.11)	17.04 (0.51)	21.86 (0.52)	4.82 (3.43 to 6.21)	4.54 (2.90 to 6.18)
Age 16-17 years							
No park	18.40 (0.59)	17.86 (0.57)	−0.54 (−1.61 to 0.52)	18.06 (0.73)	20.43 (0.68)	2.37 (0.55 to 4.19)	2.92 (0.86 to 4.97)
1 park	18.61 (0.60)	18.25 (0.56)	−0.36 (−1.49 to 0.77)	18.24 (0.73)	20.49 (0.67)	2.25 (0.41 to 4.10)	2.62 (0.47 to 4.76)
2 or more parks	17.40 (0.62)	17.22 (0.60)	−0.18 (−1.36 to 0.99)	18.07 (0.83)	18.91 (0.72)	0.84 (−1.27 to 2.96)	1.02 (−1.33 to 3.38)

Note: Total BMI measures included in the models were 425,855 from March 2019 to January 2020 (2.65 BMI measures/youth) compared with 241,699 from March 2020 to January 2021 (1.51 BMI measures/youth). After initial decrease, in-person well-child visits were back to 84% of pre-pandemic visits by June 2020. All models are adjusted for race/ethnicity (Hispanic, non-Hispanic [NH] Black, Asian or Pacific Islander [API], other, reference: White), state-subsidized health care (reference: none), parks (no parks, two or more parks, reference: one park), neighborhood education, neighborhood income, and three-way interactions pandemic × time × race, pandemic × time × state-subsidized health care, pandemic × time × parks. Estimates are shown for the reference group. Interaction terms: pandemic × time × race/ethnicity, $p = 0.49$ for 5- to 11-year-olds, $p = 0.86$ for 12- to 15-year-olds, and $p = 0.58$ for 16- to 17-year-olds; pandemic × time × state-subsidized insurance, $p = 0.63$ for 5- to 11-year-olds, $p = 0.94$ for 12- to 15-year-olds, and $p = 0.12$ for 16- to 17-year-olds; pandemic × time × parks, $p = 0.06$ for 5- to 11-year-olds, $p = 0.89$ for 12- to 15-year-olds, and $p = 0.58$ for 16- to 17-year-olds.

(95% CI: 1.02-1.29) in those with commercial or privately funded health plans.

Youth across all ages who lived in neighborhoods with two or more parks gained less excess body weight during the lockdown than during the pre-pandemic period compared with those who lived in neighborhoods with one park or no parks (p for lockdown × time × parks: $p < 0.001$ for 5- to 11-year-olds, $p = 0.03$ for 12- to 15-year-olds, and $p = 0.02$ for 16- to 17-year-olds, respectively).

In models using body weight (rather than distance from the median), the excess weight gain during the pandemic lockdown compared with pre-pandemic weight gain ranged between 1.90 kg (95% CI: 1.74-2.06) in White, 2.63 kg (95% CI: 2.50-2.76) in Hispanic, and 2.79 kg (95% CI: 2.51-3.06) in Black youth aged 5 to 11 years, respectively (Supporting Information Table S3). Among 5- to 11-year-olds, youth with state-subsidized health insurance gained 2.20 kg (95% CI: 1.99-2.41) compared with 1.90 kg (95% CI: 1.74-2.06) in those on commercial and private health plans. Among 5- to 11year-olds, youth with two or more neighborhood parks gained 1.55 kg (95% CI: 1.39-1.71) compared with 1.90 kg (95% CI: 1.74-2.06) and 1.81 kg (95% CI: 1.65-1.98) for those with one park or no parks, respectively. The adjustment for height ensures that changes in weight reflect changes independent of changes in height.

The prevalence of obesity increased among White youths aged 5 to 11 years at the time of the lockdown from 15.2% before the lockdown to 22.0% during the pandemic lockdown, an absolute excess increase of 5.3% (95% CI: 3.8%-6.7%) compared with the reference period (Table 3). This compared to an absolute excess increase of 7.0% (95% CI: 4.5%-9.6%) and 8.2% (95% CI: 7.3%-9.2%) among Black and Hispanic youth aged 5 to 11 years, respectively. Among youth aged 12 to 17 years, Black and Hispanic youth had a higher pre-pandemic prevalence of obesity than White youth, and, although we found higher excess gains for Black and Hispanic youth aged 12 to 15 years, they did not differ in the excess increase in obesity rates among older age groups (p for lockdown × time × race and ethnicity: $p = 0.49$ for 5- to 11-year-olds, $p = 0.86$ for 12- to 15-year-olds, and $p = 0.58$ for 16- to 17-year-olds, respectively). Among 5- to 11-year-olds, the increase in obesity was marginally lower in youth from neighborhoods with two or more parks (5.0% vs. 6.9% and 6.5%, respectively, for 2+ vs. 0 and 1 park; p for lockdown × time × parks: $p = 0.06$ for 5- to 11-year-olds); this association was not observed for the older age groups (p for lockdown × time × parks: $p = 0.89$ for 12- to 15-year-olds, and $p = 0.30$ for 16- to 17-year-olds, respectively). No significant difference in the increase in obesity during the pandemic between those with and without state-subsidized health insurance was observed (p for lockdown × time × state-subsidized health insurance: $p = 0.63$ for 5- to 11-year-olds, $p = 0.94$ for 12- to 15-year-olds, and $p = 0.12$ for 16- to 17-year-olds, respectively).

To visualize the additive effects of factors associated with excess weight gain among 5- to 11-year-old youth, we compared a reference youth who live with overweight and have social advantages (non-Hispanic White, without state-subsidized insurance, from neighborhoods with two or more parks) to youth who live with overweight without these social advantages (Hispanic and Black youth who are overweight, had state-subsidized insurance, and lived in neighborhoods without parks; Figure 2). For example, non-Hispanic White youth with social advantages increased their distance from the median BMI by 0.84 (95% CI: 0.71-0.97) compared with non-Hispanic White youth without these advantages who gained 1.34 (95% CI: 1.17-1.51). In contrast, Hispanic and Black youth without those social advantages gained 1.91 (95% CI: 1.78-2.04) and 1.89 (95% CI: 1.65-2.12), respectively.

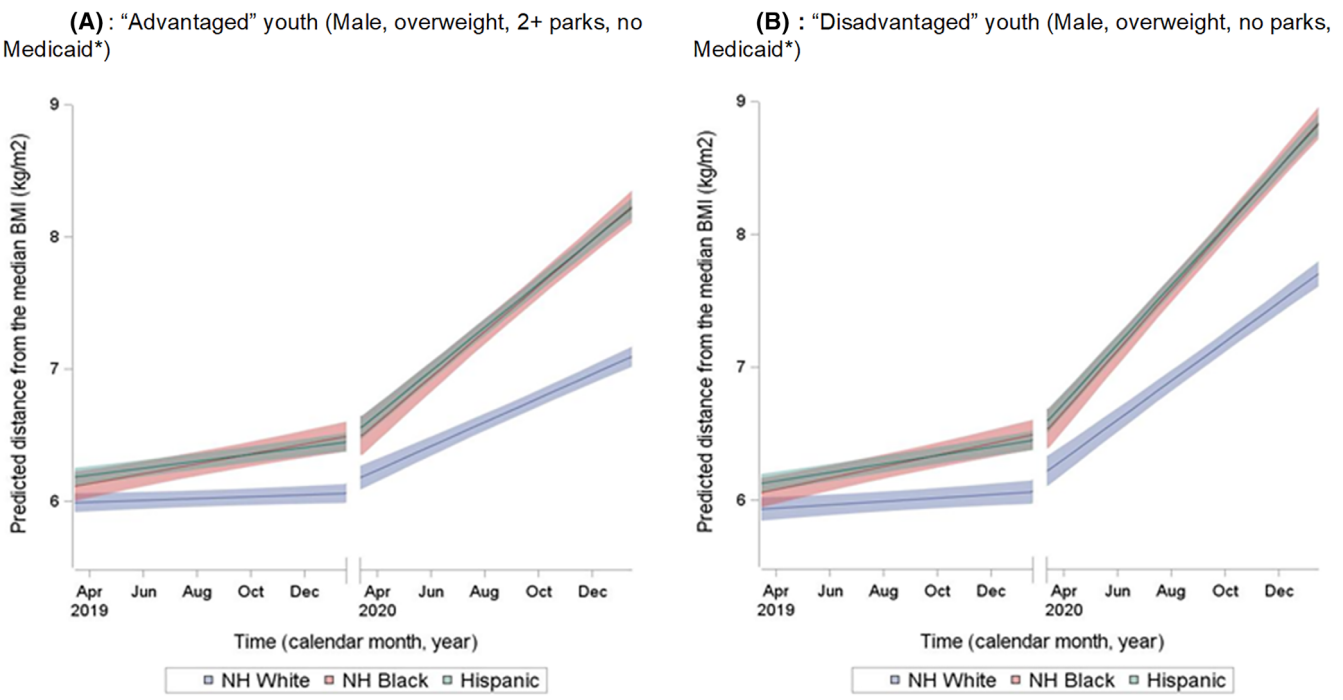
DISCUSSION

Communities of color and low-income populations have been disproportionally affected by the COVID-19 pandemic in the United States [9, 22–24], including California [25–27]. These populations carried a higher burden of infection, hospitalizations, and deaths from COVID-19. Since the beginning of the pandemic, public health experts were concerned that obesity rates might increase as a result of COVID-19 mitigation strategies such as school closings; limitations on team sports, social, and recreational activities; and alterations in eating habits and food supply as well as stress and social isolation [28].

We and others have shown a dramatic excess pandemic weight gain among US youth during the COVID-19 lockdown period when compared with the same period before the pandemic lockdown [5, 29–32]. The present study examines racial, ethnic, social, and neighborhood differences in weight changes during the during the COVID-19 pandemic lockdown. Among ~160,000 youth in Southern California, the lockdown was associated with significantly higher excess weight gain among Hispanic and Black youth, those living in families with low socioeconomic status, and youth from neighborhoods without parks. Although not a national sample, our findings, together with findings of others [5, 29–32], raise concerns of a national trend that existing gaps in youth health based on race or ethnicity, income level, and environmental inequalities have widened during the lockdown.

Socioeconomic, educational, and environmental disadvantages have historically affected vulnerable communities with strong links to disparities in nutrition and obesity [33]. Over the last almost two decades, data from the National Health and Nutrition Examination Surveys showed an annual increase in obesity of 0.20% in 6- to 11-year-olds and 0.35% in 12- 19-year-olds [34]. In contrast, we found that the increase in obesity during the 11-month pandemic lockdown in Southern California ranged from 5.1% in non-Hispanic White to 8.1% in Hispanic youth among 5- to 11-year-olds; this difference was slightly lower in older children. This means that the increase in obesity rates during the lockdown was almost equivalent to the increase observed over the last two decades. The higher excess weight gain in youth of color will, if it persists, contribute to widening of the existing disparities in childhood obesity [35].

Access to parks and playgrounds is inversely associated with childhood obesity [36–38] and cardiorespiratory fitness in children [39], especially in youth living in families with low income [36, 38]. In the



	Change in distance from the median BMI-for-age (kg/m^2) (95% CI)		
	prepandemic (Δ1, 95% CI)	pandemic lockdown (Δ2, 95% CI)	Δ2- Δ1 (95% CI)
Figure 2A			
Race/ethnicity			
Non-Hispanic White	0.07 (0.00, 0.14)	0.91 (0.80, 1.02)	0.84 (0.71, 0.97)
Non-Hispanic Black	0.37 (0.24, 0.50)	1.76 (1.55, 1.96)	1.39 (1.15, 1.63)
Hispanic	0.26 (0.19, 0.33)	1.67 (1.56, 1.78)	1.41 (1.28, 1.53)
Asian/Pacific Islanders	0.28 (0.17, 0.38)	1.31 (1.15, 1.48)	1.04 (0.84, 1.23)
Other/Unknown	0.28 (0.15, 0.40)	1.03 (0.83, 1.23)	0.75 (0.52, 0.98)
Figure 2B			
Race/ethnicity			
Non-Hispanic White	0.13 (0.04, 0.22)	1.47 (1.32, 1.62)	1.34 (1.17, 1.51)
Non-Hispanic Black	0.43 (0.30, 0.56)	2.32 (2.11, 2.52)	1.89 (1.65, 2.12)
Hispanic	0.32 (0.25, 0.39)	2.23 (2.11, 2.34)	1.91 (1.78, 2.04)
Asian/Pacific Islanders	0.33 (0.22, 0.45)	1.87 (1.68, 2.06)	1.54 (1.31, 1.76)
Other/Unknown	0.34 (0.20, 0.47)	1.59 (1.37, 1.81)	1.25 (1.00, 1.51)

FIGURE 2 Changes in the distance from median BMI-for-age before and during the COVID-19 lockdown in (A) White, Hispanic, or Black overweight boys aged 5 to 11 years who live in neighborhoods with two or more parks and who do not have state-subsidized health insurance compared with (B) those who live in neighborhoods without parks and who have state-subsidized health insurance [Color figure can be viewed at wileyonlinelibrary.com]

present study, living in communities with fewer parks was associated with higher weight gain during the pandemic lockdown, a time when schools were closed and most youth sports and other recreational activities were suspended. A higher number of neighborhood parks may have alleviated the excess weight increase in youth, especially among 5- to 11-year-olds. Additionally, youth aged between 5 and 11 years from families with low socioeconomic background gained more than their peers. However, due to the nature of the study, this association may also reflect associations with other neighborhood factors and reflect economic, financial, and health inequalities.

Structural racism has patterned wealth and shaped environments such that youth of color are more likely to live in families with low income and with limited access to parks [40]. Racial and ethnic disparities in obesity are driven by socioeconomic and environmental

disadvantages and are well-established in adults and children [33, 34, 41]. In 2016, a study conducted in Los Angeles County, the largest county in Southern California, revealed that more than half of the county had very little greenspace; about 82% of these "park-poor" areas were located in communities of color [42]. The present study demonstrates how the combination of these risk factors, such as low income and limited parks access, adds to the observed racial disparities in excess weight gain. Our data show that youth who live with social advantages gained significantly less than those without these social advantages. Because youth from communities of color will be less likely to have social advantages [33, 43, 44], this may contribute to a further widening of the health gap associated with racial disparities.

Other aspects of structural racism may explain the greater pandemic lockdown-related weight gain in Hispanic and Black youths than in their White counterparts. The emotional and financial stress faced by Black and Hispanic families caused by the COVID-19 pandemic, job losses, over representation in frontline jobs that cannot be done remotely, closed schools with limited or no access to school lunch, lack of childcare, and housing and food insecurity may impact energy balance and, consequently, body weight [4, 45]. Food insecurity increased during the pandemic and was more pronounced among Black and Hispanic families than any other group [46]. Food insecurity can lead to lower dietary quality and greater consumption of calorie-dense foods, which can predispose to weight gain [47–51]. A full discussion of the complex ways communities of color were affected in comparison to primarily White communities is beyond the scope of this study.

These findings should be considered within the context of certain limitations. In the absence of an unexposed control group in 2020, our analyses depended on comparisons to weight patterns among the same youth in the year before the pandemic lockdown. Our analysis also only included those children with in-person appointments during the time period of interest. However, in-person well-child visits resumed within 2 months (in part to ensure standard child vaccinations remained up to date), suggesting that the BMI data collected during this time reflect the BMI of the source population. Although the possibility of selection bias exists, our analytical cohort was strikingly similar to the overall population of KPSC pediatric patients in all relevant characteristics, including BMI. We used state-subsidized health insurance as proxy for socioeconomic status and number of parks in the neighborhood of the primary address of the patient a proxy for access to parks and playgrounds. Finally, in this observational study conducted in Southern California, we cannot establish causation or determine which factors other than the COVID-19 pandemic accounted for the excess weight gain noted during 2020. Our results also may not reflect populations outside of the study area.

The pandemic had a devastating effect on the physical, psychologic, and economic health of millions in the United States. Although the direct impact of the COVID-19 pandemic on morbidity and mortality was less severe for the pediatric population, the indirect impact on the weight of children may have long-term detrimental health consequences and exacerbate already existing racial and social disparities. It may place children of color at risk for comorbidities associated with excess weight such as diabetes and hypertension with higher incidence rates and at an earlier age, especially when they are from families with low socioeconomic background. In turn, this could make children more susceptible to poor outcomes after infection with SARS-CoV-2 or other similar pathogens in the future. It will be important to track this cohort to see whether the excess weight gain observed during COVID-19 is maintained. Future studies will have to show whether similar trends are observed in other states and areas outside of Southern California. Analysis of diet and activity patterns (including the increase in screen time associated with at-home education) during COVID-19 will be helpful in understanding the drivers of the weight gain. Diet and activity interventions should be developed that account for the unique stressors and lifestyle changes that occurred during the COVID-19 pandemic lockdown and that will likely persist in ways we currently do not understand.O

AUTHOR CONTRIBUTIONS

All authors conceptualized and designed the study and supervised the data collection and the statistical analyses. Margo A. Sidell and Xia Li conducted the statistical analyses. Corinna Koebnick and Susan J. Woolford drafted the initial manuscript. All authors contributed to the data interpretation and reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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CONFLICT OF INTEREST

The authors declared no conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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