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Title: Children's Rates of BMI Change Prepandemic and During Two COVID-19 Pandemic Periods, IQVIA AEMR, January 2018-November 2021

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Study Importance Questions

1. **What is already known about this subject?** Many U.S. children and adolescents experienced accelerated weight gain during the early COVID-19 pandemic. Children aged 6-11 years, Black and Hispanic children, and those with pre-existing overweight or obesity were disproportionately affected.
2. **What are the new findings in your manuscript?** In a longitudinal cohort of 241,600 children, accelerated rates of weight and BMI gain observed during the early pandemic (March-December 2020) largely attenuated during the later pandemic (January-November 2021). Although rates slowed, estimated obesity prevalence remained high in this cohort (22.5%).
3. **How might your results change the direction of research or the focus of clinical practice?** Obesity increases children's risk for chronic conditions, such as prediabetes and dyslipidemia, and for severe COVID-19 illness. Our findings underscore the importance of continued obesity prevention efforts as well as efforts to increase access to evidence-based healthy lifestyle programs for children and families struggling with obesity.

Abstract

Objective: Many U.S. youth experienced accelerated weight gain during the early COVID-19 pandemic. Using an ambulatory electronic health record dataset, we compared children's rates of BMI change in three periods: prepandemic (January 2018-February 2020), early pandemic (March-December 2020), and later pandemic (January-November 2021).

Methods: We used mixed-effects models to examine differences in rates of change in BMI, weight, and obesity prevalence among the three periods. Covariates included time as a continuous variable; a variable indicating in which period each BMI was taken; sex; age; and initial BMI category.

Results: In a longitudinal cohort of 241,600 children aged 2-19 years with ≥4 BMIs, the monthly rates of BMI change (kg/m^2) were 0.056 (95%CI: 0.056, 0.057) prepandemic, 0.104 (95%CI: 0.102, 0.106) in the early pandemic, and 0.035 (95%CI: 0.033, 0.036) in the later pandemic. The estimated prevalence of obesity in this cohort was 22.5% by November 2021.

Conclusions: In this large geographically-diverse cohort of U.S. youth, accelerated rates of BMI change observed during 2020 were largely attenuated in 2021. Positive rates indicate continued weight gain rather than loss, albeit at a slower rate. Childhood obesity prevalence remained high, which raises concern about long-term consequences of excess weight and underscores the importance of healthy lifestyle interventions.

Introduction

Public health studies using ambulatory electronic medical record (AEMR) datasets documented that many U.S. youth experienced accelerated rates of weight and body mass index (BMI) increase during the early coronavirus disease 2019 (COVID-19) pandemic (*1,2,3)*. For example, Lange et al. analyzed a longitudinal cohort of 432,302 pediatric patients and found that the overall rate of BMI change nearly doubled compared to prepandemic (0.101 vs. 0.052 BMI units per month) *(1)*. Children already disproportionately affected by obesity, including Black and Hispanic children or those with public insurance, experienced larger increases than White children and those with commercial insurance respectively *(3,4)*.

No publications to date have examined whether accelerated rates of BMI increase observed during the early pandemic persisted as the pandemic continued into 2021. Using the same dataset and methods as Lange et al. *(1)*, we leveraged newly available data to compare children's rates of BMI change prepandemic to rates of change during two pandemic periods: early pandemic (March-December 2020) and later pandemic (January-November 2021).

Methods

Data Source and Management

IQVIA's AEMR database contains clinical data for 82 million patients, including 9 million children, since 2006. AEMR data come from a single electronic health record (EHR) vendor that collects data from >100,000 healthcare providers affiliated with >800 ambulatory practices and physician networks across the United States. Data were accessed using the E360 Software-as-a-Service Platform (OMOP Version 5, May 2022 data release).

We extracted height and weight data for 7 million children aged 2-19 years during 1/1/2015-11/30/2021 and cleaned the data using growthcleanr, an automated algorithm for

detecting errors in growth data from EHRs *(5,6)*. Because growthcleanr works optimally on longitudinal data, we used approximately 7 years of data for cleaning. Height and weight values from 1/1/2018-11/30/2021 were included for this analysis, resulting in approximately 3.9 million children. BMI (kg/m^2) was calculated and categorized based on sex-specific BMI-for-age percentiles: underweight (<5th percentile), healthy weight (≥5th to <85th percentile), overweight (≥85th to <95th percentile), moderate obesity (≥95th percentile to <120% of the 95th), and severe obesity (≥120% of the 95th) *(7)*.

Study Population

Among 3.9 million patients with any BMI data in 2018-2021, we included those who had ≥2 BMIs prepandemic (with ≥1 occurring in the year directly before the pandemic), ≥1 BMI in the early pandemic after the initial 3 months (June-December 2020), and ≥1 BMI in the later pandemic (January-November 2021). BMI measurements taken during March-May 2020 were included in the analysis but not used to define cohort inclusion. This resulted in a longitudinal cohort of 241,600 patients.

Statistical Methods

We used mixed-effects models to examine differences in the rates of change in BMI (kg/m^2), weight (pounds), and obesity prevalence among the three periods. Covariates included time (in months from 3/1/2020); an indicator variable designating in which period the BMI was taken (prepandemic, early pandemic, later pandemic); sex; age on 3/1/2020; and initial BMI category. To obtain rates by patient characteristics, additional models included three-way interaction terms between time, the period indicator, and one characteristic at a time (sex, age category, or initial BMI category), including lower-order interactions and main effects; because

race/ethnicity was a single variable and often missing, we ran a separate model to examine differences between White and Black children only (n=193,112, 80%).

Mixed effects models included all BMI measurements for patients in the cohort and accounted for the correlations between repeated measurements within each patient. We performed data management in SAS v9.4 (SAS Institute Inc., Cary, NC) and modeling in Stata v15.1 (StataCorp, College Station, TX).

Results

Among 241,600 patients aged 2-19 years in 2018-2021, 70% were White, 52% were male, and 47% lived in the South. The unadjusted prevalence of obesity based on each patient's initial prepandemic BMI measurement was 16% [Table S1].

Rates of BMI change (kg/m^2/month) were 0.056 prepandemic, 0.104 early pandemic, and 0.035 later pandemic [Table 1]. During the early pandemic, we observed significantly accelerated rates of BMI increase. However, during the later pandemic, rates were largely attenuated to prepandemic rates or lower. For example, children aged 6-11 years had a prepandemic rate of 0.061, which rose to 0.146 during the early pandemic and decreased to 0.060 in the later pandemic [Table 1]. Rates of BMI change remained higher in Black children than White children (0.058 versus 0.032). All rates during the later pandemic remained positive, indicating continued BMI gain (rather than loss), albeit at a much slower rate than early pandemic.

Rates of weight change during the later pandemic attenuated similarly [Table 2]. Overall, estimated 6-month weight gain reduced by more than half from early to later pandemic (3.5 to 1.4 pounds). Even children with severe obesity experienced slower rates of weight gain, although

they continued to have the most weight gain (4.9 pounds) compared to those with moderate obesity (2.6), overweight (1.6), or healthy weight (1.0) [Table 2].

The rate of change in obesity prevalence slowed substantially during the later pandemic compared to early (slope estimate: -0.02% versus 0.39% per month); however, the prevalence of obesity remained high [Figure 1]. Estimated obesity prevalence was 18.8% in December 2019, rose to 22.7% in December 2020, and stabilized at 22.5% in November 2021.

Discussion

This is the first large, geographically diverse study to explore children's BMI change beyond the first year of the COVID-19 pandemic. In our large cohort of >240,000 children, rates of BMI change slowed substantially from 2020 to 2021, reverting to lower than prepandemic rates. Nonetheless, the prevalence of obesity in this cohort remained high.

COVID-19 mitigation strategies during the early pandemic resulted in complex and unprecedented disruptions to school and home life for millions of U.S. children. As schools and other youth-serving venues closed to in-person activities, reports of worsened food insecurity (*8*), accelerated weight gain *(1-4)*, exacerbated mental health crises (*9*), and other serious consequences ensued. However, during 2021, many U.S. schools and other education venues returned to in-person learning. We observed attenuation in rates of BMI increase during this time. School settings provide structure and consistency for youth, as well as numerous opportunities to eat nutritious meals, engage in physical activity, and enhance social connectedness. Though a causal relationship cannot be established from our dataset, time spent in schools and other youth-serving venues for in-person learning and extracurricular activities might have contributed to stabilization in weight patterns observed during the later pandemic.

Notably, our cohort was predominantly White (70%). It is well-established that obesity prevalence is highest in Black and Hispanic children (*10*) and that these children were particularly affected by accelerated weight gain during the early pandemic *(3,4)*. In our cohort, rates of BMI increase remained consistently higher among Black children than White, which is even more concerning due to pre-existing disparities in social determinants of health (*11*) and obesity risk factors (*12*) and prevalence (*10*). This highlights the need for continued efforts to equitably implement programs that reduce risk for chronic disease.

Accelerated weight gain during the early pandemic and absence of weight loss during the later pandemic suggest sustained high prevalence of obesity in this cohort. Obesity increases children's risk for chronic conditions, including prediabetes (*13*) and dyslipidemia (*14,15*), and for severe COVID-19 illness (*16*). Our findings underscore the importance of ongoing obesity prevention efforts as well as increasing access to effective treatments, such as obesity medications for adolescents and family-centered healthy weight programs that meet U.S. Preventive Services Task Force recommendations (*17*). Spread and scale of these comprehensive lifestyle programs, as well as insurance coverage and reimbursement, are important to ensure equitable access to evidence-based care for children and families struggling with obesity (*18*).

Our study has notable strengths. Using timely EHR data, we constructed a large longitudinal cohort of U.S. youth, each with ≥4 BMI measurements over approximately 4 years. Our statistical models accounted for uneven number and spacing of these measurements and individual-level heterogeneity.

Our study is subject to limitations. Although IQVIA's AEMR comprises a geographically diverse patient population, the data are not nationally representative and characterize healthcare-seeking persons only. To minimize selection bias for those who only sought care during the

pandemic, we required our cohort to have BMIs during the prepandemic period. Still, our cohort may differ from those who did not seek healthcare during the pandemic; for example, our cohort had more patients who were White, male, or living in the Northeast than the broader IQVIA patient population with prepandemic BMIs. Furthermore, race/ethnicity was a single variable and often missing, and payer and social determinant of health information was unavailable; this limited our ability to investigate outcomes by these drivers of health outcomes.

In our large longitudinal cohort of U.S. youth, accelerated rates of BMI increase observed during the early COVID-19 pandemic substantially slowed during the later pandemic (through November 2021). Nonetheless, more than 1 in 5 patients in our cohort had obesity, including 1 in 12 with severe obesity. The high prevalence of childhood obesity raises concern about potential long-term health consequences of having excess weight and underscores the importance of healthy lifestyle interventions.

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Figure 1. Monthly Rate of Change, Estimated Obesity Prevalence, and 95% Confidence Intervals Among 241,600 Patients Aged 2-19 Years, IQVIA AEMR January 2018-November 2021

Figure 1 footnote below

The mixed effects model for the estimated probability of obesity (BMI ≥95th percentile) adjusted for patient characteristics of sex, age at the start of the pandemic (March 1, 2020), and initial BMI category (underweight, healthy weight, overweight, moderate obesity, or severe obesity). Dates were classified into three periods: prepandemic (January 2018-February 2020), early pandemic (March-December 2020), and later pandemic (January-November 2021). The rate of change (i.e., slope) in estimated obesity prevalence per month was 0.09% (95% CI: 0.08%, 0.09%) prepandemic, 0.39% (95% CI: 0.39%, 0.42%) in the early pandemic, and -0.02% (95% CI: -0.04%, -0.001%) in the later pandemic. The estimated prevalence of obesity is represented by the black line; 95% confidence intervals associated with the estimates are represented by the light gray lines.

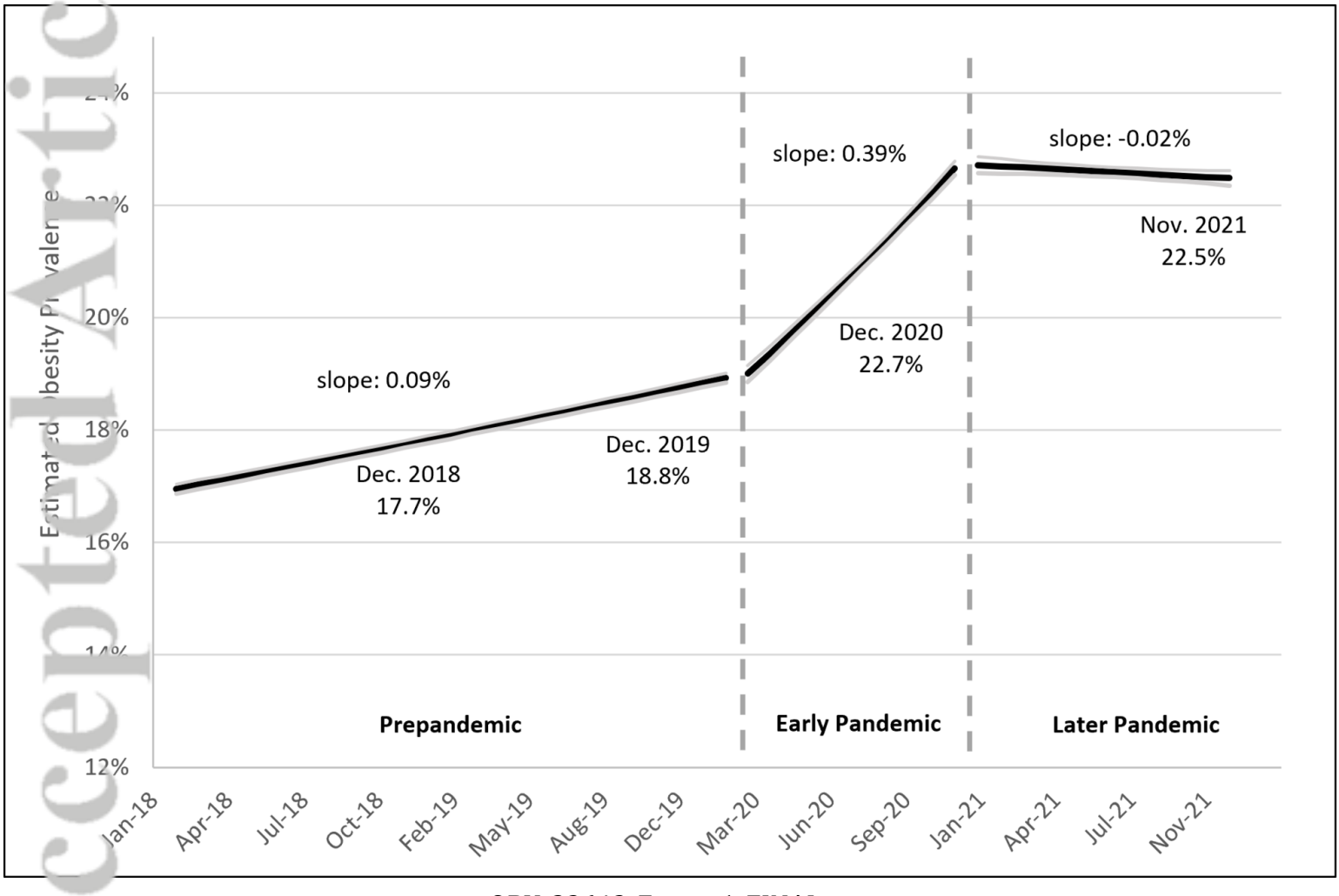

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Table 1. Adjusted Rates of Change in BMI Before the COVID-19 Pandemic and During Two Pandemic Periods Among 241,600 Patients Aged 2-19 Years, IQVIA Ambulatory Electronic Medical Records Database, January 2018-November 2021

	Prepandemic (January 2018-February 2020)		Early Pandemic (March-December 2020)		Later Pandemic (January-November 2021)	
	1-month Slope	**95% CI**	**1-month Slope**	**95% CI**	**1-month Slope**	**95% CI**
BMI (kg/m^2)[a]						
Overall	0.056	(0.056, 0.057)	0.104	(0.102, 0.106)	0.035	(0.033, 0.036)
Sex						
Male	0.055	(0.055, 0.056)	0.114	(0.112, 0.117)	0.033	(0.030, 0.034)
Female	0.057	(0.057, 0.058)	0.094	(0.092, 0.097)	0.037	(0.035, 0.039)
Age Group[b]						
3-5 years	0.002	(0.001, 0.002)	0.046	(0.043, 0.050)	0.006	(0.003, 0.009)
6-11 years	0.061	(0.060, 0.061)	0.146	(0.143, 0.149)	0.060	(0.057, 0.062)
12-17 years	0.074	(0.074, 0.075)	0.105	(0.102, 0.108)	0.034	(0.031, 0.037)
18-19 years	0.050	(0.048, 0.053)	0.051	(0.043, 0.060)	0.021	(0.006, 0.036)
Initial BMI Category[c]						
Underweight	0.047	(0.045, 0.049)	0.057	(0.048, 0.066)	0.015	(0.007, 0.022)
Healthy Weight	0.047	(0.046, 0.047)	0.083	(0.080, 0.085)	0.030	(0.028, 0.032)
Overweight	0.064	(0.063, 0.065)	0.131	(0.126, 0.136)	0.041	(0.037, 0.045)
Moderate Obesity	0.079	(0.078, 0.080)	0.159	(0.154, 0.165)	0.060	(0.056, 0.064)
Severe Obesity	0.099	(0.097, 0.101)	0.178	(0.170, 0.186)	0.102	(0.096, 0.109)
Race[d]						
White	0.054	(0.054, 0.055)	0.099	(0.097, 0.101)	0.032	(0.030, 0.034)
Black	0.066	(0.065, 0.067)	0.139	(0.134, 0.145)	0.058	(0.053, 0.062)

[a]Model controlled for time as a continuous variable; an indicator variable designating in which period the BMI was taken; sex; age on March 1, 2020; and initial BMI category. To obtain rates by patient characteristics, models included three-way interaction terms between time, the period indicator, and one characteristic at a time (sex, age category, or initial BMI category), including lower-order interactions and main effects.

[b]Based on age group at the start of the pandemic. In our longitudinal cohort, age range at the start of the pandemic was 2.7-18.7 years; at last BMI, age was 3.5-19.99 years.

[c]Based on each child's initial BMI measurement during the study period. BMI (kg/m^2) was calculated from height and weight and categorized based on sex-specific BMI-for-age percentiles: underweight (<5th percentile), healthy weight (≥5th to <85th percentile), overweight (≥85th to <95th percentile), moderate obesity (≥95th percentile to <120% of the 95th), and severe obesity (≥120% of the 95th percentile).

[d]Among 193,112 children who were White or Black. These children were 80% of the longitudinal cohort and had a total of 1,433,353 BMIs during the study period. Slope estimates by race (White versus Black) were calculated the same way as other characteristic-specific slopes.

Table 2. Adjusted Rates of Change in Weight Before the COVID-19 Pandemic and During Two Pandemic Periods Among 241,600 Patients Aged 2-19 Years, IQVIA Ambulatory Electronic Medical Records Database, January 2018-November 2021

	Prepandemic (January 2018-February 2020)		Early Pandemic (March-December 2020)		Later Pandemic (January-November 2021)	
	6-month Slope	95% CI	6-month Slope	95% CI	6-month Slope	95% CI
Weight (pounds)[a]						
Overall	2.03	(2.02, 2.05)	3.48	(3.42, 3.54)	1.38	(1.33, 1.43)
Sex						
Male	1.93	(1.91, 1.95)	3.78	(3.69, 3.87)	1.17	(1.10, 1.24)
Female	2.13	(2.11, 2.15)	3.16	(3.07, 3.24)	1.57	(1.50, 1.65)
Age Group[b]						
3-5 years	2.16	(2.13, 2.20)	2.81	(2.68, 2.94)	1.40	(1.30, 1.50)
6-11 years	1.97	(1.95, 1.99)	4.14	(4.03, 4.24)	1.65	(1.57, 1.72)
12-17 years	2.10	(2.08, 2.13)	3.56	(3.45, 3.67)	0.90	(0.82, 0.99)
18-19 years	1.83	(1.76, 1.90)	1.81	(1.54, 2.08)	0.72	(0.23, 1.20)
Initial BMI Category[c]						
Underweight	0.93	(0.87, 0.99)	1.56	(1.28, 1.85)	0.40	(0.17, 0.63)
Healthy Weight	1.43	(1.42, 1.45)	2.51	(2.43, 2.58)	0.97	(0.91, 1.03)
Overweight	2.34	(2.31, 2.37)	4.31	(4.16, 4.47)	1.63	(1.51, 1.75)
Moderate Obesity	3.23	(3.19, 3.27)	5.52	(5.36, 5.69)	2.63	(2.49, 2.76)
Severe Obesity	4.49	(4.44, 4.54)	6.78	(6.54, 7.02)	4.91	(4.71, 5.11)
Race[d]						
White	1.97	(1.95, 1.99)	3.29	(3.21, 3.37)	1.32	(1.26, 1.38)
Black	2.44	(2.40, 2.48)	4.58	(4.40, 4.76)	2.07	(1.92, 2.21)

[a]Model controlled for time as a continuous variable; an indicator variable designating in which period the BMI was taken; sex; age on March 1, 2020; initial BMI category; height (inches); and height squared. To obtain rates by patient characteristics, models included three-way interaction terms between time, the period indicator, and one characteristic at a time (sex, age category, or initial BMI category), including lower-order interactions and main effects.

[b]Based on age group at the start of the pandemic. In our longitudinal cohort, age range at the start of the pandemic was 2.7-18.7 years; at last BMI, age range was 3.5-19.99 years.

[c]Based on each child's initial BMI measurement during the study period. BMI (kg/m^2) was calculated from height and weight and categorized based on sex-specific BMI-for-age percentiles: underweight (<5th percentile), healthy weight (≥5th to <85th percentile), overweight (≥85th to <95th percentile), moderate obesity (≥95th percentile to <120% of the 95th), and severe obesity (≥120% of the 95th percentile).

[d]Among 193,112 children who were White or Black. These children were 80% of the longitudinal cohort and had a total of 1,433,353 BMIs during the study period. Slope estimates by race (White versus Black) were calculated the same way as other characteristic-specific slopes.