

Characteristics of Children 2 to 5 Years of Age With Severe Obesity

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abstract

BACKGROUND AND OBJECTIVES: As a distinct group, 2- to 5-year-olds with severe obesity (SO) have not been extensively described. As a part of the Expert Exchange Workgroup on Childhood Obesity, nationally-representative data were examined to better characterize children with SO.

METHODS: Children ages 2 to 5 ($N = 7028$) from NHANES (1999–2014) were classified as having normal weight, overweight, obesity, or SO (BMI $\geq 120\%$ of 95th percentile). Sociodemographics, birth characteristics, screen time, total energy, and Healthy Eating Index 2010 scores were evaluated. Multinomial logistic and linear regressions were conducted, with normal weight as the referent.

RESULTS: The prevalence of SO was 2.1%. Children with SO had higher (unadjusted) odds of being a racial and/or ethnic minority (African American: odds ratio [OR]: 1.7; Hispanic: OR: 2.3). They were from households with lower educational attainment (OR: 2.4), that were single-parent headed (OR: 2.0), and that were in poverty (OR: 2.1). Having never been breastfed was associated with increased odds of obesity (OR: 1.5) and higher odds of SO (OR: 1.9). Odds of >4 hours of screen time were 1.5 and 2.0 for children with obesity and SO. Energy intake and Healthy Eating Index 2010 scores were not significantly different in children with SO.

CONCLUSIONS: Children ages 2 to 5 with SO appear to be more likely to be of a racial and/or ethnic minority and have greater disparities in social determinants of health than their peers and are more than twice as likely to engage in double the recommended screen time limit.



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Dr Tester conceptualized and designed the study, conducted the majority of the data analysis, drafted the initial manuscript, and reviewed and revised the manuscript; Dr Leung conducted key data analyses required for calculation of Healthy Eating Index 2010 diet data, contributed expertise to the data analysis approach, and reviewed and revised the manuscript; Drs Phan, Tucker, Dreyer Gillette, Sweeney, and Kirk and Ms Tindall contributed topical expertise in pediatric obesity for preparation of the manuscript, assisted with analysis interpretation, and reviewed and revised the manuscript; Dr Olivo-Marston contributed to early data analysis for the study and reviewed and revised the final manuscript; Dr Eneli contributed to initial conceptualization of

WHAT'S KNOWN ON THIS SUBJECT: Preschool-aged children with severe obesity are a group with high risk of future comorbidity; however, they are poorly characterized as a distinct group.

WHAT THIS STUDY ADDS: In this study using nationally representative data, preschool-aged children with severe obesity were found to have greater disparities in social determinants of health and a particularly high level of screen time use compared with their peers.

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After decades of prevention and treatment programs to address the concern over the epidemic of obesity in children, national data reveal an increase in prevalence rates among children at all ages.¹ In 2016, the prevalence of obesity among children 2 to 19 years of age in the NHANES was 18.5%.¹ This increasing trend has been particularly observed among those with more severe forms of obesity.² Among 2- to 5-year-old children, 2.6% are estimated to have severe obesity (SO).² These young children are at increased risk of later obesity and significant morbidity, including cardiopulmonary disease and behavioral and developmental concerns. Elevated inflammatory biomarkers, antecedents of cardiovascular and metabolic disease, have been significantly associated with obesity as early as age 3.³

In response to the need for treatment options for the complex, high-acuity population of children with severe obesity, the American Academy of Pediatrics Institute for Healthy Childhood Weight and the Children's Hospital Association convened the Expert Exchange Workgroup on Childhood Obesity, which was an interdisciplinary team comprised of obesity programs across the United States. Although there have been investigations in the prevalence of SO in young children, few study authors have described this population or how children with SO compare with their peers who have overweight (OW) or obesity in regards to social determinants of health, diet, and activity patterns. It was identified as a priority to better characterize this growing population of children as an initial step to understanding their medical and psychosocial needs as we develop targeted and effective interventions.

The purpose of this study was to evaluate sociodemographic and lifestyle characteristics of children 2 to 5 years old with SO in comparison with their counterparts with normal

weight (NW), OW, and obesity in NHANES from 1999 to 2014.

METHODS

Study Population

We examined participants from NHANES, which is a complex, multistage probability cross-sectional sample designed to be representative of the US civilian, noninstitutionalized population. This analysis combined data from 7 2-year cycles of data from 1999 to 2014. We included children 2 to 5 years (≥ 24 but < 72 months of age) at the time of their examination in the mobile examination center (MEC). A total of 7028 children had complete weight and height data and composed the study sample.

Measures

Anthropometrics

Height and weight were measured by trained personnel at the MEC by using standardized protocols.⁴ Age- and sex-specific BMI percentiles were calculated by using SAS (SAS Institute, Inc, Cary, NC) code provided by the Centers for Disease Control and Prevention.⁵ Children 2 to 5 years old were classified into the following mutually-exclusive weight categories: (1) NW (BMI < 85 th percentile); (2) OW (BMI 85th to < 95 th percentile); (3) obesity (BMI ≥ 95 th percentile to $< 120\%$ (1.2 times) the 95th percentile); and (4) SO (BMI $\geq 120\%$ of the 95th percentile). The recommended definition of SO is having a "BMI $\geq 120\%$ of the 95th percentile or a BMI of 35, whichever is lower."^{2,6,7} No children in this sample had a BMI > 35 . Technically, children with SO who are at or above 140% of the 95th percentile can furthermore be classified into a higher-tier risk category (Class III obesity).² However, because of a particularly small sample size ($N = 32$), children with Class III obesity were not analyzed as a distinct group. Children

under the age of 2 years are assessed with weight for length rather than BMI. As such, they are not able to be classified by using BMI criteria for SO and were not included in the analysis.

Demographic and Birth Characteristics

The caregiver from the household who was the most knowledgeable about the child, most often a parent, completed the questionnaires. Information obtained included the child's race and ethnicity, age, sex, household income, and partnered status (married or partnered, single, divorced, or widowed) as well as educational attainment (any college, high school or less) of the household respondent. Maternal age and birth weight were reported, and we analyzed maternal age as a continuous variable and grouped birth weight into 3 categories: low (< 2500 g), normal (2500– < 4000 g), and high (≥ 4000 g). Maternal smoking "at any time" during pregnancy and a history of whether the child was "ever breastfed or fed breast milk" were assessed. Annual household income and family size are used with each cycle of NHANES to calculate the index of family income to the federal poverty level (FPL).⁸ Household income $\geq 300\%$ of the FPL was categorized as the "higher income" referent and was compared with being 200% to 299%, 100% to 199%, and $< 100\%$ of FPL.

Physical Activity and Screen Time

From 2001 to 2014, television viewing and time spent using computer and/or video games was evaluated by asking about average hours per day "over the past 30 days." For 1999–2000, these respective questions referred to "yesterday," rather than to the daily average over the past 30 days, but were otherwise analogous and were combined with responses from future years to maximize sample size, in a method consistent with that of previous studies.⁹ Response options were identical across all years

(1999–2014) and included “none,” “<1 hour,” “1 hour,” “2 hours,” “3 hours,” “4 hours,” and “5 hours or more.” Less than 1 hour was coded as 0.5 hours and 5 hours or more was coded as 5 hours. Television viewing was dichotomized: (≤ 2 vs > 2 hours) and (≤ 3 vs > 3 hours). Reported television time was summed with computer and/or video game time to create a variable representing total daily screen time and was dichotomized as ≤ 2 vs > 2 hours to correspond with current recommendations, ≤ 3 vs > 3 hours, and ≤ 4 vs > 4 hours to assess use that doubled the guidelines.^{10,11} To ensure question compatibility across years, mean screen time from NHANES cycles with altered wording (1999–2000 and 2011–2014) was compared with overall estimates, revealing no significant differences (data not shown).

Physical activity was indexed differently in 1999–2008 than in 2009–2014, and therefore the data could not be combined in the analysis; thus, physical activity data were excluded from the current analyses.

Dietary Recall Data

From 1999 to 2014, one 24-hour dietary recall was conducted in person at the MEC with the person most knowledgeable about the child’s dietary intake. Overall dietary quality was assessed by using the Healthy Eating Index 2010 (HEI-2010). Developed by the US Department of Agriculture Center for Nutrition Policy and Promotion, the HEI-2010 measures conformance with the 2010 Dietary Guidelines for Americans.¹² The HEI-2010 score is the sum of 12 component scores (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, and empty calories), with a maximum score of 100 points. For reference,

in 2007–2008, the average score for all US children combined was 49.8.¹³ The Food Patterns Equivalents Database,¹⁴ which converts foods and beverages reported in NHANES to US Department of Agriculture food pattern components, was used to estimate component scores for the HEI-2010. Of the children in the analytic sample, 6236 (89%) had a sufficiently reliable and complete dietary recall for calculating HEI-2010 scores.

Statistical Analyses

Survey weights were used to account for the complex, multistage probability sampling design used in NHANES, in accordance with recommendations from the National Center for Health Statistics.⁸ Examination weights were used to create 16-year weights for all analyses except the diet data, for which the diet recall weighting was used. Weighted means with SEs were estimated with Taylor series linearization to describe the continuous variables. Linear regression coefficients and 95% confidence intervals (CIs) are presented from unadjusted linear regression between continuous variables and weight category. Dietary data were adjusted for the child’s age and sex, and the 12 HEI-2010 components were each examined as log-transformed outcomes because of skewed distributions.

For categorical variables, multinomial logistic regression was conducted with the 4 weight categories, using NW as the reference category. Odds ratios (ORs) for sociodemographic and birth characteristic variables are presented in unadjusted models. Screen time and diet were adjusted for child’s age and sex.

All analyses were conducted by using Stata 12.1 (StataCorp, College Station, TX).

RESULTS

Demographics

Of the total sample ($N = 7028$), 5291 (76.5%) were classified as having NW, 918 (13.0%) were classified as having OW, 662 (8.4%) were classified as having obesity, and 157 (2.1%) were classified as having SO.

The mean age was higher among children with obesity (49.6 months) and SO (56.5 months) than among children with NW (47.3 months) (Table 1). In a multinomial logistic regression, the odds of obesity and SO for Non-Hispanic African American children were 1.5 (95% CI: 1.2 to 1.9) and 1.7 (95% CI: 1.0 to 3.0), respectively, compared with Non-Hispanic white children. For Hispanic children, the odds of obesity and SO were 2.0 (95% CI: 1.6 to 2.6) and 2.3 (95% CI: 1.4 to 3.7), respectively. Sex was not a significant predictor for severity of obesity.

Mean household income was 228% of the FPL (SE: 4.8), and incomes at the 25th and 75th percentiles corresponded to 91% and 361% of the FPL, respectively. In an unadjusted model, children of households with incomes below the FPL had odds of OW, obesity, and SO of 1.3 (95% CI: 1.0 to 1.7), 1.6 (95% CI: 1.2 to 2.2), and 2.1 (95% CI: 1.1 to 4.0), respectively, compared with children in households at or above 300% of the FPL.

Lower educational attainment of the household respondent (high school degree or less compared with having had some college attendance) was associated with significantly greater odds of a child having OW (OR: 1.5, 95% CI: 1.2 to 1.8), obesity (OR: 1.5, 95% CI: 1.2 to 1.9), or SO (OR: 2.4, 95% CI: 1.5 to 3.9). Children from a single caregiver household had elevated odds of obesity (OR: 1.4, 95% CI: 1.1 to 1.7) and twice the odds of SO (OR: 2.0, 95% CI: 1.3 to 3.0).

TABLE 1 Demographics of Sample (*N* = 7028): Distribution of Demographic Characteristics and Bivariate Associations With Weight Status in Children Aged 2 to 5 Years, NHANES 1999–2014

	Mean ^a (SE)	NW (<85th Percentile), <i>n</i> = 5291 (76.5%)	OW (85th Percentile–94.9th Percentile), <i>n</i> = 918 (13.0%)		Obesity (≥95th Percentile–1.2 × 95th Percentile), <i>n</i> = 662 (8.4%)		SO (≥1.2 × 95th Percentile), <i>n</i> = 157 (2.1%)		
		Mean (SE)	Coefficient ^b (95% CI)	Mean (SE)	Coefficient (95% CI)	Mean (SE)	Coefficient (95% CI)	Mean (SE)	Coefficient (95% CI)
Age									
Child (mo)	47.7 (0.2)	47.3 (0.2) ^c	Ref	47.5 (0.6)	0.16 (–1.0 to 1.3)	49.6 (0.7)	2.2* (0.7 to 3.8)	56.5 (1.3)	9.2* (6.6 to 11)
Mother (y)	27.5 (0.1)	27.6 (0.1)	Ref	27.3 (0.3)	–0.3 (–0.9 to 0.2)	27.0 (0.3)	–0.6* (–1.3 to 0.0)	26.6 (0.6)	–1.0 (–2.6 to 0.3)
	<i>n</i> (%) ^a	<i>n</i> (%)	OR (95% CI) ^c	<i>n</i> (%)	OR (95% CI)	<i>n</i> (%)	OR (95% CI)	<i>n</i> (%)	OR (95% CI)
Sex (child)									
Female	3456 (49.6)	2637 (50.2)	Ref	426 (46.8)	Ref	327 (47.8)	Ref	66 (48.1)	Ref
Male	3572 (50.4)	2654 (49.8)	Ref	492 (53.2)	1.1 (0.9 to 1.4)	335 (52.2)	1.1 (0.9 to 1.3)	91 (51.9)	1.1 (0.7 to 1.6)
Race and/or ethnicity (child)									
Non-Hispanic white	2045 (54.6)	1604 (56.3)	Ref	264 (54.2)	Ref	146 (43.6)	Ref	31 (42.3)	Ref
Hispanic	2522 (23.0)	1782 (21.0)	Ref	361 (25.8)	1.3* (1.0 to 1.6)	304 (33.1)	2.0* (1.6 to 2.6)	75 (36.1)	2.3* (1.4 to 3.7)
Non-Hispanic African American	1843 (14.4)	1401 (14.2)	Ref	224 (13.4)	1.0 (0.8 to 1.2)	174 (16.4)	1.5* (1.2 to 1.9)	44 (18.5)	1.7* (1.0 to 3.0)
Other or mixed	618 (8.0)	504 (8.5)	Ref	69 (6.6)	0.8 (0.6 to 1.2)	38 (6.9)	1.0 (0.7 to 1.7)	7 (3.1)	0.5 (0.2 to 1.2)
Household income, % FPL									
≥300	1360 (31.8)	1109 (33.6)	Ref	145 (27.3)	Ref	90 (24.9)	Ref	16 (20.0)	Ref
200–299	819 (14.8)	623 (14.8)	Ref	104 (15.0)	1.2 (0.9 to 1.7)	76 (14.6)	1.3* (1.2 to 2.2)	16 (14.6)	1.7 (0.6 to 4.1)
100–199	1810 (25.6)	1330 (24.6)	Ref	252 (28.6)	1.4* (1.1 to 1.9)	181 (28.3)	1.5* (1.0 to 2.2)	47 (31.8)	2.2* (1.0 to 4.4)
<100	2521 (27.8)	1850 (27.0)	Ref	340 (29.1)	1.3* (1.0 to 1.7)	267 (32.2)	1.6* (1.2 to 2.2)	64 (33.6)	2.1* (1.1 to 4.0)
Education (respondent)									
Any college	3014 (54.9)	2383 (57.5)	Ref	349 (48.1)	Ref	239 (47.0)	Ref	43 (35.8)	Ref
Less than HS or GED	3778 (45.1)	2735 (42.5)	Ref	544 (51.9)	1.5* (1.2 to 1.8)	392 (53.0)	1.5* (1.2 to 1.9)	107 (64.2)	2.4* (1.5 to 3.9)
Marital status (respondent)									
Married	4633 (78.8)	3533 (79.7)	Ref	594 (77.8)	Ref	421 (75.0)	Ref	85 (66.4)	Ref
Single	1932 (21.2)	1401 (20.3)	Ref	269 (22.3)	1.2 (0.9 to 1.4)	202 (25.0)	1.4* (1.1 to 1.7)	60 (33.7)	2.0* (1.3 to 3.0)

GED, general education diploma; HS, high school; Ref, reference.

^a All *N*'s and *n*'s listed are unweighted (raw), all means and proportions are survey-weighted.

^b Coefficients from unadjusted linear regression.

^c ORs from unadjusted multinomial logistic regression.

* *P* < .05.

Birth and Infancy Characteristics

Mean maternal age was lower with each progressive weight category (Table 2). However, in simple linear regression, only the mean maternal age among mothers of children with obesity (27.0 years) was significantly lower than the mean age among mothers of children with NW (27.6 years). Maternal smoking was associated with increased odds of obesity (OR: 1.4, 95% CI: 1.0 to 1.9) but not SO.

In this sample, the survey-weighted proportions of children born at a high birth weight (HBW) (>4000 g) were 12.1%, 16.3%, and 9.1%,

respectively, for children with OW, obesity, and SO, compared with 8.5% of NW children. Compared with those with normal birth weight, having had an HBW was associated with a twofold increase in odds of obesity (OR: 2.0, 95% CI: 1.5 to 2.8) but not SO. A history of low birth weight (<2500 g) was associated with lower odds of being OW (OR: 0.6, 95% CI: 0.4 to 0.9) but was not associated with obesity or SO. The proportion of children who had never been breastfed was increasingly higher in children with obesity (38.9%) and SO (44%) compared with NW children (29.3%). Having never been breastfed was associated with

increased odds of obesity (OR: 1.5, 95% CI: 1.2 to 2.0) and higher odds of SO (OR: 1.9, 95% CI [1.3 to 2.8]).

Screen Time

Roughly a quarter of children with NW and OW watched >2 hours per day of television. This proportion was higher for children with obesity (33.0%) and even higher for children with SO (37.2%). Compared with their peers with NW, the odds of watching >2 hours per day of television were 1.4 (95% CI: 1.0 to 1.7) for children with obesity (and although the odds were higher, the degree was not significant for children with SO). Compared with

TABLE 2 Birth and Infancy Characteristics: Bivariate Multinomial Logistic Regressions With Weight Status in Children Aged 2 to 5 Years, NHANES 1999–2014

	<i>n</i> (%) ^a	NW (<85th Percentile), <i>n</i> = 3907	OW (85th Percentile–94.9th Percentile), <i>n</i> = 676	Obesity (≥95th Percentile–1.2 × 95th Percentile), <i>n</i> = 510	SO (≥1.2 × 95th Percentile), <i>n</i> = 123				
		<i>n</i> (%)	OR ^b (95% CI)	<i>n</i> (%)	OR (95% CI)	<i>n</i> (%)	OR (95% CI)	<i>n</i> (%)	OR (95% CI)
Low birth wt (<2500 g)	678 (8.5)	561 (9.3)	Ref	57 (5.2)	0.6* (0.4 to 0.9)	45 (5.8)	0.7 (0.4 to 1.5)	15 (12.2)	1.0 (0.5 to 2.0)
Normal birth wt (2500–4000 g)	5598 (81.8)	4219 (82.2)	Ref	746 (82.6)	Ref	511 (77.9)	Ref	122 (78.6)	Ref
HBW (>4000 g)	591 (9.7)	391 (8.5)	Ref	98 (12.2)	1.2 (0.9 to 1.7)	100 (16.3)	2.0* (1.5 to 2.8)	17 (9.2)	1.1 (0.5 to 2.4)
Mother smoked during pregnancy	928 (16.5)	677 (14.0)	Ref	126 (15.0)	1.1 (0.8 to 1.4)	103 (18.2)	1.4* (1.0 to 1.9)	22 (20.8)	1.6 (0.9 to 2.8)
Never breastfed	2430 (30.7)	1777 (29.3)	Ref	328 (31.3)	1.1 (0.9 to 1.3)	255 (38.9)	1.5* (1.2 to 2.0)	70 (44.0)	1.9* (1.3 to 2.8)

Ref, reference.

^a All *N*'s and *n*'s listed are unweighted (raw) and all proportions are survey-weighted.^b Unadjusted ORs from multinomial logistic regression.* *P* < .05.

their peers with NW, the odds of watching >3 hours per day of television were higher for children with obesity (OR: 1.6, 95% CI: 1.2 to 2.1) and highest for those with SO (OR: 1.9, 95% CI: 1.1 to 0.3).

Total screen time exceeded the recommended limit of 2 hours in more than half of the children in the sample; it was >2 hours per day for 57.3%, 59.9%, 66.8%, and 66.5% of children with NW, OW, obesity, and SO, respectively. Compared with peers with NW, the odds of having a total screen time >2 hours per day were higher for children with obesity (OR: 1.4, 95% CI: 1.2 to 1.8), although the trend was not statistically significant for children with SO (OR: 1.5, 95% CI: 0.8 to 2.0). High levels of total screen time (>3 and >4 hours per day) were consistently associated with higher odds of obesity that were greatest for children with SO. Compared with their peers with NW, the odds of having screen time >4 hours per day were higher for children with obesity (OR: 1.5, 95% CI: 1.2 to 1.9) and particularly elevated for children with SO (OR: 2.0, 95% CI: 1.2 to 3.3).

Diet

Mean energy intake in daily kilocalories was 1575 kcal/day (SE: 10) for the

entire sample, with respective means by category as follows: NW: 1558 kcal/day (SE: 11), OW: 1619 kcal/day (SE: 29), obesity: 1644 kcal/day (SE: 34), and SO: 1644 kcal/day (SE: 59) (Tables 3 and 4). After adjusting for age and sex, the respective additional daily energy intakes among children with OW, obesity, and SO were not statistically significant.

The HEI-2010 score for the entire sample was 51.1 (SE: 0.4), and mean scores by weight status were 51.1 (SE: 0.4), 52.3 (SE: 0.7), 49.4 (SE: 0.8), and 49.7 (SE: 1.5) for children with NW, OW, obesity, and SO, respectively. In adjusted analyses, the HEI-2010 difference with peers with NW was not significant for children with OW, obesity, or SO (0.2, 95% CI: –2.9 to 3.3). The 12 HEI-2010 components were each examined in linear regression as log-transformed outcomes, and none of the 12 HEI-2010 component scores were significantly associated with SO.

DISCUSSION

Children with SO represent a growing subgroup of children with an increased risk for significant morbidity. As part of a broader effort of the American Academy of Pediatrics Institute for Healthy

Childhood Weight and the Children's Hospital Association Expert Exchange, this analysis was conducted to better characterize young children with SO and factors associated with the development of SO in early childhood by using a nationally representative data set. In the Early Childhood Longitudinal Study Birth Cohort, Flores and Lin¹⁵ found that greater odds of SO were associated with Hispanic race, preschool attendance, and food frequency questions such as number of sugary beverages per week. With our findings, we highlight multiple social determinants and excessive screen time, in particular, as key factors associated with increased odds of SO in this population.

These results reveal that, regardless of weight status, more than half of 2- to 5-year-olds in the United States surpass current guidelines to limit screen time to 2 hours per day.^{10,11} Among preschool-aged children with SO, screen time use is even more abundant, with more than two-thirds exceeding the recommended 2-hour limit and more than one-quarter reporting screen time use beyond 4 hours per day. The authors are unaware of previous studies in which associations between SO and screen time in this demographic are described; however,

TABLE 3 Screen Time: Bivariate Analysis With Weight Status in Children Aged 2 to 5 Years, NHANES 1999–2014

	Total (All wt)	NW (<85th Percentile)		OW (85th Percentile– 94.9th Percentile)		Obesity (≥95th Percentile–1.2 × 95th Percentile)		SO (≥1.2 × 95th Percentile)	
	<i>n</i> = 6762	<i>n</i> = 5084		<i>n</i> = 882		<i>n</i> = 643		<i>n</i> = 153	
	<i>n</i> ^a (%)	<i>n</i> (%)	OR ^b (95% CI)	<i>n</i> (%)	OR (95% CI)	<i>n</i> (%)	OR (95% CI)	<i>n</i> (%)	OR (95% CI)
Screen time									
Television time >2 h	2085 (27.3)	1533 (26.5)	Ref	266 (26.7)	1.0 (0.8 to 1.2)	228 (33.2)	1.4* (1.1 to 1.7)	58 (37.2)	1.5 (1.0 to 2.4)
Television time >3 h	1091 (13.4)	777 (12.6)	Ref	148 (13.3)	1.1 (0.8 to 1.4)	133 (18.6)	1.6* (1.2 to 2.1)	33 (21.8)	1.9* (1.1 to 3.3)
Total screen time >2 h	4101 (58.6)	3037 (57.3)	Ref	542 (59.9)	1.1 (0.9 to 1.3)	421 (66.8)	1.4* (1.2 to 1.8)	101 (66.5)	1.5 (0.8 to 2.0)
Total screen time >3 h	2277 (30.0)	1664 (29.0)	Ref	296 (29.5)	1.0 (0.8 to 1.2)	251 (36.6)	1.4* (1.1 to 1.8)	66 (43.2)	1.7* (1.1 to 2.7)
Total screen time >4 h	1262 (15.8)	900 (14.7)	Ref	170 (17.1)	1.2 (0.9 to 1.6)	154 (21.1)	1.5* (1.2 to 1.9)	38 (27.1)	2.0* (1.2 to 3.3)

Ref, reference.

^a All *N*'s and *n*'s listed are unweighted (raw), and all proportions are survey-weighted.^b ORs from multinomial logistic regression, adjusting for age and sex of the child.* *P* < .05.**TABLE 4** Diet Quality: Bivariate Analysis With Weight Status in Children Aged 2 to 5 Years, NHANES 1999–2014

	Total	NW		OW		Obesity		SO	
	<i>n</i> = 6236 (100%)	<i>n</i> = 4702 (76.6%)		<i>n</i> = 813 (13.1%)		<i>n</i> = 582 (8.2%)		<i>n</i> = 139 (2.1%)	
	Mean ^a (SE)	Mean (SE)	Coefficient (95% CI)	Mean (SE)	Coefficient (95% CI)	Mean (SE)	Coefficient (95% CI)	Mean (SE)	Coefficient (95% CI)
Energy intake (kcal per d)	1575 (10)	1558 (12)	Ref	1619 (33)	57.0 (−3.3 to 117.3)	1644 (37)	61.1 (−11.9 to 134.1)	1644 (63)	8.6 (−101.5 to 118.7)
HEI-2010 score (out of 100 points)	51.1 (0.4)	51.1 (0.4)	Ref	52.3 (0.7)	1.2 (−0.2 to 2.6)	49.4 (0.8)	−1.3 (−2.9 to 0.2)	49.7 (1.5)	0.2 (−2.9 to 3.3)

Coefficients from linear regression adjusting for age and sex of the child. Ref, reference.

^a Linearized means with SEs.

results are mixed when comparing previous NHANES literature in which associations of physical and sedentary activity with adiposity in children of a wider age range are described. Using the NHANES 2001–2004, Anderson et al¹⁶ found that children 4 to 11 years with obesity had increased odds of elevated screen time and low physical activity. In the NHANES 1999–2006, Fulton et al⁹ did not find increased odds of OW or obesity (BMI >85th percentile) among 2- to 5-year-olds with elevated screen time but did find increased odds among 6- to 15-year-old girls and 12- to 15-year-old boys. Our data reveal a strong dose-response relationship between screen time and obesity or SO.

It is well established that sociodemographic factors are associated with childhood obesity,^{2,17,18} and this relationship

appears to be particularly strong when it comes to risk for SO. Our results reveal an increased risk of SO among children of racial and ethnic minority status, children of parents with low educational attainment, children of single-parent households, and children of households with income below the FPL. In results consistent with those within existing literature, a lack of breastfeeding was associated increased obesity and, on the basis of our findings, increased odds of SO.^{19–21} Taken together, these findings highlight a level of disparity for this subgroup not previously described. Although the number of children with SO in this sample is not adequately powered for consideration of these multiple factors concurrently, it is important to acknowledge that for each of these sociodemographic variables, a dose-response association was evident as the severity of obesity increased.

Energy intake and diet quality in children with SO was only modestly different from that of children with NW, and these small differences were not statistically significant. Similar nonsignificant trends with respect to higher energy intake and higher weight status have been reported in children 2 to 8 years.²² The lack of a difference in reported energy intake could represent under-reporting, which is a known challenge in self-reported^{23,24} as well as in proxy-reported dietary intake by adults on behalf of children with excess weight.²⁵ It is also plausible that a diet report of appropriate energy intake and/or quality in a child with SO may represent compliance with a current obesity treatment plan under health care supervision.

These data represent a unique look at young children across different weight categories, with a specific focus on preschool-aged children with SO. An

important caveat is that even with 14 years of data, the number of children with SO in the sample was small, thus limiting the power to detect small group differences and limiting our ability to consider the simultaneous effect of multiple risk factors for SO.²⁶ In addition, because the data are cross-sectional, causality cannot be inferred.

Like the authors of previous studies, we provide evidence that children from families with socioeconomic disadvantage and children who have racial and ethnic minority status are at a higher risk for SO. This disparity reveals the need to develop culturally-sensitive interventions for subgroups. More than any other modifiable behavior studied in this analysis, increased amounts of screen

time were associated with increased odds of obesity, particularly SO. This finding adds to recent studies in which authors implicated screen time and sedentary behaviors in weight gain among children. Pediatricians should be encouraged to emphasize limiting screen time in this age group, as recommended by the American Academy of Pediatrics.^{10,11}

CONCLUSIONS

Although SO among preschool-aged children has been previously quantified, this is the first study we are aware of in which the authors attempt to better characterize this high-risk group by contextualizing them in comparison with peers who have NW, OW, or obesity. The findings suggest a possible spectrum

of risk, with children with SO having the greatest exposure to markers of socioeconomic disadvantage. Future researchers need to help us better understand the behavioral and physiologic mechanisms and relationships behind the risk factors noted in our study and their impact on long-term morbidity.

ABBREVIATIONS

CI: confidence interval
FPL: federal poverty level
HBW: high birth weight
HEI-2010: Healthy Eating Index 2010
MEC: mobile examination center
NW: normal weight
OR: odds ratio
OW: overweight
SO: severe obesity

the study, topical expertise in pediatric obesity for preparation of the manuscript, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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