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Family Structure and Childhood Obesity: An Analysis Through 8th Grade

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Abstract Research on the effect of family structure on childhood obesity is scarce. This study examines the effect of number of parents and number of siblings on US children's body mass index (BMI) and risk of obesity. We conducted a secondary data analysis of the Early Childhood Longitudinal Study—Kindergarten Cohort (ECLS-K), which consists of a nationally representative cohort of children who entered kindergarten in 1998–1999, to examine the effect of family structure on children's body mass index and risk of obesity from kindergarten through 8th grade. Study outcomes were BMI in kindergarten and 8th grade, obesity status in kindergarten and 8th grade, and change in BMI from kindergarten through 8th grade. Multivariate regressions were used to assess the association between family structure and study outcomes while adjusting for other covariates. In 8th grade, children with no siblings had higher BMI (23.7 vs. 22.6; $P \leq 0.01$) and higher probability of being obese (25.8 vs. 19.7 %; $P \leq 0.05$) than their counterparts with two or more siblings. They also had a larger increase in BMI from kindergarten through 8th grade than children living with two or more siblings (7.3 vs. 6.3; $P = 0.02$). Our analysis suggests that the association between family structure and obesity persists and even intensifies through 8th grade. These findings have important implications for targeting obesity support and counseling for families.

Keywords Obesity · Family structure · Child health outcomes

Abbreviations

BMI	Body mass index
CDC	Centers for disease control and prevention
ECLS	Early Childhood Longitudinal Study

Introduction

In the past two decades, the prevalence of obesity has doubled among adults in the US and tripled among children and adolescents 6–19 years of age [1, 2], making obesity a leading public health concern. The risk of becoming an obese adult is two to six times higher for children with BMI percentile ≥95th percentile for age and sex [3], and childhood obesity is associated with increased risk of hypertension, hyperlipidemia, type II diabetes mellitus, and cardiovascular disease [4].

Family is the primary social learning environment and source of influence for children [5]; specifically, family provides the social and interpersonal support that is instrumental in maintaining children's habits and behaviors [5, 6]. Parents, family composition, and family environment can impact the amount of food a child consumes and his/her level of physical activity [7].

Numerous studies over the past two decades have consistently linked family structure to children's developmental

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and educational outcomes [8–11]. The evidence suggests that two-parent families may be better equipped to nurture children than single-parent families [12, 13]. More recent studies have also found associations between family structure (including parent status and number of siblings) and children's physical health outcomes [7, 14–16].

In a previous study, we found that children with no siblings have a higher risk of obesity in 5th grade and a larger increase in body mass index (BMI) from kindergarten through 5th grade than children with siblings [16]. We also found that children from single-mother families were more likely to be obese in 5th grade than their peers from two-parent families. Here we extend our previous analysis to examine the association between family structure—i.e., number of parents and siblings—and children's BMI and risk of obesity from kindergarten through 8th grade.

Methods

Data

The Early Childhood Longitudinal Study—Kindergarten Cohort (ECLS-K) is a study conducted by the National Center for Education Statistics using a nationally representative cohort of children who entered kindergarten in 1998–1999 [17]. The sample was drawn from approximately 1,000 public and private schools. Data, including measured height and weight, were collected in kindergarten, 1st, 3rd, 5th, and 8th grades. We identified children in kindergarten who were from two-parent or single-mother families (excluding single-father and other family types) and tracked these children through 8th grade; we also excluded children with missing data on height, weight or other key variables (N = 6,551).

Study Outcomes

Study outcomes were BMI in kindergarten and 8th grade, obesity status in kindergarten and 8th grade, and change in BMI from kindergarten through 8th grade. We used BMI to categorize children's weight status. Obesity was defined as children with BMI percentile ≥95th percentile for age and sex, based on the Institute of Medicine and American Academy of Pediatrics expert committee recommendations [18, 19]. BMI was calculated by dividing a child's weight in kilograms by the square of his/her height in meters (kg/m^2)—BMI is widely considered the best clinical weight criterion for children because it correlates well with the risk of developing obesity in adulthood [3, 18, 19]. Percentile comparisons were based on the sex-specific BMI for age growth charts from the Centers for Disease Control and Prevention (CDC) [20].

Analysis

We used multivariate linear and logistic regression to assess the association between family structure and the study outcomes while adjusting for other variables that may influence these outcomes. The main explanatory variables in the models were an indicator variable for living in a single-mother family (versus a two-parent family), and indicator variables for number of siblings, categorized as none, one, or two or more. Covariates in the models included the following sociodemographic characteristics: indicator variables for the child's age; gender; race/ethnicity, categorized as non-Hispanic white, non-Hispanic black, Hispanic, or other; family income, categorized as poor (<1.00 times the federal poverty line), low-income (1.00–1.99 times poverty), middle-income (2.0–3.99 times poverty), or high-income (4.00+ times poverty); mother's education, categorized as high school or less, high school graduate, some college, or bachelor's degree or higher; and mother's age, categorized as 24 years or younger, 25–34, 35–44, or 45 years or older (covariates that vary with time such as age, education, and income were obtained at both kindergarten and 8th grade). Additionally, we included several variables to capture the child's health at birth: an indicator for premature birth of 4–6 weeks, and greater than 6 weeks; indicators for birth weight, categorized as less than 2,000, 2,000–2,499, 2,500–2,999, 3,000–3,499, and 3,500 g and above; birth order, categorized as first, second, or third or higher.

To facilitate interpretation of the regression results, we used the method of recycled predictions to obtain the predicted mean values of the study outcomes for each type of family while adjusting for the covariates [14, 15, 22]. Specifically, we used the estimated coefficients from the regression models to predict each outcome for each child, alternately assigning the child to each category of the family structure variable of interest (e.g., single-mother vs. two-parent family), but leaving all other explanatory variables at their original values. Next, we averaged the predictions across all the children in the sample. This procedure yields what the mean value of each outcome would be if all children in the sample lived in each particular type of family (e.g., single-mother or two-parent family), but otherwise retained the original values of all their other characteristics.

We weighed all analyses using sample weights provided by ECLS-K that reflect the sample design as well as survey non-response and adjusted all standard errors for clustering using the Huber-White sandwich estimator [21]. This study is conducted in accord with prevailing ethical principles and is IRB-exempt for public use data with no identifiable information.

Results

Descriptive Data

Table 1 describes the characteristics of the study sample at enrollment (i.e., in Kindergarten). Excluding single-father and other family types, about 15 % of the children were from single-mother families. Nearly half of the children were girls, and the majority had at least one sibling.

For our study cohort, the mean BMI in kindergarten was 16.3 and 10.9 % of the children were obese. In 8th grade, the mean BMI was 22.9 and 20.8 % of the children were obese. There was a clear increase in the rate of obesity from kindergarten to 8th grade.

Bivariate Analyses

Table 2 shows that family structure was significantly associated with childhood obesity. Children from single-mother families had higher rates of obesity than children from two-parent families. In kindergarten, 13.5 % of children from single-mother families were obese, compared to 10.5 % of children from two-parent families ($P \leq 0.01$). Similarly, in 8th grade, 25.1 % of children from single-mother families were obese, compared to 19.7 % of children from two-parent families ($P \leq 0.05$). The number of siblings was also negatively associated with the rate of obesity.

Multivariate Analyses

Adjusted results for BMI and risk of obesity, obtained using the multivariate models and recycled prediction, are presented in Table 3. The number of parents in the household was not associated with BMI or risk of obesity in kindergarten or 8th grade. However, we did find that children with no siblings had higher BMI and a higher probability of being obese than children with two or more siblings, starting in kindergarten: BMI (16.5 vs. 16.1; $P \leq 0.01$) and percent obese (14.3 vs. 8.9 %; $P \leq 0.01$); these differences persisted—8th grader with no siblings had higher BMI (23.7 vs. 22.6; $P \leq 0.01$) and higher probability of being obese (25.8 vs. 19.7 %; $P \leq 0.05$) than their counterpart with two or more siblings. Additionally, children living with no siblings had a larger increase in BMI from kindergarten through 8th grade than children living with two or more siblings (7.3 vs. 6.3; $P = 0.02$). We conducted analyses to assess the statistical significance of interactions between maternal age and education, on one hand, and preterm birth and birth weight, on the other. We also assessed the significance of interactions between single mother status and income. All interactions were non-significant.

Table 1 Characteristics of the sample in kindergarten

Explanatory variables	Categories	N	Percent[a]
Family structure			
Number of parents	Two parents	5,587	84.9
	Single mother	964	15.1
Number of siblings	None	945	14.2
	1	2,938	45.2
	2 or more	2,268	40.6
Other variables			
Sex	Female	3,253	49.1
	Male	3,298	50.9
Race/ethnicity	Non-Hispanic white	4,290	66.8
	Non-Hispanic black	556	9.3
	Hispanic	1,072	17.6
	Asian	299	2.2
	Other	329	4.1
Family income	Poor	956	15.3
	Low income	1,250	19.7
	Middle income	2,462	37.2
	High income	1,883	27.8
Maternal education	HS or less	655	10.9
	HS degree	1,750	27.2
	Some college	2,167	33.4
	College degree or more	1,979	28.5
Maternal age	<25	306	5.1
	25–34	3,021	47.4
	35–44	3,010	44.8
	45 or more	192	2.7
Birth order	First born	2,793	42.2
	Second born	2,380	36.8
	Third born or higher	1,378	21.0

[a] Weighted by sample weights

Table 2 Bivariate results (unadjusted): obesity rates and mean BMI by family structure variables

	Number of parents		Number of siblings		
	Two parent	Single mother	No sibling	One sibling	Two or more siblings
Kindergarten					
% obese[a]	10.5 %	13.5 %**	12.9 %	11.5 %	9.6 %**
Mean BMI[b]	16.2	16.5**	16.4	16.3	16.2*
8th Grade					
% obese[a]	19.7 %	25.1 %*	23.2	18.2*	22.6
Mean BMI[b]	22.7	23.6**	23.2	22.5*	23.2

* $P \leq 0.05$ for test of difference with the comparison category

** $P \leq 0.01$ for test of difference with the comparison category

[a] Pearson's Chi Square test

[b] Two-group mean comparison t test

Table 3 Multivariate results: predicted prevalence of obesity and predicted mean body mass index by family structure variables, adjusted for other covariates

	Number of Parents		Number of Siblings		
	Two parent[a]	Single mother	No sibling[a]	One sibling	Two or more siblings
Kindergarten					
% Obese	10.8 %	11.7 %	14.3 %	12.0 %	8.9 %**
Mean BMI	16.3	16.4	16.5	16.4	16.1**
8th Grade					
% Obese	20.8 %	21.0 %	25.8 %	20.4 %*	19.7 %*
Mean BMI	22.9	22.8	23.7	22.9*	22.6**

Predicted values are adjusted for the child's age, sex, race/ethnicity, family income, mother's education and age, birth order, birth weight, and premature birth. Moreover, predicted values for each family structure variable (e.g., number of parents) are also adjusted for the other family structure variable

* $P \leq 0.05$ for test of difference with the comparison category

** $P \leq 0.01$ for test of difference with the comparison category

[a] Comparison category for statistical testing

Noteworthy findings for other explanatory variables in the regression models for obesity were as follows. In kindergarten, black (OR 1.22, $P = 0.03$) and Hispanic children (OR 1.39, $P < 0.01$) were more likely to be obese than white children; children from high-income families were less likely to be obese than children from poor families (OR 0.62, $P < 0.01$). In 8th grade the risk of obesity did not differ significantly by race or ethnicity. However, eighth graders from high-income families remained less likely to be obese than poor children (OR 0.46, $P < 0.01$). For obesity risk and mean BMI, second and third born child did not differ significantly from first born child.

Discussion

In our previous study, we found that children who had no siblings had the highest risk of obesity through 5th grade [16]. Our current analysis suggests that this effect persists and even intensifies through 8th grade, as children with no siblings gained more weight over time than their counterparts with siblings. The number of siblings may influence children's weight through effects on the time and attention parents can devote to nurturing children and on the nature and extent of interactions among siblings [8–10, 23]. Additional children in the family may "dilute" available parental time and resources [9–11], which may reduce the time that parents spend with each child and make it harder for parents to attend to their children's health needs [8–10, 14, 15]. However, in the US and other developed countries, resource abundance and economy of scale may minimize the dilution effect described above. Furthermore, evidence has shown that siblings and cousins can also serve as support to encourage increased physical activity after school for children [24]. Siblings may also stimulate interactions and/or participate in play activity. Boys without any sibling have been shown to spend more time watching TV than those with siblings [25]. Our findings further suggest that the beneficial effect of siblings in reducing obesity risk may outweigh its deleterious effect.

Although we did not find a significant association between single-mother structure and childhood obesity by 8th grade, our previous study did find such an association in 5th grade [16]. It's possible that the parental effect on obesity is attenuated as the child ages and becomes more independent. Another study using NHANES III data also found that total calorie and saturated fatty acid intakes were higher among children of single-parent families than two-parent families and that those children were more likely to be overweight [7].

This study has several limitations. First, because we did not study single-father families and other less common family types, our findings may not apply to these families. Second, as with any observational study, our findings may be subject to omitted variable bias from unobserved parental or family characteristics—these characteristics can also evolve over time. Third, family structure variables are crude structural proxy of family functioning, which may not sufficiently capture the key causes or mechanisms related to children's increased obesity risk. Lastly, parenting a single child versus multiple children is a complex and dynamic process which cannot be fully captured by number of siblings.

Conclusion

Our findings shed light on the influence of family structure on childhood obesity and can have important implications for targeting obesity prevention and intervention programs; for example, school-and community-based obesity prevention and intervention programs may focus their efforts on children with no siblings and/or other vulnerable family circumstances [8, 23]. Moreover, clinicians and health care providers may be able to use this information to provide appropriate anticipatory guidance and prevention for children with increased risk. These findings highlight the important role that families play in childhood obesity and the context in which providers should plan and monitor children's health care. Additional research into the mechanisms underlying the impact of siblings in physical activity, diet, and television viewing could be helpful in better understand sibling effects in the context of childhood obesity.

Appendix

See Table 4.

Table 4 Full regression results

Variables	BMI—K		BMI—8th		Obesity—K		Obesity—8th		Change in BMI	
	Coeff	SE	Coeff	SE	O.R.	SE	O.R.	SE	Coeff	SE
No. of parents										
Two parents	–	–	–	–	–	–	–	–	–	–
Singlemother	0.16	0.11	−0.16	0.34	1.09	0.15	1.02	0.15	−0.12	0.29
No. of siblings										
None	–	–	–	–	–	–	–	–	–	–
1	−0.11	0.10	−0.81	0.34	0.82	0.12	0.72	0.11	−0.54	0.26
2 or more	−0.32	0.12	−1.16	0.37	0.58	0.10	0.69	0.12	−1.06	0.27
Age										
4/12 years (K/8th)	–	–	–	–	–	–	–	–	–	–
5/13 years	−0.16	0.16	0.35	0.54	1.41	0.39	2.03	0.60	−0.59	0.53
6/14 years	−0.08	0.15	0.12	0.47	1.14	0.29	1.23	0.34	−0.66	0.46
Sex										
Male	–	–	–	–	–	–	–	–	–	–
Female	−0.09	0.06	1.00	0.23	0.96	0.09	0.89	0.09	0.60	0.18
Race/ethnicity										
Non-Hisp. W	–	–	–	–	–	–	–	–	–	–
Non-Hisp. B	0.35	0.14	1.56	0.47	1.22	0.22	1.36	0.26	1.36	0.39
Hispanic	0.44	0.10	0.38	0.31	1.39	0.18	1.08	0.15	0.30	0.23
Asian	0.01	0.15	−0.33	0.45	1.55	0.33	1.01	0.26	−0.70	0.32
Other	0.28	0.15	1.38	0.57	1.29	0.27	1.78	0.44	0.44	0.47
Prematurity										
<4 weeks	–	–	–	–	–	–	–	–	–	–
4 to 6 weeks	0.05	0.10	−0.01	0.38	0.96	0.17	1.13	0.21	0.34	0.39
>6weeks	0.38	0.14	1.50	0.48	1.96	0.44	1.76	0.44	1.07	0.41
Birth weight										
<2,500 g	–	–	–	–	–	–	–	–	–	–
2500–2,999 g	0.33	0.14	0.54	0.44	1.29	0.34	1.12	0.29	0.19	0.38
3,000–3,499 g	0.72	0.13	1.42	0.41	1.95	0.49	1.59	0.39	0.60	0.39
≥3,500 g	1.18	0.14	2.68	0.44	2.76	0.69	2.40	0.59	1.60	0.42
Birth order										
1st born	–	–	–	–	–	–	–	–	–	–
2nd born	0.03	0.07	0.28	0.25	1.13	0.13	1.11	0.13	0.12	0.21
3rd or higher	−0.01	0.11	0.74	0.36	0.99	0.17	1.19	0.18	0.65	0.31
Maternal edu.										
HS or less	–	–	–	–	–	–	–	–	–	–
HS degree	−0.19	0.14	−0.85	0.46	0.78	0.12	0.73	0.13	−0.16	0.32
College	−0.29	0.14	−1.02	0.48	0.66	0.11	0.68	0.13	−0.46	0.34
>College	−0.38	0.15	−1.30	0.51	0.59	0.11	0.50	0.11	−0.63	0.42
Maternal age										
<25	−0.03	0.27	1.22	0.73	0.86	0.32	1.15	0.40	0.39	0.65
25–34	0.15	0.22	1.10	0.57	0.93	0.30	1.21	0.34	0.29	0.55
35–44	0.10	0.21	0.37	0.55	0.99	0.32	0.99	0.28	−0.15	0.54
45 or more	–	–	–	–	–	–	–	–	–	–

Table 4 continued

Variables	BMI—K		BMI—8th		Obesity—K		Obesity—8th		Change in BMI	
	Coeff	SE	Coeff	SE	O.R.	SE	O.R.	SE	Coeff	SE
Family income										
Poor	–	–	–	–	–	–	–	–	–	–
Low-inc	0.08	0.12	−0.71	0.46	1.23	0.18	0.73	0.18	−0.59	0.37
Middle-inc	−0.06	0.12	−1.17	0.47	0.90	0.14	0.67	0.13	−1.02	0.38
High-inc	−0.23	0.12	−2.12	0.52	0.62	0.12	0.46	0.10	−1.78	0.42

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