Evaluating Moderation of Parent-Teen Overweight/Obesity Relation by Household Socioeconomic Status

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ABSTRACT

Evidence links parent-offspring weight status, but few studies have evaluated whether markers of socioeconomic status moderate this relation. The 2014 Family Life, Activity, Sun, Health, and Eating study was used to assess intergenerational weight status in a national sample of parent-teen dyads. Multivariable logistic regression models assessed the relation between parent-teen weight status, controlling for teen and parent dietary factors, physical activity, demographic factors, and socioeconomic factors. Models with interaction assessed moderation by household food security status and participation in federal assistance programs. In fully adjusted models, sons were 2.66 (95% CI: 1.56, 4.55) times more likely to have overweight/obesity if their mother had overweight/obesity, and daughters were 3.35 (95% CI: 1.91, 5.86) times more likely. This relation was stronger in mother-son pairs in households with lower food security. These findings provide important new information that can be used to inform nutritional counseling efforts and educational programs that support families with socioeconomic disadvantage. *Curr Dev Nutr* 2021;5:nzab030.

Introduction

The combined prevalence of overweight/obesity in children and adolescents in the United States increased from 16% in 1971–1974 to 42% in 2017–2018 (1). Individual-level factors such as poor diet, sedentary behavior, and genetic influences are primary risk factors for adolescent weight gain (2). But the etiology of obesity is complex and multifaceted, and correlates of overweight/obesity can differ among population subgroups (3), with potentially important implications for policy and practice.

Increasing evidence demonstrates that maternal overweight/obesity prior to conception (4), during pregnancy (5), at birth (6), and during child-rearing (7) predict overweight/obesity in offspring. Globally, meta-analyses have demonstrated that these relations are stronger in maternal pairs than paternal pairs (8), and a recent study in England reinforced this finding (9). Prior research has also found

that this association between parental and child overweight/obesity varies among different demographic subgroups; for example, 2 studies found that associations are stronger in parent-child dyads from lower compared with higher socioeconomic status households (10, 11). However, those studies noted significant methodological limitations, including use of older datasets (10) and failure to incorporate important behavioral factors, like child diet and physical activity (PA) (11).

To fill these gaps, the Family Life, Activity, Sun, Health, and Eating (FLASHE) study was used to assess overweight/obesity status in a national sample of parent-teen dyads. The objectives of this study were to: *1)* evaluate the relations between parent-teen weight status in gendered dyads (mother-son, mother-daughter, father-son, father-daughter), and *2)* examine whether these relations are moderated by 2 markers of socioeconomic status: household food security and participation in federal assistance programs.

Methods

Data acquisition and study sample

The FLASHE study is a cross-sectional web-based study led by the National Cancer Institute (NCI) that assessed generational health behaviors related to cancer prevention (12). Complete details of the study can be found elsewhere (13). In brief, data were collected April to October 2014 from a national, nonprobability sample of parent-teen dyads (teens 12–17 y of age), balanced to approximate the demographic composition of the US population (14). Approximately one-third of teen participants were recruited in each age range (12–13, 14–15, and 16–17 y), and male/female teens were evenly represented. Recruitment procedures did not target a specific balance of parent genders, and single parents were not excluded. A total of 5027 dyads were invited to participate, and the enrollment rate was 38.7% ($n = 1945$). A total of 1573 dyads completed the demographic, dietary, and PA questionnaires, and 1410 dyads with complete data on demographics, dietary intake, PA, sex, height, and weight were included in the final sample (**Supplemental Figure 1**). Final response rates for parents were 23% for males and 32% for females, and teen response rates were 29% for males and 30% for females. The FLASHE study protocol was approved by the US Government's Office of Management and Budget and the Institutional Review Boards of NCI Special Studies and Weststat, Inc. (15). The present study is a secondary analysis of publicly available and deidentified data and was deemed exempt from human studies ethical review by the Institutional Review Board at William & Mary.

Measures and variables

NCI staff used self-reported height and weight to derive BMI (kg/m^2) for parents and BMI z-scores and percentiles for teens. Weight status was categorized according to standard definitions provided by the CDC for adults (underweight: <18.5; healthy weight: 18.5–24.9; overweight: 25–29.9; obese: ≥30) and teens (underweight: <5th percentile; healthy weight: 5th to 84th percentile; overweight: 85th to 94th percentile; and obese: ≥95th percentile). Weight status was recategorized as healthy weight and overweight/obese to provide sufficient statistical power, and dyads in which the parent or teen had underweight were not included in the analytic sample ($n = 83$ dyads).

Potential confounding variables were teens' self-reported age (continuous), race-ethnicity (Hispanic, non-Hispanic black, non-Hispanic white, other), dietary intake, and PA (16). Teen dietary intake data were collected using a 27-item frequency screener, and data were converted to daily intake amounts of major food groups using established scoring algorithms (17, 18). Multicollinearity testing procedures identified a parsimonious set of dietary variables for analysis, including non-fried fruits and vegetables (cup-equivalents, continuous), whole grains (cup-equivalents, continuous), and sugary foods (frozen dessert, cookies, cake, candy, chocolate, and sugary cereal; teaspoon-equivalents, continuous). Teens' self-reported number of minutes per day of moderate-to-vigorous PA in school and out of school (continuous) were summed to derive total daily minutes of moderate-to-vigorous activity (16).

Additional confounders and potential moderating variables were household food security and receipt of federal assistance. Household food security was indicated if in the previous 12 mo the parent indicated their food ran out and/or they worried about running out

before they could afford more (yes/no). Participation in federal assistance programs was indicated if the parent reported the household was participating in ≥1 federal assistance program at the time of data collection, including: the Supplemental Nutrition Assistance Program (SNAP); Special Supplemental Nutrition Program for Women, Infants, and Children (WIC); Temporary Assistance for Needy Families; Supplemental Security Income; or National School Lunch Program (yes/no).

Statistical analysis

Unadjusted and multivariable logistic regression models assessed the relation between parent-teen weight status for gendered dyads. Teen weight status was the dependent variable and parent weight status was the main independent variable. Potential confounding variables were assessed in subsequent models by iteratively including teen age, race-ethnicity, dietary factors, PA, household food security, and receipt of federal assistance. Parent covariates were not included in the models because high collinearity with teen covariates prevented convergence of the maximum likelihood estimations. Sensitivity analyses demonstrated substantially similar results when parent covariates were included instead of teen covariates (data not shown). Moderation analyses were conducted by interacting parent weight status with household food security and receipt of federal assistance, adjusted for teen and parent age, race-ethnicity, dietary factors, and PA. The pseudo-R^2 statistic was used to evaluate goodness-of-fit. All analyses were adjusted for survey weights provided by NCI (13). All tests were 2-tailed with $P < 0.05$ indicating statistical significance. Stata 16.1 (StataCorp) was used for data management and analysis.

Results

The analytic sample included 1410 gendered dyads (**Supplemental Table 1**). Analytic sample sizes for mother-teen dyads ($n = 418$–548) were more than twice as large as father-teen dyads ($n = 130$–192) for all analyses (**Supplemental Table 2**). In unadjusted models (Model 1), teens were more likely to have overweight/obesity if their parent had overweight/obesity ($P < 0.01$), except in father-daughter dyads (**Table 1**; $P ≥ 0.05$). In mother-teen dyads, but not in father-teen dyads, these relations persisted after further adjustment for teen age and race-ethnicity (Model 2), dietary factors and PA (Model 3), and food security status and federal assistance (Model 4; $P < 0.001$ for all models). Goodness-of-fit increased from Model 1 to Model 4 as demonstrated by increasingly greater pseudo-R^2 values (**Supplemental Table 3**).

Table 2 displays the moderating effects of household food security and participation in federal assistance programs on the relation between parent-teen weight status in fully adjusted models. In households with higher food security, sons were 1.41 (95% CI: 0.62, 3.20) times more likely to have overweight/obesity if their mother had overweight/obesity compared with a healthy weight, whereas sons that lived in households with lower food security were 4.30 (95% CI: 2.19, 8.44) times more likely to have overweight/obesity if their mother had overweight/obesity compared with a healthy weight (P-interaction = 0.039). Household food security status did not moderate the relation between mother-daughter weight status (P-interaction = 0.487). Household participation in federal assistance

TABLE 1 Relation between parent-teen weight status[1]

Parent-teen pair	Model 1	Model 2	Model 3	Model 4
	OR (95% CI)[2]			
Mother-son				
Mother with healthy weight	Referent	Referent	Referent	Referent
Mother with overweight/obesity	3.39 (2.15, 5.35)***	3.13 (1.96, 4.99)***	2.76 (1.65, 4.62)***	2.66 (1.56, 4.55)***
Mother-daughter				
Mother with healthy weight	Referent	Referent	Referent	Referent
Mother with overweight/obesity	4.11 (2.54, 6.64)***	4.13 (2.52, 6.78)***	3.89 (2.27, 6.69)***	3.35 (1.91, 5.86)***
Father-son				
Father with healthy weight	Referent	Referent	Referent	Referent
Father with overweight/obesity	2.63 (1.23, 5.63)*	2.13 (0.98, 4.63)	2.18 (0.86, 5.55)	1.98 (0.79, 4.94)
Father-daughter				
Father with healthy weight	Referent	Referent	Referent	Referent
Father with overweight/obesity	2.17 (0.78, 6.05)	2.01 (0.76, 5.36)	3.98 (0.85, 18.76)	3.16 (0.64, 15.57)

[1]Model 1 = unadjusted. Model 2 = Model 1 + teen age and race-ethnicity. Model 3 = Model 2 + teen diet and physical activity. Model 4 = Model 3 + household food security and federal assistance.
[2]Odds of teen having overweight/obesity relative to odds of being a healthy weight. *,***Significantly different compared with referent (Wald tests): *$P < 0.05$, ***$P < 0.001$.

programs (Table 2) did not moderate the relation between mother-son (P-interaction = 0.540) or mother-daughter (P-interaction = 0.181) weight status. Household food security status and participation in federal assistance programs did not moderate the relation between father-son or father-daughter weight status (P-interaction ≥0.05 for all comparisons).

Discussion

In a national sample of 1410 parent-teen dyads, teens were consistently more likely to have overweight/obesity if their mother had overweight/obesity, and this relation remained after adjustment for teen age, race-ethnicity, dietary factors, PA level, household food security

TABLE 2 Relation between parent-teen weight status by socioeconomic status characteristics

Characteristic	OR (95% CI)[1]	P	P-interaction
Mother-son			0.039
Higher food security[2]	1.41 (0.62, 3.20)	0.406	
Lower food security[2]	4.30 (2.19, 8.44)	<0.001	
Mother-daughter			0.487
Higher food security[2]	2.54 (0.95, 6.82)	0.063	
Lower food security[2]	3.88 (1.98, 7.62)	<0.001	
Mother-son			0.540
Not currently participating in a federal assistance program[3]	3.31 (1.30, 8.47)	0.012	
Currently participating in a federal assistance program[3]	2.33 (1.22, 4.45)	0.011	
Mother-daughter			0.181
Not currently participating in a federal assistance program[3]	6.02 (2.09, 17.36)	0.001	
Currently participating in a federal assistance program[3]	2.58 (1.33, 5.02)	0.005	
Father-son			0.332
Higher food security[2]	4.09 (0.79, 21.24)	0.093	
Lower food security[2]	1.51 (0.49, 4.59)	0.471	
Father-daughter			0.767
Higher food security[2]	2.16 (0.06, 73.67)	0.670	
Lower food security[2]	3.90 (0.82, 18.62)	0.089	
Father-son			0.873
Not currently participating in a federal assistance program[3]	2.24 (0.37, 13.57)	0.380	
Currently participating in a federal assistance program[3]	1.90 (0.67, 5.35)	0.227	
Father-daughter			0.191
Not currently participating in a federal assistance program[3]	16.64 (1.11, 249.09)	0.042	
Currently participating in a federal assistance program[3]	1.78 (0.31, 10.12)	0.515	

[1]Odds of teen having overweight/obesity relative to odds of having a healthy weight. Reference group within each socioeconomic status characteristic is parent-teen pairs in which the parent has a healthy weight.
[2]$BMI_{teen} = BMI_{parent} \times food\ security_{household} + age_{teen} + race\text{-}ethnicity_{teen} + nonfried\ fruits\ and\ vegetables_{teen} + whole\ grains_{teen} + added\ sugar_{teen} + physical\ activity_{teen} + food\ assistance_{household} + BMI_{parent} + food\ security_{household}$.
[3]$BMI_{teen} = BMI_{parent} \times food\ assistance_{household} + age_{teen} + race\text{-}ethnicity_{teen} + nonfried\ fruits\ and\ vegetables_{teen} + whole\ grains_{teen} + added\ sugar_{teen} + physical\ activity_{teen} + food\ security_{household} + BMI_{parent} + food\ assistance_{household}$.

status, and participation in federal assistance programs. Moderation analyses demonstrated that the association between mother-son overweight/obesity was stronger in sons from households with lower food security compared with sons from households with higher food security; there was no significant moderation of these associations in mother-daughter pairs. There was little evidence of associations between father-teen weight status and no evidence of moderation of those relations by household socioeconomic status indicators.

Our findings are consistent with previous studies demonstrating positive relations between parent-teen weight status in the United States (7, 19, 20), with the strongest associations in mother-son and mother-daughter dyads (11). These findings are also consistent with meta-analyses at the global level (8) and a more recent study conducted in an English cohort (9). These findings suggest that there could be pathways for intergenerational obesity associations that are specific to mothers and their children, and these might include factors like obesity-related intrauterine exposures (21). The relation between parent-teen weight status persisted after adjustment for dietary factors and PA, which represent the primary determinants of weight status. These findings are supported by an array of twin studies that estimate the heritable portion of BMI to range from 0.24 to 0.81 (22). Genome-wide association studies have identified multiple loci with substantial contributions to BMI inheritance, and encouraging research is progressing on polygenic and multifactorial predictive models of obesity that will continue to facilitate our understanding of the heritability of weight status (23).

This study also provides evidence that the strength of the relation between mother-son weight status can be stronger in households with lower food security compared with households with higher food security. In the present study, in households with lower food security, sons were 4.30 times more likely to have overweight/obesity if their mothers had overweight/obesity, compared with if their mothers did not. By comparison, in households with higher food security, sons were just 1.41 times more likely to have overweight/obesity if their mothers did. However, there was no significant moderation of the relation between mother-daughter weight status by household food security. The findings for mother-son pairs are similar to Zhang et al. (10) and Liu et al. (11), who found evidence that the association between parent and child weight status was stronger in lower-income households compared with higher-income ones. Other studies have demonstrated that other markers of socioeconomic status, such as parental educational attainment, can moderate the relation between parent-child weight status (24). It is possible that male teens living in more food-secure households have access to healthier dietary options or other resources that blunt the effect of genetic predisposition toward overweight/obesity inherited from their mothers.

Federal assistance programs provide an essential safety net for low-income and food-insecure households, which often exhibit lower diet quality (25) and greater risk of adverse cardiometabolic outcomes (26) compared with their higher-income counterparts. Diet quality in lower-income populations has improved since 2003–2004, including in SNAP participants, but disparities have persisted or worsened (25), and continued efforts are needed to improve dietary and other health behaviors. The present study suggests that prevention of overweight/obesity in parents, particularly mothers and especially those from less food-secure households, can have intergenerational benefits, and this information can help inform policy and practice. For example, there could be

intergenerational benefits to promoting maternal healthy weight through existing outreach efforts to lower-income populations, such as the SNAP-Ed program and WIC counseling. Others have suggested modifications to these programs that include subsidies for fruit and vegetable purchases to incentivize healthier eating (27). The Healthy Incentives Pilot, conducted in Massachusetts, demonstrated that SNAP households that received a 30% rebate on targeted fruits and vegetables led to a 0.32 cup-equivalents/d increase in consumption of total fruits and vegetables, 0.43 ounce-equivalents/d increase in refined grains, and 4.7 point increase in overall diet quality as measured by the Healthy Eating Index-2010 (28). Subsequent studies have demonstrated larger effects for larger rebates and in combination with educational outreach efforts (29), and modeling studies have demonstrated the extended benefits of these proposed policy changes on cardiometabolic health outcomes in SNAP participants and other lower-income groups (30). Still, administrative and legal challenges need to be considered to maximize the success of these programs (27).

This study has several strengths. Participants were recruited and enrolled from all US states (except Alaska) and the sample was balanced to reflect the demographics of the US population (14). Data were collected from a sufficiently large sample to assess the associations between parent and teen weight status in gendered dyads, which provides important information on the generational effects of weight status. Significant associations between mother-teen weight status were observed even after controlling for diet and PA, highlighting the potential importance of other factors, such as genetic influences, that could contribute to the intergenerational effects of obesity. Additional evaluation by measures related to socioeconomic status provides new information that can be used to target vulnerable populations through family-based interventions.

The limitations of this study should also be considered. Data were collected from a cross-sectional sample, so causation cannot be established, and reverse causation might have contributed to our findings. Data were collected in 2014 only, and additional data from subsequent years are needed to establish trends in weight status and health-related behaviors. Self-reported weight status might have contributed to measurement error, because some participants could have underreported their weight status due to social desirability bias. However, parents also reported the weight status of their teens, which similarly classified weight status for 93% of teens in the sample. Others have demonstrated that self-reported anthropometric measurements can provide accurate estimates of weight status when adjusted for sociodemographic characteristics (31). Finally, the FLASHE dataset had smaller sample sizes for father-teen dyads than for mother-teen dyads; the failure to detect statistically significant associations between father-teen overweight/obesity in certain models might therefore have been due to insufficient statistical power. Additional limitations, such as those related to recruitment procedures, have been discussed in detail in the FLASHE methodology report (15).

In conclusion, in this national sample of parent-teen dyads, this study demonstrates a relation between parent-teen weight status that persists after adjustment for diet, PA, and other factors, and these associations were strongest for mother-son and mother-daughter dyads. In mother-son dyads, this relation was stronger in less food-secure households compared with more food-secure ones. These findings have implications for the intergenerational benefits of health promotion strategies

through nutritional counseling efforts and educational programs that target families, such as SNAP-Ed and WIC.

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