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Association between Early Maternal Depression and Child Growth: A Group-Based Trajectory Modeling Analysis

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Abstract

Background: Childhood overweight and obesity have become a primary social and public health concern. Over the past 30 years, rates of childhood overweight and obesity in the United States have increased dramatically from 6% to 35%. A potential risk factor of interest is maternal depression. To date, there are mixed findings available on the association between maternal depression and childhood obesity development, and there is a dearth of longitudinal research available. To address these gaps in the literature, this study investigated the association between maternal depression at age 1 and/or age 3 years and childhood obesity longitudinally.

Methods: This study used data from the Fragile Families Child Wellbeing Study (FFCWS) to investigate the research questions. FFCWS is a national dataset that has information on 4898 women, and their children, from predominantly nonmarital, low-income minority groups in the United States. This study used information collected at the birth of the child (wave 1) through age 9 years (wave 5). The analytic sample consisted of 3500 mother-children dyads. Group-based trajectory modeling and multivariable logistic regression were used.

Results: The results indicated that there was no association between maternal depression and childhood obesity development in this sample of low-income and mostly minority participants. Maternal prepregnancy BMI, number of biological children in the house, and Latino ethnicity were significant predictors of risky growth trajectories in the full sample. Suggestions for designing childhood obesity prevention interventions based on research are discussed.

Keywords: childhood obesity; longitudinal data; maternal depression; risk factors

Introduction

Over the past 30 years, rates of childhood obesity in the United States have increased dramatically.[1–5] Childhood obesity has gathered substantial attention, given the long-lasting detrimental health and mental health consequences in children.[6–10] One of the main concerns is that children who are overweight/obese will be more likely to remain overweight/obese during adolescence and even adulthood.[11–13] Due to the detrimental and long-lasting consequences of childhood obesity, it is important to prevent its development as early as possible.

Identifying early precursors of obesity and developing prevention interventions during pregnancy and infancy can aid in the quest of *preventing* childhood obesity. Previous studies have identified that there are multiple risk factors during pregnancy and infancy that are associated with childhood obesity such as maternal BMI, gestational weight gain, gestational diabetes, and refraining from breastfeeding.[14–18] A potential risk factor of interest is maternal depression, which affects 10%–30% of US women during the perinatal period (defined as the beginning of pregnancy through 1 year postpartum), and ~14% of women at any other point in life.[19–21] Depression has been found to be more prevalent among low-income women (20%–30%) when compared to middle-class women (10%–15%).[19,21–23] A recent study indicated that ~20% of low-income women who were part of the Women, Infants, and Children program experienced postpartum depression.[21]

Previous studies have demonstrated the detrimental effects that maternal depression has on children's wellbeing, including increased risk for psychological and health issues. Mothers with postpartum depression have been found to be less responsive to their children's needs and less verbally stimulating.[24] In terms of the effects that maternal depression has on children's health, a study of 132 participants showed that children of mothers with depression have more awakenings throughout the night and more minor health issues.[25] A few studies have also examined the association between maternal depression and

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childhood obesity. However, the current state of the literature is mixed and inconclusive.[26,27]

There are only a handful of studies that have been conducted using longitudinal data to determine the association between maternal depression and childhood obesity. A recent study used data from 1000 Chilean children at ages 5, 10, 15, and 21 years to investigate the role of home environment, including maternal depressive symptoms, on obesity development.[28] Maternal depressive symptoms were assessed when the child was 1 and 10 years of age. The results demonstrated that elevated maternal depressive symptoms, when the child was 1 year, were significantly associated with higher BMI at age 21. Similarly, elevated maternal depressive symptoms when the child was 10 years were positively associated with higher BMI at age 21 years and also with linear increases in BMI over time.[28]

Contrary to these findings, a longitudinal study on 1130 children and their mothers measured maternal postpartum depressive symptoms when the child was 2 months and then again when the child was 6 years.[30] Child BMI *z*-scores were assessed when the child was 6 years of age. The results indicated that maternal depressive symptoms when the child was 2 months significantly predicted a lower child BMI *z*-score at age 6 years. Maternal depressive symptoms when the child was 6 years were not associated with child BMI *z*-scores at age 6 years.[29] These studies demonstrate that the current literature available on the association between maternal depression and childhood obesity is inconclusive.

In addition, the current literature does not investigate the role of *recurrent* maternal depression on childhood obesity development. This is of particular interest because the effect that recurrent maternal depression has on children might be stronger when they are constantly exposed to it. To that end, the purpose of this study was to investigate the relationship between early maternal depression and childhood obesity development among low-income families from different minority groups. It was hypothesized that maternal depression when the child was 1 year or when the child was 3 years of age would be associated with following a risky developmental trajectory from birth to age 9 years. It was also hypothesized that recurrent maternal depression when the child was 1 year *and* when the child was 3 years would be associated with a risky developmental trajectory from birth to age 9 years.

Methods

Data

This study used secondary data from waves 1 to 5 from the Fragile Families Child Wellbeing Study (FFCWS). FFCWS is a national prospective study of nonmarital births in the United States. Data were first collected when the children were born (wave 1), at ages 1 (wave 2), 3 (wave 3), 5 (wave 4), and 9 years (wave 5). The first wave of interviews was collected at the hospital from 1998 to 2000 on 4898 mother-children dyads. To obtain more information about this dataset (www.fragilefamilies.princeton.edu/documentation/general).

Most of the Fragile Families data files are publicly available; however, medical records are only available through contractual agreement.[30] This study was based on both public and contractual data. A contractual data protocol for use of sensitive information was approved by the University of Illinois, Boston College Institutional Review Boards, and by FFCWS research team.

Sample

The total number of participants in the study at baseline was 4898. The sample included predominantly nonmarital, low-income mothers and one focal child. For this study, the exclusion criteria were the following: children who were born low-birth weight (LBW) (<2500 g), premature, resided with their mothers less than ''half of the time'' during waves 2 and 3, had implausible BMI values at any wave 1, 3, 4, or 5, and had missing information on maternal depression. LBW and premature participants were removed from the sample because they have different growth patterns than their normal-weight counterparts.[31]

Children living with their mothers less than ''half of the time'' were also removed from the analytic sample because the main variable of interest was maternal depression and if the child lived with a mother less than half of the time, it is possible that the influence of maternal depression on the child would be confounded. Implausible values were defined as BMI *z*-scores below −5 or above 5, based on recommendations set by the World Health Organization (WHO).[33] The final analytic sample included information on 3500 mothers and children.

Measures

Childhood overweight/obesity. Infant's information regarding weight and length from birth (wave 1) was obtained from medical records. Infant BMI *z*-scores were constructed using a macro in SAS 9.4 available from the WHO (for more information, see https://www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas-who.htm). The WHO growth charts were used at wave 1, rather than the CDC growth charts, since the CDC recommends that among children younger than 2 years, WHO growth charts be used because they provide a better estimate.[32]

For waves 3–5, child's anthropometric information was measured by trained interviewers during the in-home visits. Childhood overweight/obesity status was calculated using child's BMI [weight (kg)/height (m^2)] *z*-scores, using the CDC 2000 sex- and age-adjusted growth curves. Overweight status was defined as +1.04 and obesity status as +1.64.[34] These BMI *z*-score cutoffs are equivalent to the 85th and 95th percentiles,[33] and they have been validated and previously used on empirical studies.[34,35]

Maternal depression. Maternal depression was assessed using the Composite International Diagnostic Interview-Short Form (CIDI-SF). The CIDI-SF provides the

probability of a respondent being a ''case'' (i.e., having major depression) if the full CIDI would have been administered. Therefore, the CIDI-SF provides a categorical assessment of *probable* major depression (''caseness'' coded as 0, 1), rather than level of depressive symptoms.

Participants were asked whether they had felt sad/depressed or had lost interest in activities they normally found pleasurable in the last year. Participants who had either of those feelings for at least half of the day, almost every day, for at least 2 weeks, were asked another set of questions about losing interest, feeling tired, change in weight (at least 10 pounds), trouble sleeping, trouble concentrating, feeling down, and having thoughts about death. A sum was then generated and a score from 0 to 8 was created. Based on the literature,[36,37] scores of 3 and above were coded as probable depression. In the event that a participant was taking antidepressant medication, she automatically received a positive score for probable depression.

Recurrent maternal depression. Recurrent maternal depression was a three-level categorical variable developed using information on maternal depression from waves 2 to 3.[38,39] Participants without depression at wave 2 or 3 were coded as depression = 0, those with depression at *any* wave (i.e., either wave 2 or 3) were coded as depression = 1, and those with depression at *both* waves were coded as depression = 2 to indicate *recurrent* depression.

Control Variables

Some demographic variables, along with variables that have been shown to be associated with childhood obesity in the literature, were added as controls. These variables include maternal age, maternal education, prepregnancy BMI, smoking, number of biological children in the house, poverty level, race/ethnicity, and child sex and age. Maternal age, race, education, number of biological children in the house, relationship with baby's father, and income were collected through self-report at the time of birth of the child (wave 1). Maternal prepregnancy weight and height were obtained from medical records and prepregnancy BMI was calculated using weight (kg)/height (m^2). Maternal smoking was obtained from medical records.

Statistical Analysis

The analysis for this study was carried out in two stages. The first stage consisted of identifying specific and homogeneous clusters of ''groups'' or trajectories from birth to age 9 years. For this purpose, group-based trajectory modeling was used.

To determine the most optimal number of groups that best fit the data, a number of approaches were used.[40] The first approach to determine model fit was the use of the Bayesian information criterion (BIC). Usually, a better BIC is one that is smaller. However, the BIC obtained by the SAS macro is negative; therefore, the smallest absolute value (or the least negative value) suggests a better fitting model.[40,41] The second approach was to check group membership probabilities, which indicate the percentage of the sample that belongs to each group trajectory.[40] The last approach used was to run a Wald test to determine whether the slopes were significantly different from each other.[42]

After identifying the most optimal number of groups, four risk factors were added into the model: child sex, maternal age, federal poverty line, and pregnancy smoking. These risk factors were selected because they have been shown to be associated with childhood obesity. In some cases, the most optimal number of groups changed after adding risk factors to the model.[42] Thus, the fit of the trajectories was assessed before and after adding risk factors into the model. After identifying the best model, each child was assigned to a trajectory group based on the estimated membership probabilities.

The second stage of the analysis consisted of conducting logistic regression to determine the association between maternal depression, recurrent maternal depression, and child BMI *z*-score trajectory. Given that the high-rising trajectory was the only category that was considered to be at risk, the stable and mid-rising groups were combined into one and used as the reference group. Two statistical models were tested: an unadjusted model that did not include any control variables and an adjusted model that controlled for maternal education, race, relationship with baby's father, prepregnancy BMI, and number of biological children.

Results

The plurality of participants were black (46.6%), followed by Latinos (26.9%; Table 1). The majority of participants had high school education or less and about a third of them were under 100% of the federal poverty level. Most participants were either married or cohabiting. In terms of maternal depression, 19.8% of mothers were depressed when the child was 1 or 3 years and 7.9% of them were depressed at both time points. Compared to those retained in the analytic sample (Table 1), participants who were excluded were more likely to be black, be under 100% of the poverty line, be slightly older, have lower levels of education, have more biological children, and have a lower average prepregnancy BMI.

Group-Based Trajectory Modeling

A three-group solution was the best fitting model. These trajectories were categorized as ''stable,'' ''mid-rising,'' and ''high-rising'' (Fig. 1). The stable group started off around −0.8 BMI *z*-score and remained low throughout time. This group was characterized by 12.9% of the sample. The next group, the mid-rising group, started off closer to zero and it continued rising over time. At age 9 years, where the highest peak was, the BMI *z*-score was ∼0.7. The last group, the high-rising group, started off around 0.3 BMI *z*-score, but it grew rapidly until age 5 years, where it

Table 1. Descriptive Characteristics of Participants Retained in the Analytic Sample ($N = 3500$) Compared to Participants Excluded ($N = 1398$)

Variables	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)	*p*
Child sex (from W1)	3500		1397		0.28
Female	1669 (47.69)		660 (47.21)		
Male	1831 (52.31)		737 (52.72)		
Maternal race	3491		1395		<0.01
White	797 (22.83)		233 (16.70)		
Black	1626 (46.58)		700 (50.18)		
Latino	938 (26.87)		398 (28.53)		
Other	130 (3.72)		64 (4.59)		
Maternal education	3496		1396		<0.01
High school or less	2192 (62.70)		987 (70.70)		
Some college or more	1304 (37.30)		409 (29.30)		
Federal poverty level	3500		1397		<0.01
0%–99%	1200 (34.29)		571 (40.87)		
100%–199%	913 (26.09)		349 (24.98)		
200%–299%	541 (15.46)		218 (15.60)		
300% or more	846 (24.17)		259 (18.54)		
Maternal relationship with baby's father	3500		1396		<0.01
Married	915 (26.14)		272 (19.46)		
Cohabiting	1262 (36.06)		521 (37.27)		
Other[a]	1323 (37.80)		603 (43.13)		
Maternal depression	3500		499		0.09
No depression	2532 (72.34)		340 (68.14)		
Depression at W2 or W3	693 (19.80)		108 (21.64)		
Depression at W2 and W3	275 (7.86)		51 (10.22)		
Maternal age	3500	25.13 (5.98)	1390	25.63 (6.18)	0.01
Number of biological children	3484	1.09 (1.27)	1390	1.37 (1.60)	<0.01
Pre-pregnancy BMI	2138	26.43 (6.66)	861	25.76 (6.37)	0.01

[a]Mothers whose relationship with the baby's father was other than married or cohabiting were included in this category. Thus, this category was made up of fathers whose relationship with the mother was as follows: visiting, friends, hardly talking, or never talking.

SD, standard deviation; W1, wave 1; W2, wave 2; W3, wave 3.

reached a BMI *z*-score of 1.8 and then started to plateau. This group was made up of 20.1% of the sample and it is the most at-risk group because their BMI *z*-score is well over the 1.04 cutoff, thus placing children at a high risk of overweight/obesity.

After adding the risk factors to the model, the BIC improved, demonstrating a better fit. The results showed that maternal poverty was a significant risk factor for following a high-rising trajectory ($B = -0.24$, $p = 0.01$; Table 2).

Association between Maternal Depression and Child Growth Trajectories

The high-rising trajectory was the only group that was considered to be ''at risk'' since this trajectory surpassed the 1.04 cutoff of overweight and even the 1.64 obesity cutoff. Given that the stable and the mid-rising trajectories were not considered to be at risk, these two trajectories were ''combined'' and compared the high-rising group using logistic regression. The unadjusted model

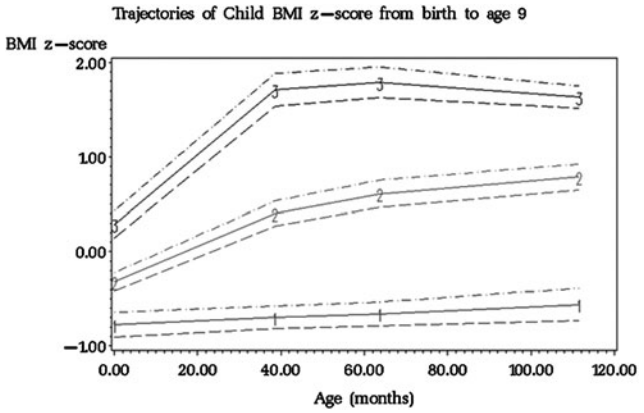

Figure 1. Trajectories of child BMI *z*-score from birth to age 9 years (waves 1–5).

demonstrated that neither maternal depression when the child was 1 year or when the child was 3 years, nor recurrent maternal depression, were associated with increased risk of developing a high-rising trajectory (Table 3).

After adjusting for maternal education, race, relationship with baby's father, prepregnancy BMI, and number of biological children, maternal depression was not associated with developing a high-rising trajectory. However, the results showed that children of Latino background had 2.09 times the odds of developing a high-rising trajectory [95% confidence interval (CI) = 1.50–2.90], compared to children of white background. It was also found that maternal prepregnancy BMI was strongly associated with the high-rising trajectory. A 1-unit increase in prepregnancy BMI was associated with a 0.07 increase in the odds of developing a high-rising trajectory. Finally, it was found that the number of biological children was associated with the high-rising trajectory. Each additional child in the home was associated with a 0.12 increase in the odds of the focal child developing a high-rising trajectory (95% CI = 1.03–1.22).

Discussion

This study found that there was not an association between early maternal depression or between *recurrent* maternal depression and following an at-risk growth trajectory. Thus, the hypotheses were not supported. Although these results are surprising, they contribute to the current mixed literature by demonstrating that in a highly diverse sample of low-income children, early maternal depression is not associated with childhood obesity development.

Table 2. Risk Factors for the High-Rising Trajectory Group Membership

Risk factor	Estimate	*p*
Child sex	0.18	0.22
Maternal smoking	–0.22	0.26
Maternal age	0.01	0.33
Maternal poverty	–0.24	0.01

The findings from this study are similar to other studies that have found a null or negative association between maternal depression and childhood obesity,[17,29,43–45] particularly in low-income samples.[43–45] A longitudinal study followed 201 Latina mothers from the prenatal period through 9 years postpartum.[45] The study found there was no association between maternal depressive symptoms or maternal depression and childhood obesity at age 9 years. The study also showed that maternal depressive symptoms during the prenatal period and also when the child was 5 years were associated with *lower risk* of child chronic obesity, defined as having obesity at age 5 years and again at age 9 years.[45]

Other studies among low-income populations have demonstrated similar findings. It is possible that low-income children might have multiple sources of stress, including more systemic issues that are masking the effect of maternal depression. A study using data from FFCWS investigated the cumulative effect that intimate partner violence, food insecurity, housing insecurity, maternal substance use, depression, and paternal incarceration had on children's overweight and obesity status at age 5 years.[46] The authors found that girls who had two or three risk factors had 1.77 times the odds of being obese and girls with three or more risk factors had 1.89 times the odds of being obese at age 5 years. These findings demonstrate that children in this sample experience many adverse conditions in life; thus, it is possible that other more prevailing conditions, or rather, the accumulation of them, place children at risk for overweight and obesity, rather than maternal depression alone.

Although the findings from this study suggest that there is no association between early maternal depression and childhood growth patterns over time, it is important not to rule out maternal depression as a risk factor, but rather investigate other home and family characteristics that can place children at a higher risk for childhood obesity development.[28,29] Also, it is necessary to conduct more studies to understand for whom and under which conditions maternal depression may have repercussions on children's health. More importantly, it is necessary to identify the sensitive windows when maternal depression can be a risk factor for childhood development. For example, it is possible that maternal depression during the first 3 years of life does not impact childhood obesity development, but maternal depression later in life might have a stronger impact on child's health.

This study also found that race, maternal prepregnancy BMI, and an increased number of biological children in the home were associated with developing a high-risk trajectory. These findings are similar to what previous research has found.[45] Consistently, it has been demonstrated that Latino children are at a higher risk of overweight and obesity.[3,11,47–49] A systematic review on the incidence of childhood obesity reported that four out of six studies

Table 3. Logistic Regression Predicting High-Rising Growth Trajectory

	Model 1				Model 2			
Predictor	***B***	**SE**	**OR**	**95% CI**	***B***	**SE**	**OR**	**95% CI**
Maternal depression at W2 or W3	0.06	0.11	1.06	0.86–1.31	0.09	0.14	1.09	0.84–1.43
Maternal depression at W2 and W3	–0.06	0.16	0.94	0.68–1.29	–0.02	0.21	0.98	0.65–1.48
Education: at least some college					0.05	0.12	1.05	0.83–1.34
Race/ethnicity								
Black					0.12	0.17	1.13	0.82–1.57
Latino/a					0.74	0.17	2.09	1.50–2.90
Other					0.42	0.31	1.52	0.83–2.77
Relationship								
Cohabiting					–0.05	0.15	0.95	0.71–1.28
Other					–0.03	0.15	0.97	0.72–1.31
Prepregnancy BMI					0.07	0.01	1.07	1.05–1.09
Number of biological children					0.11	0.04	1.12	1.03–1.22

CI, confidence interval; Model 1, unadjusted model; Model 2, fully adjusted model; OR, odds ratio; SE, standard error.

found that Latino and black children had higher incidence of obesity, compared to their white counterparts.

Maternal prepregnancy BMI continues to be found as a significant predictor of child BMI and child growth over time. A meta-analysis of 45 studies worldwide investigated the association between maternal prepregnancy BMI and offspring birthweight and subsequent offspring BMI.[50] The meta-analysis reported that although only 12 studies investigated the association between maternal prepregnancy BMI and child overweight/obesity, a significant positive association was found. Given the significant association between maternal prepregnancy BMI with child BMI, future studies should always try to control for maternal prepregnancy BMI.

Finally, this study found that the number of biological children in the household was also a main predictor of following a high-risk trajectory. Our findings differ from previous research that has demonstrated that having more siblings is a protective factor against childhood obesity development.[51–54] One possibility for the discrepant findings is that FFCWS collects information on the number of biological children; however, there is no information on the age of the children or on whether all the children live at home. It is also possible that controlling for the number of biological children in the household in every wave can have a different impact than controlling for it at baseline only.[52] Overall, future studies should continue investigating the effect that the family environment has on children's growth.

This study is not without its limitations. The main limitation was that it was necessary to use two different metrics growth and curve, which could potentially produce biased estimates. For birth, the WHO growth curves were used, whereas for ages 3, 5, and 9 years, the CDC growth curves were used. The decision to use different metrics follows the CDC recommendation to use the WHO growth curves before 2 years of age.[32] A second limitation was that the analysis was not stratified between girls and boys, given that the growth curves are already adjusted by sex. However, previous findings have found different results on how adiposity on girls and boys might be affected differently based on the adversity they have faced.[42,50,55] A final limitation was that child adiposity was grouped into three categories. It is possible that there could be a relationship between child BMI *z*-scores and maternal depression if a different longitudinal analysis was used.

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