



Body Mass Index at 3 Years of Age: Cascading Effects of Prenatal Maternal Depression and Mother-Infant Dynamics

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Objective To investigate the effects of mothers' prenatal depression on parenting during infancy, ensuing childhood regulation, and body mass index (BMI) at age 3 years.

Study design The sample (N = 284) included teen mothers (n = 157), adult mothers with low education (n = 69), and adult mothers with high education (n = 58), and their first-born children. Maternal depressive symptoms were assessed prenatally through self-report; observational methods and self-report were used to assess mothers' parenting at 4, 6, and 8 months and children's regulation at 18, 24, and 30 months of age. Child BMI was measured at 36 months of age in the laboratory.

Results Structural equation modeling supported mediating processes such that mothers who reported more depressive symptoms prenatally exhibited less positive parenting during infancy. In turn, less positive parenting predicted lower levels of child regulation during toddlerhood, which predicted higher child BMIs at 36 months of age, even after controlling for infant birth weight and concurrent maternal BMI. Models comparing groups (teen mothers, adult low-educated mothers, and adult-high educated mothers) indicated mean differences in maternal depression, parenting, and child regulation, but similar patterns of prediction across groups.

Conclusions The present study provides evidence of cascading psychosocial processes beginning prenatally and continuing through infancy, toddlerhood, and into early childhood. Results have implications for family-wide intervention strategies to help lower the risk for early onset obesity in children. (*J Pediatr* 2016;177:128-32).

Nearly one-third of low-income children aged 2-4 years in the US are overweight or obese.¹ Learning more about the psychosocial processes that contribute to an unhealthy weight can inform the development of more effective obesity prevention and treatment strategies for young children and their families, particularly for those at greater risk.

There is substantial evidence that children whose mothers experience postnatal depression are more likely to have behavior problems² and poorer cognitive development.³ Far fewer studies, however, have focused on potential deleterious effects of prenatal depression.⁴ Given that the strongest predictor of postnatal depression is prenatal depression,⁵ it is critical to understand potential harmful trajectories before the infant is born, identify women at risk, and treat them as early as possible. Problems with regulation seem to be strongly linked to parenting.⁶

A number of studies have examined maternal depression,⁷ parenting,⁸ and child regulation⁹ as separate potential correlates of child body mass index (BMI) but have not yet tested these factors simultaneously in a prospective longitudinal model. One study found evidence for mediating mechanisms such that aspects of family demographic risk, depression, and negative parenting predicted heightened child BMI indirectly through children's poor regulation and food approach behaviors.¹⁰ Although this study offers preliminary insights about mediational processes, it was limited by its small sample (N = 40), cross-sectional design, and inability to determine whether early maternal characteristics are predictive of children's later behavior and BMI.

The goal of the present study was to examine how early psychosocial processes unfold in relation to children's later BMI. Longitudinal mediation models have been likened to a line of dominos where the fall of the first domino triggers the sequence, and the remaining dominos follow as a result.¹¹ In the study of childhood obesity, such analyses may illuminate sequences and connections that could more fully inform intervention design, either to prevent the process from starting or curtail its progression towards obesity. We hypothesized that higher levels of prenatal maternal depression would lead to less positive parenting practices during infancy, lower levels of regulation during toddlerhood, and, ultimately, greater BMI by 3 years of age. In addition, we explored whether mediational processes differed across demographic risk groups.

Methods

The original sample consisted of 682 mothers and their first-born children (50% males) who were followed from the last trimester of pregnancy through the children's

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BMI Body mass index

first 3 years of life.^{12,13} All infants had to be ≥ 36 weeks gestation to be included. The study was designed to observe the impact of at-risk parenting on children; therefore, 2 groups of high-risk mothers, as well as a comparison sample, were recruited for the project: 58.1% were teen mothers, 23.8% were adult mothers with little to no advanced education, and 18.2% were adult mothers with high education (≥ 2 years of post-secondary). The mothers were recruited during their pregnancies through primary care facilities in 4 US cities.¹² Institutional review board approval was obtained at all sites. All mothers completed consent (or assent if < 18 years of age) forms at each time point. The sample of mothers was ethnically and racially diverse (64.5% African American, 18.8% white, 13.6% Hispanic American, and 3.1% other races).

Interview and questionnaire data were gathered during the third trimester of pregnancy (demographic information and depressive symptoms); mothers were also contacted by phone before their first visit to obtain information such as the infant's sex and birthweight. Questionnaire data were obtained when the children were 6 (parenting) and 24 months of age (child regulation), observational data of dyadic interactions (child regulation and parenting) were collected at 4, 8, 18, and 30 months of age. Child and mother BMI were assessed at 36 months of age. Individual, in-person interviews took place in a professional setting such as a research laboratory or doctor's office. All questions were read to the mothers by the interviewers to ensure comprehension.

All observational data were recorded at the mothers' home. Mothers were asked to do what they would typically do during that time but to keep the child within their visual range. Dyads were observed for approximately 30 minutes. Parenting and child behaviors were coded using procedures similar to those described by Landry et al.¹⁴ In addition, mothers were interviewed about the home environment using the Infants/Toddlers Home Observation for Measurement of the Environment¹⁵ and observed with their infant during the interview. Coders were certified using video and in vivo coding until they reached at least an 80% concordance with a master coder. For the present study, parenting behaviors from the 4- and 8-month interactions (inter-rater agreement = 0.97 for Landry and 0.98 for the Infants/Toddlers Home Observation for Measurement of the Environment) and child behaviors from the 18- and 30-month interactions were included (inter-rater agreement = 0.98).

Children's height and weight were measured during a laboratory visit when they were 36 months of age. Each measurement was taken 3 times and the average was used.¹⁶ Mothers were also asked to report their own height and weight. Mothers were compensated financially for their time for each assessment with gift certificates, reflecting dollar values that increased with each successive visit (starting at \$25 for the prenatal visit and ending with \$80 for the 36-month visit).

Maternal depression was assessed via self-report using the Beck Depression Inventory-II¹⁷ at the prenatal interview. Internal consistency (α) for this measure was 0.86. Based on

scoring criteria, 26.8% of mothers were mildly depressed, 12% were moderately depressed, and 2.6% were severely depressed. Overall scores, not clinical cutoffs, were used in the present study.

Observations of both positive maternal behaviors (eg, warmth, responsiveness, positive affect) and negative maternal behaviors (eg, intrusiveness, negative tone, hostility) were assessed at 4 and 8 months. Because specific behavior ratings were on different scales (5-point intensity ratings or frequency counts), each rating was *z*-transformed before creating the positive and negative parenting scales. At 6 months, mothers also completed the Parenting Style Questionnaire,¹⁸ which included 20 items on 5-point scales ranging from 1 (strongly agree) to 5 (strongly disagree). Three subscales are derived from this measure: punishment ($\alpha = 0.86$), abuse/neglect ($\alpha = 0.64$), and authoritarianism ($\alpha = 0.52$), and were averaged together given the strong correlations between them (*r*s ranged from 0.48-0.64). The alpha was 0.77 for the total self-report score. Given how the measure is scaled, high scores reflect more positive parenting,

Regulation was composed of 3 measures: observations of behavioral regulation at 18 and 30 months of age¹⁴ and maternal ratings of impulsivity (poor regulation) at 24 months of age (Infant-Toddler Social and Emotional Assessment).¹⁹ Observed child self-regulatory behaviors were rated on a 5-point scale reflecting the amount of time during the interval that the behaviors occurred (eg, low frustration tolerance, overwhelming negative affect, difficulty organizing self, trouble sustaining attention, adjusts easily to change). Mothers' responses on the impulsivity subscale (6 items) of the Infant-Toddler Social and Emotional Assessment yielded an α of 0.73.

BMI was calculated from the child's height and weight measured at 36 months of age using standard procedures outlined by the Centers for Disease Control and Prevention. In the present sample, 16 children were underweight (5.6%), 173 were healthy (60.7%), 44 were overweight (15.4%), and 52 children were obese (18.2%). The current study used actual BMIs, not weight classifications. Two additional weight/BMI measures were included as covariates in subsequent analyses: infant birth weight and mothers' BMI when children were 36 months of age.

To examine if mothers who dropped out of the study (or had missing child BMI data) differed from those who remained and had BMI data at 36 months of age, we conducted a series of ANOVAs comparing these families on the study variables (depression, positive parenting at 4 and 8 months, negative parenting at 4 and 8 months, self-reported parenting at 6 months, behavioral regulation at 18 and 30 months of age, and parent-reported child impulsivity at 24 months of age). None was significant. We also conducted a χ^2 test to examine if teen mothers, lower-educated adult mothers, or higher-educated adult mothers differed in dropout rates. This analysis was also nonsignificant. Subsequent model-fitting relied on full information maximum likelihood estimation,²⁰ which has been recommended as a state-of-the-art technique for analyzing datasets that include missing data.²¹

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