Impact of Maternal Depressive Symptoms on Growth of Preschool- and School-Aged Children

AUTHORS: Pamela J. Surkan, ScD,^{a,b} Anna K. Ettinger, MSW, MPH,^b Saifuddin Ahmed, MBBS, PhD,^b Cynthia S. Minkovitz, MD, MPP,^b and Donna Strobino, PhD^b

Departments of ^aInternational Health and ^bPopulation, Family and Reproductive Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland

KEY WORDS

maternal depressive symptoms, child growth, mother-child relations

ABBREVIATIONS

CAPi—computer-assisted personal interviews

CES-D—Center for Epidemiological Studies, Depression Scale

CI—confidence interval

ECLS-B—Early Childhood Longitudinal Study, Birth Cohort

Dr Surkan was instrumental in conceptualizing and designing the study, interpreted results, and took the lead on drafting the introduction, Results, and Discussion sections and making revisions to the manuscript. Ms Ettinger conducted data analyses, drafted the Methods section and Results tables, and revised draft and final versions of the manuscript. Dr Ahmed provided significant input into the statistical analyses and methods of the paper, interpretation of results, and edited the final version to be published. Dr Minkovitz provided substantial contributions to the conceptualization and methods of the study, interpretation of the data, and revisions to draft and final versions of the manuscript. Dr Strobino provided substantial contributions to the conceptualization and methods of the study, interpretation of the data, and revisions to draft and final versions of the manuscript.

www.pediatrics.org/cgi/doi/10.1542/peds.2011-2118

doi:10.1542/peds.2011-2118

Accepted for publication May 23, 2012

Address correspondence to Pamela J. Surkan, ScD, Social and Behavioral Interventions Program, Department of International Health, Johns Hopkins Bloomberg School of Public Health, 615 North Wolfe St, Room E5523, Baltimore, MD 21205-2179. E-mail: psurkan@jhsph.edu

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Copyright © 2012 by the American Academy of Pediatrics

FINANCIAL DISCLOSURE: *The authors have indicated they have no financial relationships relevant to this article to disclose.*

FUNDING: This study is supported by grant R40MC17175 from the US Department of Health and Human Services, Health Resources and Services Administration Maternal and Child Health Research Program.

WHAT'S KNOWN ON THIS SUBJECT: Few longitudinal studies from developing countries have assessed the relation between early maternal depressive symptoms and child growth beyond age 2. The results of these studies have been inconclusive.

WHAT THIS STUDY ADDS: Early maternal depressive symptoms were related to higher odds of deficits in stature but not to deficits in weight among preschool- and school-aged children. Well-child care provides opportunities to identify maternal depressive symptoms to prevent future child growth delays.

abstract

OBJECTIVE: The aim of our study was to examine whether maternal depressive symptoms at 9 months postpartum adversely affect growth in preschool- and school-aged children.

METHODS: We used data from the US nationally representative Early Childhood Longitudinal Study, Birth Cohort. We fit multivariable logistic regression models to study maternal depressive symptoms at 9 months postpartum (using the Center for Epidemiologic Studies Depression Scale) in relation to child growth outcomes, $\leq 10\%$ height-for-age, $\leq 10\%$ weight-for-height, and $\leq 10\%$ weight-for-age at 4 and 5 years.

RESULTS: At 9 months, 24% of mothers reported mild depressive symptoms and 17% moderate/severe symptoms. After adjustment for household, maternal, and child factors, children of mothers with moderate to severe levels of depressive symptoms at 9 months' postpartum had a 40% increased odds of being $\leq 10\%$ in height-for-age at age 4 (odds ratio = 1.40, 95% confidence interval: 1.04–1.89) and 48% increased odds of being $\leq 10\%$ in height-for-age at age 5 (odds ratio = 1.48, 95% confidence interval: 1.03–2.13) compared with children of women with few or no depressive symptoms. There was no statistically significant association between maternal depressive symptoms and children being $\leq 10\%$ in weight-for-height and weight-for-age at 4 or 5 years.

CONCLUSIONS: Maternal depressive symptoms during infancy may affect physical growth in early childhood. Prevention, early detection, and treatment of maternal depressive symptoms during the first year postpartum may prevent childhood height-for-age ≤ 10 th percentile among preschool- and school-aged children. *Pediatrics* 2012;130:e847–e855

Impaired growth during childhood is associated with poor developmental outcomes including low educational performance, reduced adult and offspring body size, and increased morbidity and mortality.¹ Early caregiving environments and experiences are critical for adequate childhood growth and development.² Although findings are inconsistent, several studies from developing countries suggest that maternal depressive symptoms during infancy may contribute to inadequate growth in the first 2 years of life.³ Suggested pathways linking maternal depressive symptoms to child growth may involve suboptimal feeding and caregiving practices^{4,5} including decreased likelihood or shorter duration of breastfeeding.^{6–8}

Less is known about whether maternal depressive symptoms in a child's first year of life, when the mother-infant relationship becomes established, are associated with growth in later childhood. Although the role of maternal depression on early childhood growth has generated interest,³ most investigations have been cross-sectional and limited to the first 2 years of life. Few studies on preschool or older children or from developed countries have been published.^{3,9} Given the 10% to 15% prevalence of depressive symptoms after childbirth in the United States,¹⁰ this question warrants additional exploration.

Parenting styles established in the first 12 to 18 months of life may have sustained influences on maternal and child behavioral outcomes after age 3.^{11,12} Given the close link between depressive symptoms and parenting,^{4,13} we hypothesized that maternal depressive symptoms in the first year postpartum would have consequences for child growth, extending through preschool and kindergarten. The goal of our study was to examine the relation between depressive symptoms in mothers at 9

months' postpartum with subsequent child growth at ages 4 and 5 years.

METHODS

Study Design and Sample

Data were from the Early Childhood Longitudinal Study, Birth Cohort (ECLS-B), a nationally representative sample of ~10 700 children born in the United States in 2001 and followed prospectively through 2007. Sponsored by the National Center for Education Statistics, ECLS-B collected data on children's cognitive, socioemotional, psychomotor, and physical development from birth through kindergarten.¹⁴ Children born to mothers <15 years and infants who died or were adopted before 9 months were ineligible. Low birth weight infants, multiple births, and ethnic minority children including American Indians were oversampled in the ECLS-B.

Our study used data from 3 time points when children were 9 months (preschool sample), and 5 to 6 years (kindergarten 2006 and 2007 samples). Children who had not yet started kindergarten in 2006 and children who repeated kindergarten were included in the 2007 data collection. Data were obtained from birth certificates, direct child assessments, and parent or caregiver computer-assisted personal interviews (CAPI). Self-administered questionnaires at nine months were used for sensitive items including depressive symptoms. The response rates for the CAPI were 74% at 9 months, 63% at 4 years, and 58% at 5 years.¹⁴ Direct child assessments, including anthropometric measurements, were collected by trained staff during home visits at each wave of data collection. Among children with parent data, weighted response rates for the direct child assessments were 96% at 9 months, 98% at 4 years, and 99% at 5 years.^{15–17}

Our study focused on ~6550 singleton children with growth data at 4 years and/or 5 years and whose mothers had

depressive scores at 9 months (Fig 1). Twins and higher order multiple births were dropped from the study because of the potentially different growth trajectories of these children compared with singleton births ($n = 1350$). When child length/height decreased by ≥ 5 cm between time points, we also removed these observations from the analysis ($n < 50$). We also excluded children if all z score values for weight for length, length-for-age, or weight-for-age were greater than 5 or less than -5 at both 4 years and 5 years ($n < 50$). The sample size used in the analysis was ~6450 at 4 years and 5000 at 5 years, with 100 children having growth measurements at age 5 but not at age 4 years. Some children had weight values that appeared to be data-entry errors due to units of measurement and for whom there was no trend of weight gain over time; their data were transformed into kilograms because of the presumed data-entry errors ($n = 50$). Children who were missing weight or height but not both were included in the analyses. Because of the varying number of outlying z scores for growth indicators, sample sizes for children at risk for being $\leq 10\%$ for height-for-age, weight-for-age, or weight-for-length vary slightly.

Dependent Variables

A Measure Mat and Portable Stadiometer were used to assess child length at 9 months and height at 4 and 5 years, respectively. At 9 months, the mother and child were weighed together with a digital scale, and the mother's weight was subtracted to obtain the child's weight.¹⁸ Children were weighed individually at ages 4 and 5.¹⁹ At 9 months, children were measured and weighed twice independently, and the average score was used. When there was a difference $> 5\%$ for either weight or length between repeated measures, the measurement closest to the weighted

FIGURE 1
Identification of Study Participants.

average for the sample children of the same age and birth weight was used.¹⁸ At 4 years, 2 measurements were taken, entered into the CAPI, and averaged. The CAPI prompted the researcher to obtain a third measurement for differences $\geq 5\%$.¹⁹ At 5 years, 3 measurements were taken for each assessment, and the closest 2 measurements were entered in CAPI and averaged. The CAPI prompted researchers to confirm any values outside a range of plausible measurements.¹⁴

Normalized weight-for-age, height-for-age, and weight-for-height ratios at 4 and 5 years were calculated based on the 2000 US Centers for Disease Control and Prevention growth charts, standardized for child age and gender.²⁰ This was done by using zanthro to calculate z scores (Centers for Disease Control. Growth Charts: Percentile Data Files with LMS Values: http://www.cdc.gov/growthcharts/percentile_data_files.htm.) and then defining the cutoff corresponding to below or equal to the 10th percentile. Cutoffs for the dependent variables were defined at below the 10th percentile for height-for-age, weight-for-height, and weight-for-age. Because we were interested

in studying growth deficits corresponding to the risk of stunting, wasting, and underweight, we set our cutoff at the 10th rather than 5th percentile, in accordance with the Special Supplemental Nutrition Program for Women, Infants and Children Nutrition Risk Criteria.²¹

Independent Variable

The independent variable, maternal depressive symptoms, was assessed by using a 12-item version of the Center for Epidemiologic Studies Depression Scale (CES-D).^{22,23} The short form has been validated and used in other large national studies including the National Longitudinal Study of Children and Youth.²⁴ The CES-D assesses depressive feelings and behaviors during the past week by using a 4-point Likert scale: 0 = rarely or never, 1 = some or a little, 2 = occasionally or moderately, and 3 = most or all.¹⁹ The scale gives a total score from 0 to 36, which was categorized into 3 groups: none (<5), mild (5–9), moderate/severe (≥ 10) depressive symptoms; the score of ≥ 10 is calibrated to the score of ≥ 16 for the original 20-item scale. Mothers missing ≥ 9 of the 12 items from the CES-D scale were excluded ($n = 1200$). Mothers with

at least 4 completed CES-D items were eligible to be included in the sample for analysis (~ 9500 mothers, 88.9% of the total original sample), and their missing item scores were imputed using the average scale score from the remaining items. In the final sample of 6550 singleton children, fewer than 150 mothers were missing ≥ 2 items. Rerunning the analyses with the group of 6400 mothers missing 0 or 1 CES-D item produced comparable estimates to using imputed data. The 12-item CES-D had high internal consistency in this sample (Cronbach's $\alpha = 0.88$).

Covariates

Covariates included household characteristics (household income, household food security, home ownership, family structure), maternal characteristics (maternal age, race/ethnicity, employment, pre-pregnancy weight, weight gain during pregnancy, smoking during and after pregnancy, and parity), and child characteristics (child gender, birth weight, age, gestational age at birth, health status, and ever breastfed). Household food security was based on 18 items from the US Department of Agriculture Household Food Security

Scale assessing availability of food items in the home and hunger during the previous 12 months.²⁵ Information on all covariates was collected when children were 9 months old.

Statistical Analysis

Unadjusted analyses of the association between maternal depressive symptoms and all covariates were conducted with cross-tabulations and simple logistic regression, as were unadjusted associations between growth indicators and all covariates. Multiple logistic regression was used to determine the adjusted odds of being $\leq 10\%$ height-for-age, $\leq 10\%$ weight-for-height, and $\leq 10\%$ weight-for-age at 4 and 5 years for children whose mothers experienced depressive symptoms. Baseline demographic and social characteristics included in multivariable models were chosen on a theoretical basis, as they were identified as predictors of child growth from previous literature. Because of the complex sampling design, sample weights were applied to account for stratification, clustering, and unit nonresponse. In accordance with the National Center for Education Statistics (NCES) requirements for ECLS-B data usage, numbers reported are rounded to the nearest 50. Analyses were conducted by using Stata 11.0 (Statacorp, College Station, TX).

The extent and type of missingness of the covariates were assessed. All variables had $< 3\%$ of responses missing. Hot Deck imputation was used to impute missing values for these variables.²⁶ When possible, other variables related to the missing variable were used to sort the data before conducting imputation. Imputation was not used for the growth outcomes.

RESULTS

Descriptive Statistics

The sample included 6550 children, consisting of 57.3% non-Hispanic white,

12.5% non-Hispanic black, 23.1% Hispanic, and 2.2% Asian children, and 4.8% of another race/ethnicity. At 9 months, the majority of the respondents were biological mothers (99%); $< 1\%$ of respondents were nonbiological (step or adoptive) parents. Children dropped from the study because of missing maternal CES-D scores or weight/length measurements were more likely to be racial/ethnic minorities and to report having a poor health status compared with children included in analyses. Mothers excluded from the analyses had less education and lower incomes; they also were younger, less likely to own their homes, to work, to have food secure households, and more likely to be racial/ethnic minorities and single parents than study mothers (data available upon request; $P < .05$ for differences).

Prevalence of Maternal Depressive Symptoms and Child Undernutrition

At 9 months, weighted estimates indicated that 59.1% of mothers had no depressive symptoms, 23.6% of mothers had mild symptoms, and 17.3% of mothers had moderate/severe symptoms. The weighted mean CES-D score was 5.1 (95% confidence interval [CI]: 4.9–5.3). A higher proportion of mothers with more severe depressive symptoms were in low socioeconomic status categories (including income, food security, and home ownership categories) and education categories. Black mothers and those of other race had increased depressive symptoms (Table 1).

The weighted estimate for average child weight was 18.3 kg (95% CI: 18.2–18.3) at 4 years and 21.1 kg (95% CI: 20.9–21.3) at 5 years. The weighted average child height was 104.6 cm (95% CI: 104.4–104.7) at 4 years and 111.9 cm (95% CI: 111.7–112.0) at 5 years. The weighted prevalence of children who were $\leq 10\%$ for height-for-age was 8.3% at 4 years and 6.2% at 5 years. The weighted pre-

valence of $\leq 10\%$ for weight-for-height was 4.0% at 4 years and 3.2% at 5 years, whereas the weighted prevalence of $\leq 10\%$ for weight-for-age was 4.6% at 4 years and 4.1% at 5 years. There were no differences in unadjusted mean child height and weight by maternal depressive symptoms. The proportion of children who were $\leq 10\%$ for height-for-age was higher for mothers with moderate/severe symptoms than for mothers with no depressive symptoms (9.9% vs 7.1%, $P = .01$).

Unadjusted and Adjusted Analyses

Compared with children of mothers without symptoms, children of mothers with both mild and moderate/severe depressive symptoms had higher odds of being $\leq 10\%$ for height-for-age at age 4 (Table 2). This relation remained at age 5 for children of mothers with moderate/severe symptoms but was not significant for mild maternal depressive symptoms. There were no significant relations between maternal depressive symptoms and $\leq 10\%$ for weight-for-height or $\leq 10\%$ for weight-for-age when children were 4 or 5 years old. After adjustment for covariates, results of multivariate analyses remained almost identical (Table 3). The odds ratio corresponding to $\leq 10\%$ height-for-age did not change significantly after controlling for weight gain at 9 months, breastfeeding initiation or duration, or after restricting analyses to mothers missing none or only one CES-D item (see Supplemental Table 4). Also, analyses using 20% cutoffs attenuated the relation between depressive symptoms and height-for-age ($P < .05$) (see Supplemental Table 5).

DISCUSSION

Our results suggest that maternal depressive symptoms in the first year of a child's life are associated with later odds of a child being $\leq 10\%$ for height-for-age at ages 4 and 5. At age 4, both

TABLE 1 Unweighted and Weighted Percentages of Sociodemographic Characteristics of Sample Population at 9 Months by Maternal Depressive Symptoms (*n* = ~6550)

	Unweighted	Weighted Percentages			<i>P</i> Value ^a
	Total <i>n</i> (%)	No Depressive Symptoms	Mild Depressive Symptoms	Moderate-Severe Symptoms	
Household characteristics					
Household income					<.001
<\$25 000	2300 (35.3)	48.0	27.2	24.9	
\$25 000–\$49 999	1900 (29.2)	57.5	25.9	16.6	
\$50 000–\$99 999	1600 (24.7)	70.8	18.1	11.1	
≤ \$100 000	700 (10.8)	73.6	18.3	8.2	
Household food security					<.001
Food secure	5750 (87.9)	63.0	22.8	14.2	
Food insecure	800 (12.1)	36.0	27.2	36.8	
Home ownership					<.001
Own your home	3050 (46.7)	67.8	20.3	11.9	
Do not own home	3500 (53.3)	51.6	26.4	21.9	
Family structure					<.001
Two parents	5200 (79.0)	63.8	22.2	14.1	
Single parent	1400 (21.0)	43.0	28.1	28.8	
Maternal characteristics					
Age (y)					<.001
15–19	500 (7.7)	44.2	29.0	26.8	
20–24	1650 (25.2)	50.1	27.3	22.2	
25–29	1600 (24.4)	58.5	25.4	16.1	
30–34	1600 (24.3)	68.7	18.5	12.8	
≥35	1200 (18.5)	67.5	19.6	12.9	
Race/ethnicity					<.001
White, non-Hispanic	3050 (46.3)	62.5	22.7	14.9	
Black, non-Hispanic	1000 (15.4)	45.8	28.8	25.4	
Asian, non-Hispanic	850 (12.7)	61.5	23.2	15.3	
Hispanic	1100 (17.0)	62.5	21.0	16.5	
Other	550 (8.7)	48.5	28.5	23.0	
Education					<.001
Some high school or less	1150 (17.6)	49.8	25.3	24.9	
High school graduate	2000 (30.3)	53.8	25.6	20.7	
Some college	1650 (25.2)	59.9	24.6	15.5	
College and beyond	1750 (26.9)	73.2	18.2	8.6	
Employment					.53
Working	4000 (60.8)	60.5	23.2	16.3	
Not working	2550 (39.2)	59.0	23.4	17.5	
Pre-pregnancy wt					.18
Low tertile	2300 (35.3)	60.1	22.6	17.3	
Middle tertile	2150 (32.6)	61.3	23.5	15.2	
High tertile	2100 (32.1)	58.4	23.8	17.8	
Wt gain in pregnancy					.007
Low tertile	2400 (36.7)	60.0	23.6	16.4	
Middle tertile	2700 (40.7)	62.5	22.1	15.4	
High tertile	1500 (22.5)	55.5	24.8	19.7	
Parity					.65
First birth	2150 (33.0)	60.3	23.6	16.1	
Later birth	4400 (67.0)	59.70	23.2	17.1	
Smoking					<.001
Never smoked	4800 (73.0)	64.1	21.8	14.1	
Smoked after pregnancy	300 (4.6)	53.0	27.1	19.9	
Smoked during and after pregnancy	1450 (22.4)	46.3	27.8	25.9	
Child characteristics					
Health status					<.001
Excellent/very good	5700 (87.3)	61.0	22.8	16.2	
Good/fair/poor	850 (12.7)	51.2	27.4	21.5	

TABLE 1 Continued

	Unweighted	Weighted Percentages			P Value ^a
	Total n (%)	No Depressive Symptoms	Mild Depressive Symptoms	Moderate-Severe Symptoms	
Birth weight					<.001
>2500 g	5300 (81.0)	60.4	23.1	16.5	
1500–2500 g	1600 (10.2)	52.5	26.2	21.3	
<1500 g	400 (8.9)	50.9	26.7	22.3	
Breastfed					<.001
Never	2000 (30.8)	52.6	26.9	20.5	
Ever	4550 (69.2)	63.0	21.8	15.3	
Gender					.69
Boy	3350 (51.1)	60.5	23.0	16.5	
Girl	3200 (48.9)	59.3	23.6	17.1	
Age, mo (mean, SE)	10.5 (0.02)	10.4 (0.06)	10.4 (0.07)	10.5 (0.10)	
Gestational age, wk (mean, SE)	37.9 (0.05)	38.9 (0.04)	38.8 (0.06)	38.8 (0.08)	

Weighted by 9 mo parent wt.

^a P value based on design-based F statistic.

mild as well as moderate to severe maternal depressive symptoms were associated with approximately a 40% higher odds of a child being $\leq 10\%$ for height-for-age. At age 5, these associations remained and increased slightly to nearly a 50% higher odds of being $\leq 10\%$ for height-for-age among children of mothers with moderate to severe depressive symptoms.

Results from other developed countries on the association between maternal depressive symptoms and child growth have been mixed.^{27–32} Two studies from the United Kingdom examined failure-to-thrive in children age ≤ 1 ; one found no association,³⁰ and the other reported an association only at 4 months that disappeared by 1 year of age.²⁹ In studies

including children followed only until age 2, pooled data from 5 countries showed no differences by depressive symptoms for child weight, length, weight for length, or body mass index.³² However, a case-control study reported that children ≤ 2 years old with growth faltering were more likely to have depressed mothers.³¹

The only US study with follow-up until at least age 3 was from an affluent mostly white sample.²⁷ Unlike other studies, Ertel et al found maternal depressive symptoms at 6 months postpartum associated with increased child height-for-age z scores at age 3.²⁷ Using longitudinal growth models from birth to age 3 to examine weight-for-height z scores over time, they reported no

difference between children with and without depressed mothers.²⁸

Varying study results may be due to differences in length of follow-up and in how growth impairment and maternal depressive symptoms were defined and timed. In addition, sample characteristics and sample sizes varied between studies. For example, the effects of maternal depressive symptoms may not be as pronounced in a high-income sample like that of Ertel et al.^{27,28}

Results from developing countries are similarly mixed; 3 studies demonstrated a positive relation between maternal depressive symptoms and stunting,^{33–35} and 3 have shown null results or reported only significant associations in unadjusted models.^{36–38} To our knowledge, only 1 other study from southern Brazil has followed children until 4 years.³⁶ Investigators found no associations between maternal depressive symptoms and any growth outcome, including stunting.³⁶ A recent meta-analysis of 17 studies conducted in developing countries showed overall positive and significant associations between maternal depressive symptoms and child stunting and underweight.³⁹ The association between maternal depression and child growth may differ in developing and developed countries because of differences in social

TABLE 2 Weighted Unadjusted Odds Ratio for Poor Growth at 4 and 5 Years by Level of Maternal Depressive Symptoms at 9 Months

	4 y (Preschool)		5 y (Kindergarten)	
	OR (95% CI)	P	OR (95% CI)	P
$\leq 10\%$ height-for-age	n ~6400		n ~4950	
No DS	Reference		Reference	
Mild DS	1.41 (1.08–1.85)	.01	1.17 (0.80–1.71)	.42
Moderate/severe DS	1.43 (1.09–1.89)	.01	1.47 (1.04–2.08)	.03
$\leq 10\%$ wt-for-height	n ~6300		n ~4750	
No DS	Reference		Reference	
Mild DS	1.09 (0.75–1.58)	.65	1.26 (0.84–1.90)	.26
Moderate/severe DS	1.21 (0.83–1.77)	.31	1.15 (0.68–1.94)	.60
$\leq 10\%$ wt-for-age	n ~6350		n ~4950	
No DS	Reference		Reference	
Mild DS	1.20 (0.88–1.64)	.25	1.00 (0.67–1.51)	.99
Moderate/severe DS	0.93 (0.62–1.39)	.72	0.89 (0.59–1.35)	.58

DS, depressive symptoms; OR, odds ratio.

TABLE 3 Weighted Adjusted Odds of Poor Growth at 4 and 5 Years by Level of Maternal Depressive Symptoms at 9 Months^a

	4 y (Preschool)		5 y (Kindergarten)	
	OR (95% CI)	P	OR (95% CI)	P
≤10% height-for-age	n ~6400		n ~4950	
No DS	Reference		Reference	
Mild DS	1.39 (1.08–1.80)	.01	1.22 (0.83–1.78)	.31
Moderate/severe DS	1.40 (1.04–1.89)	.03	1.48 (1.03–2.13)	.04
≤10% wt-for-height	n ~6300		n ~4750	
No DS	Reference		Reference	
Mild DS	1.09 (0.75–1.58)	.63	1.31 (0.86–1.99)	.20
Moderate/severe DS	1.21 (0.82–1.77)	.34	1.26 (0.74–2.15)	.38
≤10% wt-for-age	n ~6350		n ~4950	
No DS	Reference		Reference	
Mild DS	1.24 (0.90–1.71)	.19	1.08 (0.70–1.68)	.73
Moderate/severe DS	0.95 (0.61–1.47)	.81	0.90 (0.58–1.39)	.63

DS, depressive symptoms; OR, odds ratio.

^a Model adjusted for household income, home ownership, maternal age, maternal employment, family structure, maternal race, maternal pre-pregnancy weight, maternal pregnancy weight gain, maternal smoking, child health status, gestational age at birth, and birth weight.

resources, caregiving norms, and prevalence of undernutrition.

Deficits in stature suggest prolonged long-term illness or chronic undernutrition.⁴⁰ Low height for weight reflects acute undernutrition or severe disease, whereas low weight for age is often an indication of problems that underlie both stunting and wasting.⁴⁰ The fact that maternal depressive symptoms were associated with a child being at risk for deficits in stature but not the other growth indicators suggests that maternal depressive symptoms may be associated with a pattern of caregiving behaviors that have a prolonged effect on child growth over time, as reflected in child short stature at least 3 and 4 years later.

Maternal depressive symptoms are associated with insecure attachment in children and with poor parenting behaviors^{4,13,41} and feeding practices (eg, nonresponsive and restrictive feeding^{4,42} including decreased likelihood of or shorter duration of breastfeeding^{6–8}). Maternal depression is also associated with increased stress re-

sponse in children, which may affect growth. In particular, chronically elevated levels of the stress hormone cortisol are related to lower growth hormone levels in children, which could lead to reduced stature.^{43,44} Our study does not, however, elucidate mechanisms; thus, additional studies are needed to understand the behavioral and physiologic processes that link early caregiving to child growth.

To our knowledge, our study is the first from a developed country to report on maternal depressive symptoms with follow-up of child growth beyond 3 years of age. An additional strength of this study is the large, nationally representative nature of the cohort. ECLS-B provides rich information on potential confounders and independent predictors of child growth. Height and weight were measured by trained study personnel rather than relying on self-report. Likewise, the use of the CES-D, a well-validated and widely used measure of depressive symptoms provides a basis for direct comparison with other studies.

One limitation is the differential loss to follow-up of families for whom there were no data on depressive symptoms or child growth. Because the mothers who dropped out of the study may be at higher risk for depression, this loss may have led to a bias in the magnitude of the associations. The survey weighting helps account for nonresponse bias but may not address its full impact. Although we adjusted for key variables, data on parental height and body mass index were not available. The study also did not have data on feeding modes/styles, such as responsive feeding practices, so we could not examine how maternal depressive symptoms may influence growth through these pathways. In addition, we did not have data on birth length or maternal depressive symptoms before 9 months and thus could not examine the effect of maternal depressive symptoms on growth at earlier time points, which may affect later growth outcomes. Adjustment for weight gain during the first 9 months changed the estimates only negligibly. Our study, using a US nationally representative sample, demonstrated associations between maternal depressive symptoms at 9 months postpartum and reduced stature but not deficits in weight, as defined as ≤10% of weight-for-height and weight-for-age indicators, in children aged 4 and 5 years. The findings underscore the potential of early detection and treatment of maternal depressive symptoms during the first year postpartum in the prevention of reduced child stature at preschool- and school-age. Additional studies are needed to examine mechanisms, differences between populations, and whether differences persist into later elementary school years.

REFERENCES

1. Victora CG, Adair L, Fall C, et al; Maternal and Child Undernutrition Study Group. Maternal and child undernutrition: consequences for adult health and human capital. *Lancet*. 2008;371(9609):340–357.
2. Shonkoff JP, Boyce WT, McEwen BS. Neuroscience, molecular biology, and the childhood roots of health disparities: building

- a new framework for health promotion and disease prevention. *JAMA*. 2009;301(21):2252–2259
3. Stewart RC. Maternal depression and infant growth: a review of recent evidence. *Matern Child Nutr*. 2007;3(2):94–107
4. Lovejoy MC, Graczyk PA, O'Hare E, Neuman G. Maternal depression and parenting behavior: a meta-analytic review. *Clin Psychol Rev*. 2000;20(5):561–592
5. Black MM, Baqui AH, Zaman K, El Arifeen S, Black RE. Maternal depressive symptoms and infant growth in rural Bangladesh. *Am J Clin Nutr*. 2009;89(3):951S–957S
6. Papinczak TA, Turner CT. An analysis of personal and social factors influencing initiation and duration of breastfeeding in a large Queensland maternity hospital. *Breastfeed Rev*. 2000;8(1):25–33
7. McLearn KT, Minkovitz CS, Strobino DM, Marks E, Hou W. Maternal depressive symptoms at 2 to 4 months post partum and early parenting practices. *Arch Pediatr Adolesc Med*. 2006;160(3):279–284
8. Bick DE, MacArthur C, Lancashire RJ. What influences the uptake and early cessation of breast feeding? *Midwifery*. 1998;14(4):242–247
9. Hurley KM, Surkan PJ, Black MM. Maternal depression and child growth in developing countries: a focus on the post-natal period. In: Preedy VR, ed. *Handbook of Growth Monitoring and Health and Disease*. London, England: Springer Publications; 2011:2023–2046
10. Moses-Kolko EL, Roth EK. Antepartum and postpartum depression: healthy mom, healthy baby. *J Am Med Womens Assoc*. 2004;59(3):181–191
11. van den Boom DC. Do first-year intervention effects endure? Follow-up during toddlerhood of a sample of Dutch irritable infants. *Child Dev*. 1995;66(6):1798–1816
12. Fearon RP, Bakermans-Kranenburg MJ, van Ijzendoorn MH, Lapsley AM, Roisman GI. The significance of insecure attachment and disorganization in the development of children's externalizing behavior: a meta-analytic study. *Child Dev*. 2010;81(2):435–456
13. McLearn KT, Minkovitz CS, Strobino DM, Marks E, Hou W. The timing of maternal depressive symptoms and mothers' parenting practices with young children: implications for pediatric practice. *Pediatrics*. 2006;118(1). Available at: www.pediatrics.org/cgi/content/full/118/1/e174
14. Snow K, Derecho A, Wheelless S, et al. *Early Childhood Longitudinal Study, Birth Cohort (ECLS-B), Kindergarten 2006 and 2007 Data File User's Manual (2010-010)*, chapter 7. Washington, DC: US Department of Education, Institute of Education Sciences, National Center for Education Statistics; 2009:422
15. Flanagan KD, McPhee C, Mulligan G. *The children born in 2001 at kindergarten entry: first findings from the kindergarten data collections of the Early Childhood Longitudinal Study, Birth Cohort (ECLS-B)*. Washington, DC: National Center for Education Statistics, US Department of Education; 2009
16. NationalCenterforEducationStatisticsInstituteofEducationSciences. Birth Cohort (ECLS-B) Study Information. Available at: <http://nces.ed.gov/ecls/birth.asp>. Accessed March 14, 2011
17. Wheelless S, Ault K, Park J. *Early Childhood Longitudinal Study—Birth Cohort (ECLS-B) Methodology Report for the Preschool Data Collection (2005–2006)*, Vol II: Sampling. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, US Department of Education; 2008
18. Nord C, Edwards B, Hilpert R, Branden L, Andreassen C, Elmore A. *Early Childhood Longitudinal Study, Birth Cohort (ECLS-B): User's Manual for the ECLS-B Nine-month Restricted-use Data File and Electronic Code Book (NCES 2004-092)*. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, US Department of Education; 2004
19. Snow K, Thalji L, Derecho A, et al. *Early Childhood Longitudinal Study, Birth Cohort (ECLS-B), Preschool Year Data File User's Manual, 2005–2006 (NCES 2008-024)*. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, US Department of Education; 2007
20. Kuczarski RJ, Ogden CL, Guo SS, et al. 2000 CDC Growth Charts for the United States: methods and development. *Vital Health Stat 11*. 2002 May;(246):1–190
21. Institute of Medicine. *WIC Nutrition Risk Criteria*. Washington, DC: National Academy of Science; 1996
22. Ross CE, Mirowsky J, Huber J. Dividing work, sharing work, and in-between: marriage patterns and depression. *Am Sociol Rev*. 1983;48(6):809–823
23. Radloff LS. The CES-D scale: A self-report depression scale for research in the general population. *Appl Psychol Meas*. 1977;1(3):385–401
24. Poulin C, Hand D, Boudreau B. Validity of a 12-item version of the CES-D used in the National Longitudinal Study of Children and Youth. *Chronic Dis Can*. 2005;26(2–3):65–72
25. Nord M, Andrews M, Carlson S. *Household Food Security in the United States*, 2003. Washington, DC: Economic Research Service, US Department of Agriculture; 2003
26. Mander A, Clayton D. *Hotdeck Imputation*. College Station, TX: Texas A & M University; 1999
27. Ertel KA, Koenen KC, Rich-Edwards JW, Gillman MW. Maternal depressive symptoms not associated with reduced height in young children in a US prospective cohort study. *PLoS ONE*. 2010;5(10):e13656
28. Ertel KA, Koenen KC, Rich-Edwards JW, Gillman MW. Antenatal and postpartum depressive symptoms are differentially associated with early childhood weight and adiposity. *Paediatr Perinat Epidemiol*. 2010;24(2):179–189
29. Wright CM, Parkinson KN, Drewett RF. The influence of maternal socioeconomic and emotional factors on infant weight gain and weight faltering (failure to thrive): data from a prospective birth cohort. *Arch Dis Child*. 2006;91(4):312–317
30. Drewett R, Blair P, Emmett P, Emond A; ALSPAC Study Team. Failure to thrive in the term and preterm infants of mothers depressed in the postnatal period: a population-based birth cohort study. *J Child Psychol Psychiatry*. 2004;45(2):359–366
31. O'Brien LM, Heycock EG, Hanna M, Jones PW, Cox JL. Postnatal depression and faltering growth: a community study. *Pediatrics*. 2004;113(5):1242–1247
32. Grote V, Vik T, von Kries R, et al; European Childhood Obesity Trial Study Group. Maternal postnatal depression and child growth: a European cohort study. *BMC Pediatr*. 2010;10:14
33. Patel V, DeSouza N, Rodrigues M. Postnatal depression and infant growth and development in low income countries: a cohort study from Goa, India. *Arch Dis Child*. 2003;88(1):34–37
34. Rahman A, Iqbal Z, Bunn J, Lovel H, Harrington R. Impact of maternal depression on infant nutritional status and illness: a cohort study. *Arch Gen Psychiatry*. 2004;61(9):946–952
35. Avan B, Richter LM, Ramchandani PG, Norris SA, Stein A. Maternal postnatal depression and children's growth and behaviour during the early years of life: exploring the interaction between physical and mental health. *Arch Dis Child*. 2010;95(9):690–695
36. Santos IS, Matijasevich A, Domingues MR, Barros AJ, Barros FC. Long-lasting maternal depression and child growth at 4 years of age: a cohort study. *J Pediatr*. 2010;157(3):401–406
37. Tomlinson M, Cooper PJ, Stein A, Swartz L, Molteno C. Post-partum depression and infant growth in a South African peri-urban

- settlement. *Child Care Health Dev.* 2006;32(1):81–86
38. Adewuya AO, Ola BO, Aloba OO, Mapayi BM, Okeniyi JA. Impact of postnatal depression on infants' growth in Nigeria. *J Affect Disord.* 2008;108(1–2):191–193
 39. Surkan PJ, Kennedy CE, Hurley KM, Black MM. Maternal depression and early childhood growth in developing countries: systematic review and meta-analysis. *Bull World Health Organ.* 2011;89(8):608–615
 40. Physical Status WHO. *The Use and Interpretation of Anthropometry.* Geneva, Switzerland: World Health Organization; 1995
 41. Martins C, Gaffan EA. Effects of early maternal depression on patterns of infant-mother attachment: a meta-analytic investigation. *J Child Psychol Psychiatry.* 2000;41(6):737–746
 42. Hurley KM, Black MM, Papas MA, Caulfield LE. Maternal symptoms of stress, depression, and anxiety are related to non-responsive feeding styles in a statewide sample of WIC participants [published correction appears in *J Nutr.* 2008;138(10):1982]. *J Nutr.* 2008;138(4):799–805
 43. Preece MA. The effect of administered corticosteroids on the growth of children. *Postgrad Med J.* 1976;52(612):625–630
 44. Simon D, Lucidarme N, Prieur AM, Ruiz JC, Czernichow P. Treatment of growth failure in juvenile chronic arthritis. *Horm Res.* 2002;58(suppl 1):28–32