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OBSTETRICS

Maternal stress and neonatal anthropometry: the NICHD Fetal Growth Studies

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BACKGROUND: The effect of maternal mood disorders on neonatal measurements is not well-defined. The Fetal Growth Studies—Singletons provide a unique opportunity to evaluate the relationship between perceived maternal stress and neonatal growth measurements.

OBJECTIVE: The purpose of this study was to determine whether perceived maternal stress during pregnancy is associated with anthropometric measurements in the neonate.

STUDY DESIGN: This analysis was based on a prospective, multicenter longitudinal study of fetal growth. Women 18-40 years old with a body mass index of 19.0—29.9 kg/m^2 were screened at 8+0 to 13+6 weeks gestation for low-risk status associated with optimal fetal growth (eg, healthy, nonsmoking) and underwent serial sonographic examination at 6 study visits throughout gestation. At each study visit, women completed the Cohen's Perceived Stress Survey, which could have a score that ranges from 0—40. We used a latent class trajectory model to identify distinct groupings (ie, classes) of the Perceived Stress Survey trajectories over pregnancy. Trend analysis was used to determine whether neonatal measurements including birthweight, length, head circumference, and abdominal circumference differed by Perceived Stress Survey class and whether this relationship was modified by maternal race/ethnicity, after adjustment for gestational age at delivery, maternal height, age, and parity.

RESULTS: Of the 2334 women enrolled in the study, 1948 women had complete neonatal anthropometry and were included in the analysis. Latent class analysis identified 3 Perceived Stress Survey trajectory classes, with mean Perceived Stress Survey scores of 2.82 (low), 7.95 (medium), and 14.80 (high). Neonatal anthropometric measures of birthweight, length, head circumference and abdominal circumference were similar (P=.78, =.10, =.18, and =.40 respectively), regardless of the participants' Perceived Stress Survey class. There was no effect modification by maternal race/ethnicity.

CONCLUSION: Neonatal measurements did not differ by levels of perceived stress among low-risk pregnant women.

Key words: anthropometry, maternal stress

Major stressful life events during pregnancy, such as wars and natural disasters, have been demonstrated to be associated negatively with gestational age at birth, birthweight, and length.[1-5] A variety of psychosocial factors, which include food insecurity, single-parent households, sedentary lifestyles, and poor coping skills, also have been associated significantly with low birthweight at delivery.[6,7] The association between perceived maternal stress and pregnancy outcomes in populations that are not exposed to such catastrophic events is less clear. Rondo et al[8] discovered a nearly 2-fold increased risk of low birthweight among 865 women with higher self-reported stress and anxiety during pregnancy; other large cohort studies have failed to demonstrate an association.[9,10] It has been postulated that excessive maternal stress contributes to the development of fetal growth restriction through abnormal placental function.[11,12] For example, greater stress has been associated with higher levels of Epstein-Barr virus titers and C-reactive protein in the peripheral blood; higher levels of these 2 biomarkers have been associated with increased placental inflammation.[12-15]

The uncertain relationship between maternal stress and fetal growth may be explained by the many confounding factors that exist and have not been controlled for adequately in previous studies. The National Institute of Child Health and Human Development (NICHD) Fetal Growth Studies—Singletons provide a unique opportunity to assess the relationship between maternal stress and neonatal anthropometric measurements in a group of healthy pregnant women in the United States. Our objectives were to describe longitudinal changes in perceived stress throughout pregnancy and to investigate whether perceived stress was associated with neonatal anthropometry, which includes birthweight, length, and head and abdominal circumferences. We hypothesized that neonatal anthropometric measurements would be smaller for women with greater perceived stress with the use of the Cohen's Perceived Stress Scale (PSS)[5] as compared with those with lower levels of stress.

Methods

The NICHD Fetal Growth Studies—Singletons was a prospective cohort study in which pregnant women were recruited from 12 participating clinical sites from July 2009 through January 2013. Women were eligible for the study if they were at low risk of obstetric or medical complications. Psychiatric

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disorders, which included an anxiety disorder currently requiring medication, depression, or bipolar disorder, were exclusion criteria. Our protocol required concordance with the last menstrual period so that women who required redating were not enrolled. Women underwent an ultrasound screening between 8 0/7 and 13 6/7 weeks gestation to ensure that sonographic dating was consistent with last menstrual period dating. The ultrasound estimate of gestation had to match the last menstrual period—based gestational age within 5 days for women between 8 0/7 and 10 6/7 weeks gestation, within 6 days for those between 11 0/7 and 12 6/7 weeks gestation, and within 7 days for participants between 13 0/7 and 13 6/7 weeks gestation. Gestational age therefore was based on the menstrual date. Consenting women were assigned randomly to 1 of 4 serial sonography schedules for a total of 6 targeted visits throughout pregnancy. Full details of the protocol and study methods have been published previously.[16] Human subjects' approval was obtained from all participating sites before initiation of the study, and all women gave informed consent before enrollment and data collection.

During the study, research nurses conducted in-person interviews that ascertained a variety of data that included demographic and psychosocial information. Women were administered the Cohen's PSS[5] at every visit. This is a 10-item validated survey in which each question is coded 0—4 and then summed to compute a total score that ranges from 0—40. Higher scores indicate greater perceived stress.

Our trained research coordinators followed standardized protocols using uniform equipment, which included a portable stadiometer (Seca Corporation, Hamburg, Germany), at enrollment to measure height and weight. Recalled prepregnancy weight was also recorded, and body mass index was calculated. Women's race/ethnicity was categorized as non-Hispanic white, non-Hispanic black, Hispanic, and Asian or Pacific Islander. These categorizations were based on self-identified race/ethnicity provided by participants on their study questionnaire. Neonatal anthropometric measurements were conducted by trained research coordinators per protocol within 12—24 hours after delivery so as not to interfere with the hospital's routine newborn care. Measurements were targeted closer to 24 hours if possible, given that less head molding and flexion are present. The examination included measurements of the neonatal length, birthweight, head circumference, and abdominal circumference. Neonatal length was measured as the distance from the soles of the infant's feet to the top of the head, with the infant supine and with the use of an approved infantometer (infant measuring board). The assistant positioned the infant's head flush against the headboard, with the infant looking upward and with the head in the Frankfort horizontal plane, which runs through the inferior bones of the bony orbits and the upper margin of the auditory meatus. Supine, the plane should be perpendicular to the horizontal during measurement. The measurer held the infant's legs flat as the footboard was moved flat against the infant's heels. Birthweight was measured with an infant beam balance scale or an infant electronic (digital) scale and recorded in pounds or grams. The head circumference was measured with a tape placed anteriorly on the forehead just above the eyebrows and posteriorly at the maximum protrusion of the occiput, so that the maximum head circumference was measured. The tape was pulled to be snug against the head but not tight and recorded to the nearest 0.1 cm. The abdominal circumference was measured midway between the xiphoid process of the sternum and umbilicus. All measurements were taken in duplicate. If the 2 measurements differed by a prespecified tolerance limit, a third measurement was taken.

To estimate the course of stress throughout the pregnancy, we used a latent-class trajectory model, which is a flexible semiparametric method that can be used to discover patterns. This approach allows for multiple latent trajectories in which each trajectory follows a linear mixed model. This method provides a data-driven approach to identify whether distinct individual patterns of stress exist and the corresponding probability of falling into each pattern (posterior probability). Subjects were then classified based on their highest posterior probability. We compared the fit of 2—4 trajectories by choosing the model with the lowest Bayesian information criterion value. Latent-class trajectory analyses were conducted with R software (version 3.1.2).[17]

After the stress trajectories were estimated, we examined the proportion of women in each trajectory. Of the 2334 women who were enrolled in the study, 1962 women had complete neonatal information. Among these women, we excluded pregnancies with missing covariate information (n=14). The final analysis therefore included 1948 women. Linear regression was used to assess whether an association was present between stress levels across pregnancy and neonatal anthropometry. In this analysis, the outcome variable was a neonatal anthropometric measurement; the independent variable was the stress class, and we adjusted for the following potential confounders: gestational age at delivery, neonatal measurement date, maternal height, maternal age, and parity. We tested whether the relationships were modified by maternal race/ethnicity using linear regression models with interaction terms between stress level and maternal race/ethnicity (likelihood ratio test conducted at the 0.05 significance level). In addition to accounting for the time between birth and neonatal measurements with the use of the previously discussed regression analysis, we conducted a sensitivity analysis that excluded neonates (n=188) who had measurements taken >24 hours after birth.

Results

Characteristics of the study population are presented in Table 1. As illustrated, the women in the study population were racially and ethnically diverse and represented a wide range of

TABLE 1
Characteristics of the study population by perceived stress latent class

Variable	Total (N=1948)	Class: Low (n=336)	Medium (n=871)	High (n=741)	*P* value
Maternal age, y[a]	28.23±5.47	28.88±5.07	28.69±5.38	27.40±5.64	<.0001
Gestational age at enrollment, wk[a]	12.69±0.96	12.68±0.92	12.68±0.97	12.72±0.97	.38
Gestational age at delivery, wk[a]	39.32±1.35	39.35±1.20	39.35±1.35	39.27±1.41	.42
Height, cm[a]	162.49±6.96	162.37±7.08	162.54±6.94	162.48±6.93	.88
Weight, kg[a]	64.65±10.55	64.27±10.36	64.31±10.28	65.21±10.94	.18
Maternal prepregnancy body mass index, kg/m^2[a]	23.63±3.03	23.46±2.91	23.46±3.04	23.85±3.05	.02
Race/ethnicity, n (%)					
Non-Hispanic white	531 (27.3)	125 (37.2)	275 (31.6)	131 (17.7)	<.0001
Non-Hispanic black	496 (25.5)	68 (20.2)	184 (21.1)	244 (32.9)	
Hispanic	539 (27.7)	84 (25.0)	229 (26.3)	226 (30.5)	
Asian and Pacific Islander	382 (19.6)	59 (17.6)	183 (21.0)	140 (18.9)	
Parity, n (%)					
Nulliparity	952 (48.9)	167 (49.7)	446 (51.2)	339 (45.7)	.09
Parity ≥1	996 (51.1)	169 (50.3)	425 (48.8)	402 (54.3)	
Marital status, n (%)					
Never married	414 (21.3)	53 (15.8)	165 (19.0)	196 (26.5)	<.0001
Married/living as married	1481 (76.1)	279 (83.0)	690 (79.4)	512 (69.1)	
Divorced/separated/widowed	51 (2.6)	4 (1.2)	14 (1.6)	33 (4.5)	
Education (highest level), n (%)					
Less than high school	200 (10.3)	22 (6.5)	73 (8.4)	105 (14.2)	<.0001
High school diploma or general education diploma or equivalent	346 (17.8)	50 (14.9)	139 (16.0)	157 (21.2)	
Some college or associate degree	564 (29.0)	95 (28.3)	235 (27.0)	234 (31.6)	
Bachelor's degree	479 (24.6)	101 (30.1)	234 (26.9)	144 (19.4)	
Master's degree or advanced degree	359 (18.4)	68 (20.2)	190 (21.8)	101 (13.6)	
Family income, n (%)					
≤$29,999	462 (27.5)	48 (16.6)	182 (23.7)	232 (37.4)	<.0001
$30,000-49,999	284 (16.9)	42 (14.5)	117 (15.2)	125 (20.1)	
$50,000-$74,999	202 (12.0)	34 (11.8)	101 (13.1)	67 (10.8)	
$75,000-$99,999	232 (13.8)	41 (14.2)	109 (14.2)	82 (13.2)	
≥$100,000	499 (29.7)	124 (42.9)	260 (33.8)	115 (18.5)	
Health insurance, n (%)					
Private/managed care	1132 (58.1)	213 (63.4)	545 (62.6)	374 (50.5)	<.0001
Medicaid, other	771 (39.6)	120 (35.7)	304 (34.9)	347 (46.8)	
Self-pay	45 (2.3)	3 (0.9)	22 (2.5)	20 (2.7)	

[a] Data are presented as mean±standard deviation.

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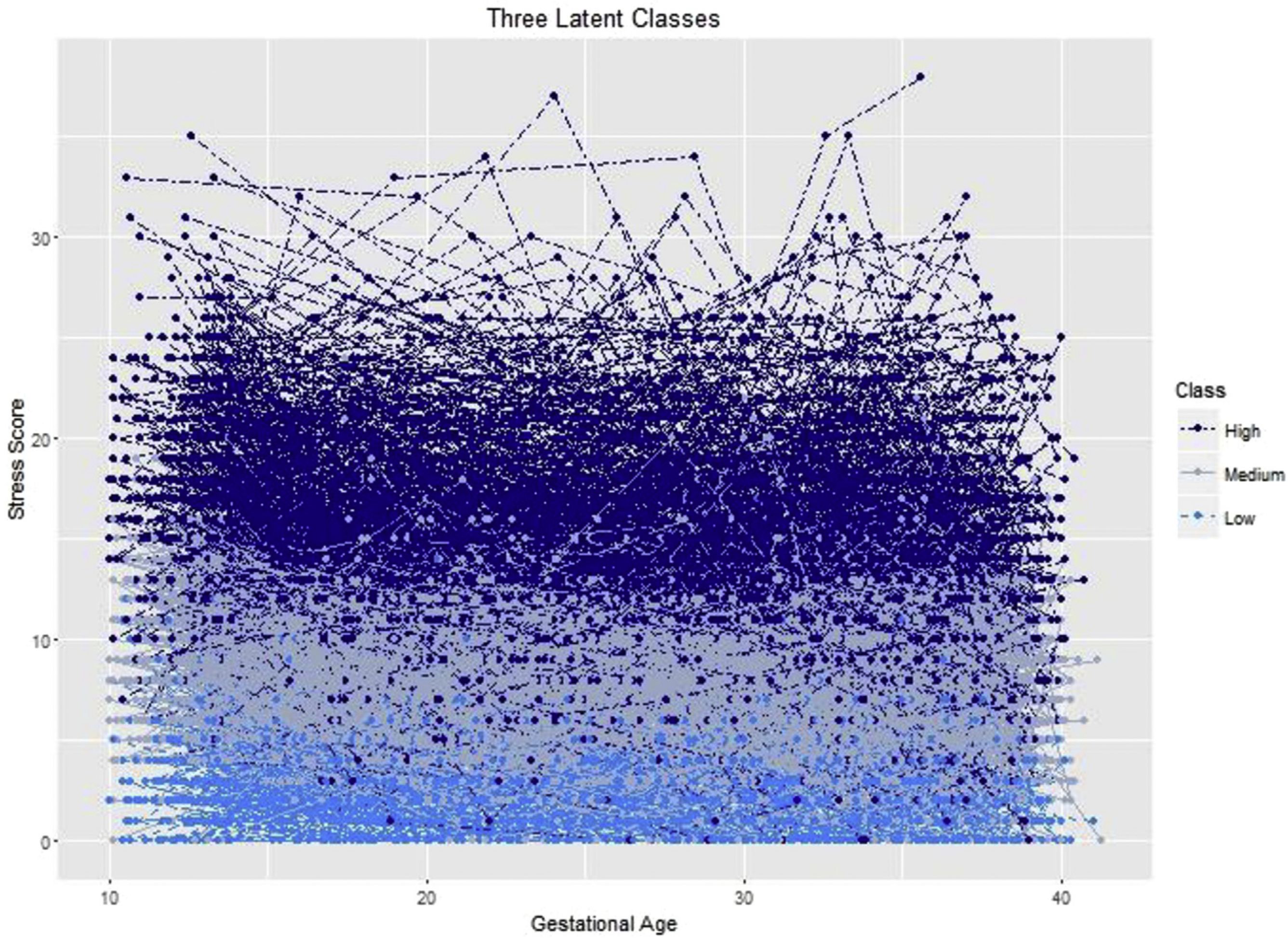
socioeconomic strata. We discriminated 3 separate groups of women who had low (n=336: 17.2%), medium (n=871; 44.7%), or high (n=741; 38.0%) stress across gestation (Figure 1). The mean PSSs for each group were 2.82 (low), 7.95 (medium), and 14.80 (high; Figure 1; Table 2). Regardless of class, on average, stress was relatively

FIGURE 1
Longitudinal-derived Cohen's perceived stress trajectories for the National Institute of Child Health and Human Development Fetal Growth Studies



Each *dot-dashed line* reflects an individual stress trajectory. The lines are color coded to indicate the subject's class.

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constant or slightly decreased over the course of pregnancy (Figure 2). The group with the highest perceived stress was more likely to be younger, non-Hispanic black, heavier, multiparous, never married, receiving Medicaid, of lower educational status, and with lower income (Table 1).

TABLE 2
Posterior classifications that represent probability of falling into each perceived stress class

	Class		
Variable	Low	Medium	High
N	336	871	741
Percent	17.2	44.7	38.0
Average probability	0.77	0.70	0.84
Perceived stress score	2.82	7.95	14.79

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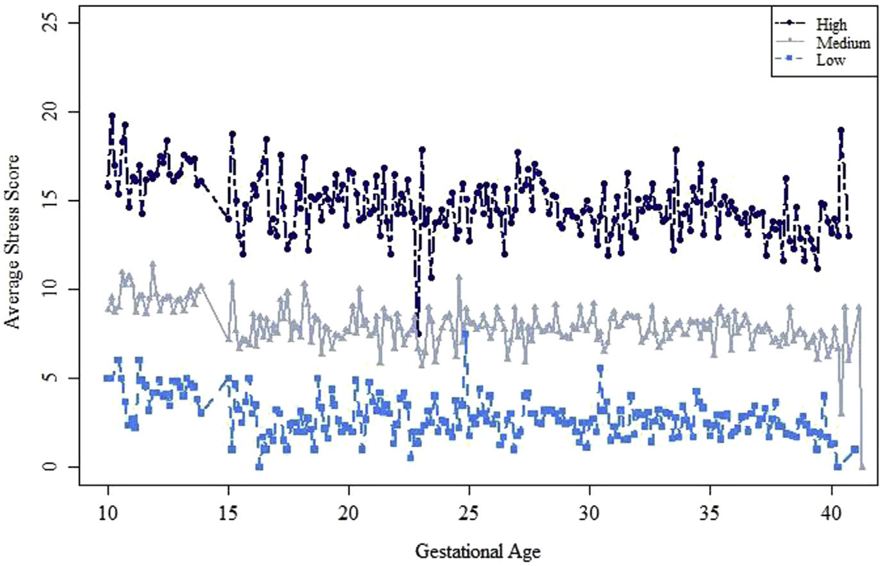
Table 3 illustrates the individual biometric parameters of birthweight, length, head circumference, and abdominal circumference stratified by PSS classes. There was no significant difference in the mean±standard deviation birthweight among low (3274±432.17 g), medium (3300±457.43 g), and high (3268±474.34 g) stress groups. Neonatal length, head circumference, and abdominal circumference followed a similar pattern. Maternal race/ethnicity did not modify any of the aforementioned relations, which suggests that the relationship between perceived stress

FIGURE 2
Average derived Cohen's perceived stress trajectories from the National Institute of Child Health and Human Development Fetal Growth Studies



Average measurements for those patients who were classified in the high, medium, or low class. Subjects were classified into these groups via highest posterior probability.

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and neonatal anthropometry was similar across race/ethnicity groups (Table 3). In a sensitivity analysis that excluded the neonates for whom the anthropometric measurements were obtained >24 hours after birth, the findings were consistent with the main analysis (data not shown).

The current analysis excluded voluntary termination of pregnancies (n=7; <1%), miscarriages (n=23; 1%), women who moved away from the study catchment area (n=26; 1%), refused to continue before delivery (n=85; 4%), did not meet the inclusion criteria after enrollment (n=14; <1%), had unknown birth outcomes if the participant delivered at home or another hospital and medical records could not be obtained (n=11; <1%), had at least 1 neonatal anthropometry variable not measured (n=29l 1%), measurements were not collected because the newborn infant was in the neonatal intensive care unit or the patient was discharged before measurements could be collected (n=10; <1%) or were missing for other reasons (n=167; 7%). The final sample size for this analysis consisted of 1962 (84%) women with low-risk singleton pregnancies.

Comment

We discriminated 3 separate longitudinal trajectories of perceived stress in pregnancy. Higher scores on the PSS throughout pregnancy were not associated with alterations in neonatal anthropometry that included birthweight, length, and head and abdominal circumferences, even after we accounted for important confounders. Further, this lack of association was similar, regardless maternal race/ethnicity. Our results are consistent with previous findings from the same study population regarding the lack of association of sonographic trajectories of fetal biometry with either maternal perceived stress or depression (unpublished data). This study, however, did not assess actual neonatal measurement.

An inverse association between psychosocial burden and neonatal measurements has been reported inconsistently in the literature. Zhu et al[18] studied 1800 women who delivered after 32 weeks gestation and found that each unit increase of perceived life events stress during the first trimester was associated with a 99-gram decrease in infant birthweight. Similarly, Khashan et al[19] found a significant association between antenatal PSSs and the risk of small-for-gestational age birth (adjusted odds ratio, 1.01; 95% confidence interval, 1.01−1.02) in a longitudinal prospective cohort investigation performed in the Australia, New Zealand, and parts

TABLE 3
Mean neonatal measurements of perceived stress classes

Variable	Class Low[b]	Medium[b]	High[b]	Adjusted *P* value[a]
Birthweight, g	3274±432.17	3300±457.43	3268±474.34	.80
Length, cm	50.29±2.46	50.18±2.52	49.95±2.54	.08
Head circumference, cm	34.10±1.40	34.11±1.48	33.91±1.55	.12
Abdominal circumference, cm	33.14±2.16	33.16±2.26	32.95±2.30	.38

[a] Adjusted for measurement date, maternal age, race/ethnicity, height, and parity; [b] Data are given as mean±standard deviation.

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of the United Kingdom Other European studies have echoed these results.[20,21] Yet, other studies such as ours have not been able to reproduce these associations. Broekman et al[22] found no relation of anxiety and depression in pregnancy at 26 weeks gestation with birthweight, although they did note an association with birth length in a large cohort of Asian women. This last report has been cited by some investigators as evidence that birth length is a more sensitive marker of fetal growth than is birthweight.[4] Explanations for the conflicting results include differing sample sizes, study designs, and measures of maternal mental health.

There are several strengths of our investigation. Exposure data related to stress were obtained prospectively and serially from participants. The neonatal examinations were performed with standardized equipment and protocols by trained research personnel. Because the inclusion criteria for NICHD Fetal Growth Studies—Singletons were designed to capture a healthy obstetric population, our subjects were without histories of previous adverse pregnancy outcomes or other preexisting comorbidities, other extrinsic factors such as smoking, alcohol, or illicit substance ingestion, or extreme poverty. Women with all these factors have been present in other studies, which could contribute to perturbations in perinatal growth but which, at best, are difficult to quantify in statistical modeling.

Even if greater perceived stress during pregnancy has no association with alterations in neonatal anthropometric measurements, the possibility exists that the psychosocial environment affects pregnancy outcomes, especially when the levels of perceived stress are more extreme than observed here or when the women are less physically healthy. We assessed perceived stress because its relationship with neonatal birth parameters is biologically plausible and has been suggested by other observational studies.[6,18,23] However, other unmeasured psychosocial constructs may have stronger associations with pregnancy outcomes.[6,7,18] The stress survey used assessed events and feelings that were relatively acute and proximate to the pregnancy. Yet, it may be that other elements such as chronic stress and affective symptoms, which were not measured in the present study, are the etiologic factors in the psychosocial domain more likely responsible for adverse pregnancy outcomes.[24]

There was no evidence in this longitudinal cohort study that perceived stress translated into reductions in overall neonatal weight, length, or individual biometric parameters. The similarity in neonatal measures existed whether women experienced the exposure of interest relatively early in pregnancy or persistently throughout pregnancy, because our observed stress trajectories were relatively flat. Moreover, race/ethnicity did not explain the lack of association. From this investigation, we conclude that perceived stress alone is not sufficient to result in altered neonatal anthropometric parameters. This should be reassuring to pregnant women. Future studies are necessary to delineate whether a greater psychosocial burden, either alone or in combination with maternal health or other environmental factors and experienced at critical times in pregnancy, contributes to impairments in neonatal biometry. ■

References

1. Khashan AS, McNamee R, Abel KM, et al. Reduced infant birthweight consequent upon maternal exposure to severe life events. Psychosom Med 2008;70:688-94.

2. Khashan AS, McNamee R, Abel KM, et al. Rates of preterm birth following antenatal maternal exposure to severe life events: a population-based cohort study. Hum Reprod 2009;24:429-37.

3. Class QA, Lichtenstein P, Långström N, D'Onofrio BM. Timing of prenatal maternal exposure to severe life events and adverse pregnancy outcomes: a population study of 2.6 million pregnancies. Psychosom Med 2011;73:234-41.

4. Dancause KN, Laplante DP, Oremus C, Fraser S, Brunet A, King S. Disaster-related prenatal maternal stress influences birth outcomes: project Ice Storm. Early Hum Dev 2011;87:813-20.

5. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav 1983;24:385-96.

6. Borders AE, Grobman WA, Amsden LB, Holl JL. Chronic stress and low birth weight neonates in a low-income population of women. Obstet Gynecol 2007;109:331-8.

7. Savard N, Levallois P, Rivest LP, Gingras S. Impact of individual and ecological characteristics on small for gestational age births: an observational study in Quebec. Chronic Dis Inj Can 2014;34:46-54.

8. Rondo PH, Ferreira RF, Nogueira F, Ribeiro MC, Lobert H, Artes R. Maternal psychological stress and distress as predictors of low birth weight, prematurity and intrauterine growth retardation. Eur J Clin Nutr 2003;57:266-72.

9. Andersson L, Sundström-Poromaa I, Wulff M, Aström M, Bixo M. Neonatal outcome following maternal antenatal depression and anxiety: a population-based study. Am J Epidemiol 2004;159:872-81.

10. Henrichs J, Schenk JJ, Roza SJ, et al. Maternal psychological distress and fetal growth trajectories: the Generation R Study. Psychol Med 2010;40:633-43.

11. Lewis AJ, Austin E, Galbally M. Prenatal maternal mental health and fetal growth restriction: a systematic review. J Dev Orig Health Dis 2016;7:416-28.

12. Entringer S, Buss C, Wadhwa PD. Prenatal stress, development, health and disease risk: a psychobiological perspective-2015 Curt Richter Award Paper. Psychoneuroendocrinology 2015;62:366-75.

13. Christian LM, Iams JD, Porter K, Glaser R. Epstein-Barr virus reactivation during pregnancy and postpartum: effects of race and racial discrimination. Brain Behav Immun 2012;26:1280-7.

14. Borders AE, Wolfe K, Qadir S, Kim KY, Holl J, Grobman W. Racial/ethnic differences in self-reported and biologic measures of chronic stress in pregnancy. J Perinatol 2015;35:580-4.

15. Ernst LM, Grobman WA, Wolfe K, et al. Biological markers of stress in pregnancy: associations with chronic placental inflammation at delivery. Am J Perinatol 2013;30:557-64.

16. Buck Louis GM, Grewal J, Albert PS, et al. Racial/ethnic standards for fetal growth: the NICHD Fetal Growth Studies. Am J Obstet Gynecol 2015;213:449.e1-41.

17. Proust-Lima C, Philipps V, Diakite A, Liquet B, et al. CRAN - Package lcmm. Cranrprojectorg 2016. Available at: http://CRAN.R-project.org/package=lcmm. Accessed March 28, 2017.

18. Zhu P, Tao F, Hao J, Sun Y, Jiang X. Prenatal life events stress: implications for preterm birth and infant birthweight. Am J Obstet Gynecol 2010;203:34.e1-8.

19. Khashan AS, Everard C, McCowan LM, et al. Second-trimester maternal distress increases the risk of small for gestational age. Psychol Med 2014;44:2799-810.

20. Bödecs T, Horváth B, Szilágyi E, Gonda X, Rihmer Z, Sándor J. Effects of depression, anxiety, self-esteem, and health behaviour on neonatal outcomes in a population-based Hungarian sample. Eur J Obstet Gynecol Reprod Biol 2011;154:45-50.

21. Maina G, Saracco P, Giolito MR, Danelon D, Bogetto F, Todros T. Impact of maternal psychological distress on fetal weight, prematurity and intrauterine growth retardation. J Affect Disord 2008;111:214-20.

22. Broekman BF, Chan YH, Chong YS, et al. The influence of anxiety and depressive symptoms during pregnancy on birth size. Paediatr Perinat Epidemiol 2014;28:116-26.

23. Khashan AS, McNamee R, Henriksen TB, et al. Risk of affective disorders following prenatal exposure to severe life events: a Danish population-based cohort study. J Psychiatr Res 2011;45:879-85.

24. Messer LC, Kaufman JS. Invited commentary: the socioeconomic causes of adverse birth outcomes. Am J Epidemiol 2010;172:135-9.

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