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The association between prenatal stress and infant birth weight and gestational age at birth: A prospective investigation

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OBJECTIVE: The aim was to test a model of the influence of maternal prenatal psychosocial stress on birth outcomes after controlling for biomedical risk.

STUDY DESIGN: In a prospective study a sociodemographically homogeneous sample of 90 women was assessed during the third trimester with standard, reliable questionnaires that measured episodic and chronic stress, strain (response to stress), and pregnancy-related anxiety. Birth outcomes included infant birth weight, gestational age at birth, and intrapartum complications. Parity and biomedical (antepartum) risk was also coded. Bivariate and multivariate analyses were performed after controlling for the effects of biomedical risk factors.

RESULTS: Independent of biomedical risk, each unit increase of prenatal life event stress (from a possible sample range of 14.7 units) was associated with a 55.03 gm decrease in infant birth weight and with a significant increase in the likelihood of low birth weight (odds ratio 1.32), and each unit increase of prenatal pregnancy anxiety (from a possible sample range of 5 units) was associated with a 3-day decrease in gestational age at birth.

CONCLUSION: Independent of biomedical risk, maternal prenatal stress factors are significantly associated with infant birth weight and with gestational age at birth. (Am J Obstet Gynecol 1993;169:858-65.)

Key words: Prenatal stress, life event stress, pregnancy anxiety, biomedical risk, birth outcomes, infant birth weight, gestational age at birth, low birth weight, preterm birth

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Prenatal obstetric risk assessments predict at most two thirds of all poor birth outcomes.[1, 2] The predictive values (sensitivity) of five commonly used risk scoring systems for risk of preterm birth were found to be in the range of 26% to 64%,[2] and those for risk of cesarean section delivery, Apgar scores, birth weight, and gestational age at birth were 34%, 25%, 27%, and 22% for each of the outcomes, respectively.[3] The sensitivity of obstetric risk assessment instruments has been found to be even lower in primiparous, black, socioeconomically disadvantaged,[4] or indigent[5] women. The limitations of risk scoring systems are attributed to relative ignorance about the multiple factors that produce poor outcomes, dependence of scoring systems on previous pregnancy outcome, and risk identification not being cause specific.[2] However, the greatest limitation is that several causes of adverse birth outcomes are currently unknown.[1] Psychosocial factors, such as high levels of prenatal stress, health-related behaviors (smoking, alcohol use),[6] and availability of prenatal care[7] have been suggested as possible mediators of the effects of sociodemographic variables on birth outcome.

Reports on prenatal stress and birth outcome can be categorized broadly into studies of prenatal maternal anxiety or studies of life event stress during pregnancy. Of the 10 studies reviewed[8-17] that examined the relationship between prenatal maternal anxiety and birth outcomes, seven[8-14] reported that higher levels of prenatal anxiety were significantly related to such adverse birth outcomes as duration of labor, use of anesthesia during delivery, and delivery complications. Of the eight studies reviewed[18-25] that examined the relationship between perinatal life event stress and birth outcomes, five[18-22] reported a significant association between life event stress and poor outcomes such as pregnancy or birth complications, preterm birth, low birth weight, and gestational age at birth. One study[26] used a composite prenatal stress variable that included anxiety, perceived stress, and life event distress and found a significant relation with lower birth weight and earlier delivery.

Although a majority of the studies reviewed indicate a small-to-moderate relationship between prenatal stress and birth outcomes, several conceptual and methodologic weaknesses limit the generalizability of these findings and make the comparison of findings across studies difficult. These weaknesses (see reviews by Lobel[27] and by Wadhwa[28]) relate to sampling issues such as small sample sizes (e.g., Gorsuch and Key,[12] Williamson et al.[21]) and attrition (e.g., Beck et al.[15]), to unsatisfactory definition, operationalization, and measurement of psychosocial and biomedical risk and birth outcome variables (e.g., McDonald,[11] Crandon,[13] Nuckolls et al.[18]), to the use of inappropriate study designs (e.g., Newton et al.,[19] Stein et al.[24]), and to inadequate control of covariates of adverse outcomes such as sociodemographic or biomedical risk factors (e.g., Davids et al.,[10] Crandon,[13] Nuckolls et al.[18]). Hence findings are tentative at best, and conclusions should be drawn conservatively.

Because of the above limitations in this body of research, the main objective of this study was to prospectively examine the relationship between prenatal psychosocial stress and infant birth outcomes after controlling for the effects of biomedical (antepartum) risk and sociodemographic factors.

Methods

Subjects. The sample was composed of 90 adult (>18 years old), English-speaking women with a singleton, intrauterine pregnancy; the women were receiving antenatal care at the faculty practice or the residents' clinic of a large, metropolitan teaching hospital affiliated with the University of California, Irvine. Of the 130 women approached for participation 102 initially consented to the study—indicating an initial consent rate of 78.4%. Of these 102 women, 12 were withdrawn because they moved to another geographic location and no longer received prenatal care at this institution ($n = 4$), because they were delivered at another hospital ($n = 3$), or because they did not attend one or more their scheduled study appointments ($n = 5$). The current sample of 90 thus consists of subjects who had been recruited into the study, had attended all study appointments, and were delivered at the study hospital.

The sample characteristics, described in Table I, indicate that the population studied included predominantly white, married, upper middle class, employed women.

Procedures. After approval was obtained from the Institutional Review Board, subjects were recruited into the study between the twenty-second and twenty-eighth week of pregnancy, and informed consent was obtained. Data were collected over two appointments, each approximately 1 hour's duration, that coincided with the subject's twenty-eighth and thirtieth week antenatal clinic appointment. Self-report data were collected by means of a two-part questionnaire. Biomedical risk and birth outcomes were obtained from the medical record after delivery.

Measures. Questionnaires were self-administered to obtain measures of prenatal psychosocial stress, sociodemographic factors, and health practices (smoking, alcohol, and substance use). The questionnaires included standardized measures used in stress research (e.g., the Schedule of Recent Life Events, the Hopkins Symptom Checklist), measures from previous research

Table I. Sample characteristics

Age (yr)	
Mean	29.7 ± 5.8
Range	18-45
Parity	
Primiparous	34.9%
Multiparous	65.1%
Education	
High school graduates	61%
College graduates	32.2%
Other	6.8%
Marital status	
Married	84.5%
Separated or divorced	9.8%
Single	5.6%
Ethnicity	
White	77.4%
Hispanic	12.9%
Black	6.5%
Asian or other	3.2%
Occupation	
Employed	62%
Not employed	38%
Annual family income	
< $20,000	19%
$20,000-$39,999	23%
$40,000-$49,999	14%
> $50,000	43%

on prenatal stress and birth outcome (e.g., the Perceived Stress Scale used by Lobel and Dunkel-Schetter[29]), and certain questions specific to the experience of pregnancy from the assessment protocol of the Comprehensive Perinatal Services Program of the State of California, Department of Health Services.

Prenatal stress. Previous stress research has defined psychosocial stress in terms of its stimulus, perceptual, and emotional response components.[29] On the basis of this framework prenatal stress was conceptualized as life event stress, strain, and pregnancy-related anxiety and assessed with five instruments measuring life event changes, daily hassles, chronic stress, strain, and pregnancy-related anxiety.

LIFE EVENT CHANGES. A 99-item version of the Schedule of Recent Life Events[30] modified and refined by Kobasa et al.[31] was used to assess disruptive changes in personal (e.g., involved in a lawsuit or court case), family (e.g., a death in the family), interpersonal (e.g., a separation or divorce from one's spouse), social (e.g., broke up with a friend), financial (e.g., took a cut in wage or salary), and work-related (e.g., unemployment) areas that are not usually everyday occurrences. Subjects were asked to indicate whether they had experienced any of the listed events separately during the first or second trimester and, if so, whether once or more than once. According to a 5-point scale ranging from "not stressful at all" to "extremely stressful," subjects were asked to make an appraisal of the severity of distress experienced for each of the events that occurred.

DAILY HASSLES. The 117-item Daily Hassles Questionnaire[32] was used to assess frequently occurring psychosocial disruptions in the content areas of work (e.g., don't like work), family (e.g., not enough time for family), social activities (e.g., unexpected company), the environment (e.g., pollution), practical considerations (e.g., misplacing or losing things), finances (e.g., someone owes me money), and health (e.g., not getting enough rest). Subjects rated the overall degree of severity of each applicable event since the beginning of their pregnancy with a 4-point scale that ranged from "did not occur" to "extremely severe."

CHRONIC STRESS. The 14-item Perceived Stress Scale[33] was used to assess the degree to which situations during the last month were appraised as stressful (i.e., the degree to which respondents found their lives unpredictable, uncontrollable, and overloading). It included items such as, "In the last month, how often have you been upset because of something that happened unexpectedly?" and "In the last month, how often have you felt confident about your ability to handle your personal problems?," which were rated on a 5-point scale ranging from "never" to "very often."

PSYCHOLOGIC AND PHYSICAL SYMPTOMS (STRAIN). The 45-item Hopkins Symptom Checklist,[34] a frequently used reliable and valid scale, was used to measure physical and psychologic symptoms (e.g., nervousness, lower back pain, a lump in the throat, feeling blue). Subjects rated the frequency of occurrence of the listed symptoms since the beginning of their pregnancy with a 4-point scale that ranged from "not at all" to "continuously." A total symptom score, and subscores for anxiety and depression were computed.

PREGNANCY-RELATED ANXIETY. Pregnancy-related anxiety was measured with a 5-item scale, extracted by factor analysis from a larger set of items designed for this study by the authors; it consisted of modified items from previous work by Lederman[35] and from a part of the psychosocial assessment protocol of the Comprehensive Perinatal Services Program of the State of California, Department of Health Services. This instrument assesses maternal fears and anxiety related to the health of the baby, toward the labor and delivery process, and confidence in the obstetrician and other health care providers (Table II). On the basis of whether the statement was generally true for them, respondents were asked to check either a "True" or a "False" response to each item. After the responses on the positively worded items were reversed, scores were summed to yield a pregnancy anxiety score for each subject.

In the current sample the reliability of the above measures of prenatal stress was moderate to high—the internal consistency coefficient ranged between 0.71 and 0.96. A comparison of mean sample scores of prenatal stress with published norms (when available)

indicated that the average level of psychologic distress (as reflected by scores of prenatal daily hassles, chronic stress, and strain) during pregnancy in the study sample was significantly higher (all p's < 0.001) than that of community-based adult, normative samples.

To include both occurrence and subjective severity of prenatal life events, "Life event stress" scores were computed by summing the product of frequency and subjective severity for each of the life events that occurred since the beginning of the pregnancy. Scores of daily hassles, chronic stress, and strain were highly intercorrelated (r's ranged between 0.68 and 0.76, p's < 0.001), and their standardized scores were summed to create a composite variable "Perceived stress." Scores of pregnancy-related anxiety were not significantly correlated with life event stress and only moderately correlated with daily hassles, chronic stress, and strain and were therefore used independently to measure "pregnancy anxiety."

Demographic information and health practices. Demographic information, including age, parity, highest level of subject's and spouse's or partner's education, ethnicity, marital status, occupation, and annual family income were obtained from the personal information questionnaire designed for this study. A set of items was used to obtain information about smoking, alcohol, and substance use since the beginning of the pregnancy. In the current sample the incidence of smoking, alcohol, and substance use was very low (<3%) and therefore not included in subsequent analyses.

Biomedical risk and birth outcome measures. Medical charts and records were used to obtain measures of prenatal care, parity, antepartum complications, infant birth outcomes (birth weight, gestational age at birth, 1- and 5-minute Apgar scores), and intrapartum complications.

Biomedical risk was determined by the presence of antepartum complications during pregnancy. These included anomaly, diabetes, eclampsia, fetal death, heart disease, herpes, hypertension, induction of labor, intrauterine growth retardation, isoimmunization, nonimmune hydrops, pregnancy-induced hypertension, preterm labor, placenta previa, and premature rupture of membranes. Because there are currently no standard criteria for the computation of degree or weight of antepartum risk, we adopted a conservative strategy and created a dichotomous high-low risk variable. A subject was judged to be at high antepartum risk for poor outcome if she experienced one or more of the above conditions during her pregnancy.

Infant birth outcomes included birth weight, gestational age at birth, and 1- and 5-minute Apgar scores. Two birth weight–related variables were computed—one, a continuous variable (infant birth weight) measured in grams and, two, a dichotomous (yes/no) variable for low birth weight (LBW) using the "<2500 gm" clinical criterion. Gestational age was determined by best obstetric estimate with a combination of last normal menstrual period and early uterine size. In most cases this was confirmed by obstetric ultrasonographic biometry before 24 weeks' gestation. Two gestational age–related variables were computed—one, a continuous variable (gestational age at birth) measured in completed weeks at delivery and, two, a dichotomous variable for preterm birth using the "<37 weeks" clinical criterion. Apgar scores at 1 and 5 minutes were continuous variables ranging from 1 to 10.

Table II. Items on pregnancy-related anxiety scale

1. I feel well informed about the labor and delivery of my baby
2. I am confident with my doctor and other health-care workers
3. I have a lot of fear regarding the health of my baby
4. I think my labor and delivery will go normally
5. This pregnancy has caused me to be financially insecure

A dichotomous index was computed for intrapartum complications to indicate whether any occurred. Possible intrapartum complications recorded included abruptio placentae, amnionitis, augmentation, fetal distress, neonatal death, postpartum hemorrhage, prolapsed cord, retained placenta, ruptured uterus, and vaginal delivery after a prior cesarian section failure.

In all bivariate analyses the Pearson product-moment correlation coefficient was computed for all continuous variables, and the Spearman ρ correlation coefficient was computed for all categoric variables. All tests of statistical significance were two-tailed. In multivariate analyses linear regressions were performed for continuous dependent variables, and logistic regressions were performed for dichotomous dependent variables.

Results

Fifty-eight, or approximately two thirds (63.7%) of the women in our sample, had a low-risk pregnancy; they did not experience any antepartum complications. The other 36.3% were classified as high risk because they experienced at least one antepartum complication. Of this group a majority (27.5%) experienced only one antepartum complication. From the maximum possible number of 15 antepartum complications the sample mean was 0.49 (SD 0.79), and the number of complications ranged from 0 to 4. The more frequently occurring complications were diabetes (12.5%), hypertension (including pregnancy-induced hypertension) (10%), and premature rupture of membranes (7.5%).

Sixty-eight women (74.7%) in our sample were deliv-

ered vaginally, whereas the remaining 23 (25.3%) delivered by cesarean section. Of the 68 vaginal deliveries 60 were normal, spontaneous vaginal deliveries, and eight were vacuum-assisted vaginal deliveries. Conduction anesthesia (epidural or spinal) was used in 59 (64.8%) deliveries—in all 23 cesarean deliveries and in 37 of the vaginal deliveries.

The mean infant birth weight in our sample was 3293.65 gm (SD 572.9) and ranged from 1580 to 4955 gm. Seven infants (7.7%) were classified as (LBW) (<2500 gm). The mean gestational age of the above infants at birth was 38.91 weeks (SD = 2.08 weeks) and ranged between 32 and 42 weeks. Twelve infants (13.2%) were delivered preterm (<37 weeks).

The mean 1-minute Apgar score was 8.07 (SD 0.94) with a range between 4 and 9, whereas the mean 5-minute Apgar score was 8.95 (SD 0.55) with a range between 5 and 10. Five infants (5.5%) had a low (<7) 1-minute Apgar score, and one infant (1.1%) had a low 5-minute Apgar score.

Forty-five subjects, or half of the sample, experienced no intrapartum complications. From a maximum possible number of 10 intrapartum complications, the sample mean was 0.68 (SD 0.78), and the number of complications ranged from 0 to 3. The more frequently occurring conditions were augmentation of labor (22.5%) and fetal distress (10%).

The intercorrelations between biomedical risk and birth outcomes were examined. Biomedical risk (antepartum complications) was significantly and negatively associated with gestational age at birth ($r = -0.42$, $p < 0.001$) and with the 5-minute Apgar score ($r = -0.22$; $p < 0.05$), indicating that women who were in the high biomedical risk category for poor birth outcomes were more likely to be delivered at an earlier gestational age and that their infants were more likely to be born with a lower 5-minute Apgar score. Correlations between infant birth weight and gestational age at birth, between the 1- and 5-minute Apgar scores, and between Apgar scores and intrapartum complications were all of expected magnitude and direction. Parity, measured both as a continuous and a dichotomous variable, was not significantly associated with any of the infant birth outcomes and was therefore not included in subsequent analyses.

Bivariate analyses were performed to examine direct associations between the three prenatal stress factors and biomedical risk and birth outcome variables, as shown in Table III. There was no significant association between any of the prenatal stress factors and biomedical risk. Life event stress was negatively associated with infant birth weight ($r = -0.21$, $p < 0.05$) and positively associated with the clinical incidence of low birth weight ($r = 0.20$, $p < 0.05$), indicating that women who reported higher levels of prenatal life event stress were more likely to be delivered of infants of lower birth weight and of infants of birth weight <2500 gm (LBW). Pregnancy anxiety was negatively associated with gestational age at birth ($r = -0.31$, $p < 0.01$) and positively associated with the clinical incidence of preterm birth ($r = 0.25$, $p < 0.05$), indicating that women who reported higher levels of prenatal pregnancy-related anxiety were more likely to be delivered of an infant of shorter gestational age and more likely to deliver a preterm infant. Perceived stress was not significantly associated with any of the birth outcomes.

On the basis of the above bivariate results multivariate analyses were performed to examine whether specific prenatal stress factors and specific birth outcomes were significantly related after controlling for the effects of biomedical risk. Two linear regression analyses were performed to examine the multivariate effects of life event stress and biomedical risk simultaneously on infant birth weight and of pregnancy anxiety and biomedical risk simultaneously on gestational age at birth, respectively. After we controlled for biomedical risk, the association between life event stress and infant birth weight was significant ($b = -55.03$, $t = 1.94$, $p < 0.05$), indicating that independent of risk, each unit increase of prenatal life event stress (from a possible sample range of 14.7 units) was associated with a 55.03 gm decrease in infant birth weight. The overall model, however, was not statistically significant ($F = 1.95$, $p = 0.14$). After biomedical risk was controlled for, the association between pregnancy anxiety and gestational age at birth was significant ($b = -0.42$, $t = -2.18$, $p < 0.05$), indicating that independent of risk, each unit increase of prenatal pregnancy anxiety (from a possible sample range of 5 units) was associated with a 0.42-week, or a 3-day, decrease in gestational age at birth. The overall model was statistically significant ($F = 10.00$, $p < 0.01$), with pregnancy anxiety and biomedical risk together accounting for 22.7% of the sample variance of gestational age at birth.

As described above, life event stress and pregnancy anxiety had significant bivariate associations with the incidence of LBW and of preterm birth, respectively. Two logistic regression analyses were performed to examine the multivariate effects of life event stress and biomedical risk simultaneously on LBW and of pregnancy anxiety and biomedical risk simultaneously on preterm birth, respectively. After controlling for the effects of biomedical risk, life event stress was significantly associated with LBW (χ^2 3.7, degrees of freedom 1, $p < 0.05$, exp(B) 1.32). This indicates that when biomedical risk was controlled for, each unit increase in prenatal life event stress (from a possible sample range of 14.7 units) was associated with a 1.32 times increase (odds ratio) in the likelihood of occurrence of an LBW infant. The overall model was also statistically signifi-

Table III. Intercorrelations among prenatal stress factors and biomedical risk and infant birth outcomes

	Life event stress	*Perceived stress*	*Pregnancy anxiety*
Antepartum risk	− 0.03	− 0.21	0.21
Infant birth weight	− 0.21*	0.02	− 0.04
LBW	0.20*	− 0.04	0.08
Gestational age at birth	− 0.07	0.02	− 0.31†
Preterm birth	0.08	− 0.01	0.25*
Apgar score at 1 min	− 0.10	− 0.13	0.00
Apgar score at 5 min	− 0.01	0.19	0.09
Intrapartum complications	0.07	0.10	0.10

Minimum pairwise $N = 90$.
*Two-tailed, $p < 0.05$.
†Two-tailed, $p < 0.01$.

cant (χ^2 8.08, degrees of freedom 2, $p < 0.01$). The second logistic regression indicated that although the overall model was significant (χ^2 11.53, degrees of freedom 2, $p < 0.01$) pregnancy anxiety was not significantly associated with the incidence of preterm birth (χ^2 5.2, degrees of freedom 1, $p = 0.11$, exp(B) 0.54) after we controlled for biomedical risk.

Comment

In the current sample the direction and magnitude of the associations between various birth outcomes conformed to expected norms, indicating reliable measurement of birth outcomes. As expected, biomedical risk was significantly related to the incidence of adverse birth outcomes (e.g., biomedical risk accounted for approximately 20% of the sample variance of preterm birth). The magnitude of this relationship is comparable to that predicted by commonly used obstetric risk-assessment instruments.[2]

A comparison of mean sample scores of prenatal stress with published norms (when available) indicated that the average level of psychosocial stress during pregnancy in the study sample was significantly higher than that of community-based adult, normative samples, suggesting that pregnancy was a stressful event in this sample. Because instruments used to measure prenatal psychosocial factors vary widely across studies, meaningful comparisons of levels of prenatal stress with those of other samples of pregnant women was not possible. On the basis of the earlier work of Lobel and Dunkel-Schetter[9] composite factors were computed for life event stress and perceived stress. These composite prenatal stress factors offered two advantages over the individual measures. First, they enhanced the measurement of prenatal stress conceptually and empirically by combining the common variance of related individual measures. Second, the independence of the three factors eliminated the risk of violating statistic assumptions related to multicollinearity in multivariate analyses. For these reasons the measurement of prenatal stress factors in this report was conceptually and operationally more thorough than that in most previous studies of psychosocial factors and birth outcome. Major infant birth outcomes, which included infant birth weight and gestational age at birth, were examined separately and not combined into a single, nonclinical "birth complications" index.

A significant, direct relationship was found between life event stress and infant birth weight. In this sample women who reported a higher level of prenatal life event stress were more likely to deliver infants of lower birth weight. This finding is consistent with recent studies.[20-22] Williamson et al.[21] found that LBW was associated with an increase in life change scores from the second to the third trimester but not with second or third trimester levels of life stress, whereas Pagel et al.[20] and Mutale et al.[22] found associations with the level, or amount, of life event stress over the duration of pregnancy. Lobel[27] also found a relationship between lower birth weight and prenatal stress. However, that author's latent measure of prenatal stress included only one component of life event stress—life event severity—and was weighted more toward perceived stress and anxiety.

Pregnancy anxiety also had a significant, direct relationship with gestational age at birth. Most previous studies of prenatal anxiety[13-15] used a measure of general anxiety (as opposed to pregnancy-specific anxiety) and found associations with labor and delivery parameters and with intrapartum complications but not with gestational age at birth. The current study demonstrated that when specific fear and anxiety related to the labor and delivery process and to the health of the baby was assessed, it predicted gestational age at birth.

Sociodemographic factors such as maternal age, parity, ethnicity, and socioeconomic status, availability of prenatal care, and health practices such as smoking, alcohol, and substance use are known covariates of LBW and preterm birth. The present sample was homogenous on these parameters. They were older, white, educated, upper-middle class, multiparous women, receiving the same quality of prenatal care, and reported

a low incidence of smoking, alcohol, and substance use.

Independent of biomedical risk, life event stress and pregnancy anxiety significantly predicted infant birth weight and gestational age at birth, respectively. Each unit increase of prenatal life event stress (from a possible sample range of 14.7 units) was associated with a 55.03 gm decrease in infant birth weight and with a 1.32 times increase in the likelihood of occurrence of LBW (< 2500 gm). Each unit increase of prenatal pregnancy anxiety (from a possible sample range of 5 units) was associated with a 3-day decrease in gestational age at birth. The magnitude of association between prenatal stress and birth weight and gestational age at birth in this sample may be a conservative estimate of the effect-size in the general population. Because this sample was relatively affluent, levels of prenatal stress were likely to have been lower than those in socioeconomically disadvantaged samples.

The results of this study add to the growing body of literature that suggests that prenatal stress influences infant birth outcome and that this influence is independent of biomedical risk and sociodemographic factors. The absence of human research that assesses prenatal psychosocial factors and concurrently evaluates possible physiologic mechanisms by which these factors may influence various birth outcomes is perhaps the most major limitation of this entire body of work. An emerging literature and our preliminary data[28] support a biopsychosocial model of maternal neuroendocrine responses to stress influencing fetal physiologic characteristics and birth outcomes. Physiologic responses to psychosocial stress have been well documented,[36-39] and there are conceivably a number of ways by which this stress-related disregulation of the autonomic nervous system and of the hypothalamic-pituitary-adrenal axis during pregnancy could contribute to poor birth outcomes. For instance, elevated levels of pituitary hormones such as oxytocin and prostaglandins may result in premature uterine contractions and contribute to the initiation of premature labor.[40] Vasoconstriction may reduce uteroplacental perfusion and exchange and contribute to intrauterine growth retardation.[41] Opiate or β-endorphin elevations in maternal plasma, and placental opiate release in response to hypothalamic-pituitary-adrenal activation, could cause disregulation of the immature and still-developing fetal nervous system and thus have neurodevelopmental consequences.[42, 43] Finally, the immunosuppressive effects of hypothalamic-pituitary-adrenal axis activation may leave a woman more susceptible to infection,[44] which in turn is a risk factor for preterm labor.[45]

A study in progress, the University of California, Irvine Perinatal Outcomes Project, is designed to investigate the role of stress-related, maternal neuroendocrine hypothalamic, pituitary, adrenal, and placental responses on fetal growth and development; uteroplacental circulation; fetal cardiovascular reactivity; fetal habituation; and maternal and infant birth outcomes. The success of intervention programs to reduce the high rates of infant mortality and morbidity in this country depend on a more comprehensive understanding of the role of and mechanisms by which medical, psychologic, and social factors cause adverse birth outcomes; the findings of the current study may support strategies for prevention and intervention efforts.

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