Pregnancy-Specific Stress, Prenatal Health Behaviors, and Birth Outcomes

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Objective: Stress in pregnancy predicts earlier birth and lower birth weight. The authors investigated whether pregnancy-specific stress contributes uniquely to birth outcomes compared with general stress, and whether prenatal health behaviors explain this association. Design: Three structured prenatal interviews (N = 279) assessing state anxiety, perceived stress, life events, pregnancy-specific stress, and health behaviors. Main Outcome Measures: Gestational age at delivery, birth weight, preterm delivery (<37 weeks), and low birth weight (<2,500 g). Results: A latent pregnancy-specific stress factor predicted birth outcomes better than latent factors representing state anxiety, perceived stress, or life event stress, and than a latent factor constructed from all stress measures. Controlling for obstetric risk, pregnancy-specific stress was associated with smoking, caffeine consumption, and unhealthy eating, and inversely associated with healthy eating, vitamin use, exercise, and gestational age at delivery. Cigarette smoking predicted lower birth weight. Clinically-defined birth outcomes were predicted by cigarette smoking and pregnancy-specific stress. Conclusion: Pregnancy-specific stress contributed directly to preterm delivery and indirectly to low birth weight through its association with smoking. Pregnancy-specific stress may be a more powerful contributor to birth outcomes than general stress.

Keywords: pregnancy, stress, birth weight, prematurity, health behaviors

Research over the last two decades establishes that women who experience high stress during pregnancy deliver infants earlier, and deliver infants who weigh less at birth (Copper et al., 1996; Davis et al., 2005; Dole et al., 2003; Hedegaard, Henriksen, Secher, Hatch, & Sabroe, 1996; Hoffman & Hatch, 1996; Lobel, Dunkel-Schetter, & Scrimshaw, 1992; Lobel, 1994; Wadhwa, Sandman, Porto, Dunkel-Schetter, & Garite, 1993). Preterm delivery (<37 weeks) and low birth weight (<2,500g) are leading causes of infant mortality, infant morbidity, and health problems that may persist into childhood, adolescence and adulthood (Barker, 2007; Grodenberg et al., 1996; Hack & Merkatz, 1995; Mathews & MacDorman, 2006; Newnham, 1998; O’Connor, Heron, & Glover, 2002).

Prenatal maternal stress (PNMS) has been operationalized in a variety of ways (Lobel, 1994). Much of the research has assessed stress that is general or nonspecific to pregnancy. For example, two longstanding approaches involve the assessment of emotions during pregnancy, especially anxiety, and assessment of stressful prenatal stimuli or conditions, especially major life events (Lobel & Dunkel-Schetter, 1990). These approaches to PNMS have methodological and conceptual shortcomings that may help explain why such assessments have yielded inconsistent associations with birth outcomes across studies (Dunkel-Schetter, 1998; Hogue, Hoffman, & Hatch, 2001; Lobel, 1994; Stanton, Lobel, Sears, & DeLuca, 2002). For example, focusing on state anxiety alone or counting the number of life events that occur during pregnancy does not reveal what women are anxious about or whether they experience life events as stressful. In other words, these approaches fail to consider women’s perceptions or appraisals of their experiences (Lobel, 1994). Several research teams (e.g., Molfese et al., 1987; Norbeck & Tilden, 1983) have operationally defined PNMS as the aggregate of negative emotional state and stressful events or conditions during pregnancy, and in some cases have also included pregnant women’s perceptions or appraisals of their circumstances (e.g., Lobel et al., 1992; Rini, Dunkel-Schetter, Wadhwa, & Sandman, 1999). Such multivariable operationalizations have shown more consistent associations with birth outcomes (Lobel, 1994; Roesch, Dunkel-Schetter, Woo, & Hobel, 2004).

A more recent approach to prenatal stress measurement focuses on pregnancy-specific stress. Pregnant women experience stress originating from a variety of pregnancy-specific issues, including physical symptoms, parenting concerns, relationship strains, bodily changes, anxiety about labor and delivery, and concerns about the baby’s health (Affonso, Liu-Chiang, & Mayberry, 1999;

An important issue that arises from this work concerns the independent ability of pregnancy-specific stress to predict birth outcomes relative to general stress. Some investigators have suggested that pregnancy-specific stress may be a more powerful contributor to birth outcomes than stress from sources unrelated to pregnancy (DiPietro et al., 2002, 2004; Huizink et al., 2004; Roech et al., 2004). Roech et al. found that pregnancy anxiety predicted younger gestational age at birth, whereas its correlate, general anxiety, did not (general perceived stress and life events also did not predict gestational age in this study). Similarly, examining fetal behavior rather than birth outcomes, DiPietro et al. (2002) found that their measure of pregnancy-specific hassles and uplifts was a better predictor than general stressors. However, neither DiPietro et al. nor Roech et al. compared the predictive validity of their pregnancy-specific measure to a multivariable aggregate of general, nonspecific PNMS such as those that have shown excellent success in predicting birth outcomes in prior research (Lobel et al., 1992; Rini et al., 1999).

An important reason to investigate the predictive validity of pregnancy-specific stress vis-à-vis more elaborate measures of PNMS is to evaluate whether it is a more powerful contributor to birth outcomes than general stress. A second reason involves practical utility. While they may offer conceptual and psychometric strength, multivariable operationalizations of PNMS are probably unwieldy for use in clinical settings, where a brief and simpler means of measuring stress may be needed. Thus, evaluating the ability of a brief assessment of pregnancy-specific stress to predict birth outcomes also has important clinical relevance.

We used a measure of pregnancy-specific stress adapted from our prior research on PNMS (Lobel et al., 2000; Yali & Lobel, 1999) and examined its ability to predict birth outcomes compared to a multivariable operational definition of PNMS that included pregnancy-specific stress and general stress measures that have been investigated in prior studies, including state anxiety, perceived stress, and life events. Additionally, we compared the predictive power of the pregnancy-specific stress measure to each of the individual general stress measures that comprised the multivariable operational definition (state anxiety, perceived stress, and life events). These comparisons offered a direct test of the independent contribution of pregnancy-specific stress, and an opportunity to determine whether it is a stronger contributor to birth outcome than general stress.

Behavioral Mechanisms

An additional goal was to examine prenatal health behaviors that may help explain the impact of PNMS on birth outcomes. Identifying behavioral mechanisms can help guide interventions against the effects of PNMS. Highly stressed people engage in unhealthful behaviors (Ng & Jeffery, 2003; Stetson, Rahn, Dubbert, Wilner, & Mercury, 1997) that are likely to contribute to poor birth outcomes (Dunkel-Schetter, Gurung, Lobel, & Wadhwa, 2001). Stress has been shown to be related to poor nutrition, inadequate physical activity, cigarette smoking, and alcohol and other substance use in pregnant women (Barnet, Duggan, Wilson, & Joffe, 1995; Borrelli, Bock, King, Pinto, & Marcus, 1996; Bresnahan, Zuckerman, & Cabral, 1992; Chomitz, Cheung, & Lieberman, 1995; Hutchins & DiPietro, 1997; McCormick et al., 1990; Pritchard, 1994; Rodriguez, Bohlin, & Lindmark, 2000; Zuckerman, Amaro, Bauchner, & Cabral, 1989). These studies provide a basis for proposing that health behaviors during pregnancy help account for the impact of PNMS on birth outcomes.

Method

Overview

All aspects of the research were approved by an Institutional Review Board. The study was conducted at a public, university-affiliated prenatal care facility in a suburban area of the Northeastern United States. PNMS and health behaviors were assessed at three prenatal time points through structured interviews conducted by trained research assistants with volunteer participants. Medical records were abstracted after birth by obstetric research nurses. Structural equation modeling (SEM) was used for data analyses.

Participants

Participants were required to speak English fluently, to be less than 20 weeks pregnant at recruitment, and to be a minimum of 18 years old. The gestational age requirement was later relaxed to 25 weeks to meet recruitment goals. Approximately 73% of eligible women approached consented to participate, and 57% of these (339 women) completed study measures. Others did not complete the study for reasons including miscarriage, referral to other health care providers, and relocation. No differences were found between study completers and noncompleters, with two exceptions. Non-completers were 47% non-White and 22% had household incomes under $10,000, compared with 34% and 13% of study completers (p’s < .05). Of the 339 study completers, 7 participants with multiple pregnancies and 27 who had substantial missing data (i.e., entire measures missing) were deleted from the sample. A negligible amount of data was missing for other participants (0.1% of all study items); these were replaced using a linear interpolation replacement technique in SPSS, which is superior to other missing data replacement techniques (McKnight, McKnight, Sidani, & Figueredo, 2007).

After replacement, we followed systematic procedures to evaluate multivariate normality (Breckler, 1990; Byrne, 2001). Although sometimes overlooked, multivariate non-normality has important consequences for SEM results, resulting in inflated chi square values, underestimated fit indices, and spuriously low stan-
standard errors that can produce apparently significant regression coefficients that may not be true of the population (Breckler, 1990; Byrne, 2001). Mardia’s coefficient was greater than 1.96, indicating non-normality. We therefore ran the first model and examined Mahalanobis distance (to assess robustness of the departure from normality) and its two associated p values. Since both p values were statistically significant (< .05), we removed the participant farthest from the centroid. The model was rerun, and Mahalanobis distance was re-examined. We continued to remove one participant at a time until at least one of the two p values associated with Mahalanobis distance was no longer statistically significant, as recommended (Arbuckle, 2003). Using this iterative procedure, 26 multivariate outliers were deleted, resulting in a total sample size of 279 women.

Participant characteristics are presented in Table 1. The sample was heterogeneous with respect to sociodemographic variables and parity. The rate of low birth weight and preterm delivery was lower than population norms, but this is a likely result of the sample’s restriction to adults with singleton pregnancies initiating prenatal care in the first half (approximately) of pregnancy. Each of these characteristics is associated with lower prevalence of adverse birth outcomes. A number of maternal characteristics were correlated. For example, older women had more prior pregnancies and births, greater education and income, and were more likely to be married or partnered (all p’s < .05).

Because of the small number of women in each ethnic group, we combined all participants who identified themselves in any of the non-White categories and investigated whether they differed from self-identified White women on all study variables. There were no ethnic differences in any of the stress variables at the three time points, in medical risk or other maternal characteristics such as age, income, or education, nor in the birth outcome variables. There were some differences in health behaviors: White women smoked, consumed caffeine, experienced physical strain, and ate unhealthy more often than non-White women (all p’s < .05). Although prior studies have often reported ethnic differences in birth outcomes, these tend to be confounded with socioeconomic status, which was not the case in the present study.

### Procedures

The first interview was conducted between 10 and 20 weeks of pregnancy (later extended to 25 weeks after relaxation of the eligibility requirement described earlier), $M = 16.6$ ($SD = 4.4$) weeks. The second interview was conducted between 21 and 30 weeks (later, extended to 35 weeks), $M = 26.1$ ($SD = 3.8$) weeks, and the third interview was conducted after 30 weeks, $M = 34.1$ ($SD = 2.4$) weeks. A minimum of 2 weeks was maintained between participant interviews, and in no case did a participant complete a second or third interview prior to completing the preceding one(s).

### Assessment of PNMS and Prenatal Health Behaviors

PNMS was assessed with multiple measures: pregnancy-specific stress, stressful life events, state anxiety, and perceived stress. Each measure has been used previously and possesses good psychometric properties, including test–retest reliability and convergent and predictive validity (Hamilton & Lobel, 2008; Lobel & Dunkel-Schetter, 1990; Lobel et al., 1992; 2000; Yali & Lobel, 2002). Life events since conception were assessed in the third interview; events occurring between the third interview and birth were assessed in a telephone interview 1 month after birth. The remaining assessments were administered in all three prenatal interviews. Each measure is described below.

A revised version of the Prenatal Distress Questionnaire (PDQ; Yali & Lobel, 1999) assesses stress originating from issues common in pregnancy (see Appendix). The revised PDQ includes 9 items administered at each interview, plus unique items added to the second and third interviews to assess issues that become more relevant as pregnancy progresses (e.g., concerns about caring for a newborn). Respondents indicate the extent to which they are feeling “bothered, upset, or worried at this point” about issues including medical care, physical symptoms, parenting, bodily changes, and the infant’s health. Responses are on a 3-point scale ranging from 0 (not at all) to 2 (very much). Average pregnancy-specific distress scores were calculated for each time point. As indicated by Cronbach’s alphas (see Table 2), items comprising the revised PDQ were modestly intercorrelated at each time point, reflecting the expected independence of some of the items.

1 To ensure that study results would not have been substantially different if departures from multivariate normality were ignored, we reran some of the main models, retaining the outliers. The pattern of findings was essentially the same, although as expected, there were some differences in the value of fit statistics.

### Table 1

**Characteristics of Study Participants (N = 279)**

<table>
<thead>
<tr>
<th>Frequency</th>
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<tbody>
<tr>
<td>Birthweight</td>
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<tr>
<td>&lt;2500g</td>
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</tr>
<tr>
<td>2500+g</td>
<td>268</td>
</tr>
<tr>
<td>Weeks gestation at birth</td>
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</tr>
<tr>
<td>Preterm (&lt;37 weeks)</td>
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</tr>
<tr>
<td>Full-term (37+ weeks)</td>
<td>258</td>
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<tr>
<td>Age</td>
<td></td>
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<tr>
<td>$M = 27.0; SD = 5.9$</td>
<td></td>
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<tr>
<td>Ethnicity</td>
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<tr>
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<tr>
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<tr>
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<td>102</td>
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<tr>
<td>Graduate degree</td>
<td>3</td>
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suggests that the measure differentiates concerns about specific aspects of pregnancy.

The Prenatal Life Events Scale (PLES) was adapted from prior versions (Lobel et al., 1992, 2000). Respondents report which of 28 events they experienced during pregnancy (e.g., being robbed, being involved in a serious accident, having someone close die). For each event endorsed, respondents report how undesirable or negative the event was on a scale from 0 (very much) to 3 (very much). Two indices were computed: number of life events and mean life event distress.

The 10-item State Anxiety subscale of the State-Trait Personality Inventory (STPI; Spielberger, 1995) assesses how anxious respondents feel currently. Participants rated the applicability of items such as “I feel nervous,” and “I feel calm” (reverse scored) on a 4-point scale from 0 (not at all) to 3 (very much). The STPI is highly correlated with its 20-item parent measure, the State-Trait Anxiety Inventory, and possesses equivalently strong psychometric properties. A 4-item version of the Perceived Stress Scale (Cohen & Williamson, 1988) assessed appraisals of nonspecific stress. Each item is rated on a 5-point scale from 0 (never) to 4 (very often).

Self-reported health behaviors over the prior two weeks were assessed using the Prenatal Health Behaviors Scale (DeLuca & Lobel, 1995). This measure examines a range of healthful and unhealthful behaviors including nutrition, exercise, smoking, and substance abuse. Responses are provided on a 5-point scale from 0 (never) to 4 (very often). Seven subscales were identified through factor analyses of the measure: cigarette smoking (1 item), caffeine consumption (1 item), healthy eating (3 items—calcium, high-fiber foods, & fruits and vegetables), prenatal vitamin use (1 item), and fiber foods, high-factor analyses of the measure: cigarette smoking (1 item), caffeine consumption (1 item), healthy eating (3 items—calcium, high-fiber foods, & fruits and vegetables), prenatal vitamin use (1 item), and

<table>
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<tbody>
<tr>
<td>1. Pregnancy-specific stress T1</td>
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</table>
| 2. Pregnancy-specific stress T2 | | | | | | | | | | | | .65**
| 3. Pregnancy-specific stress T3 | | | | | | | | | | | | .64** .72**
| 4. Perceived stress T1 | | | | | | | | | | | | .51** .50* .47**
| 5. Perceived stress T2 | | | | | | | | | | | | .34** .52** .44** .58**
| 6. Perceived stress T3 | | | | | | | | | | | | .40** .50** .45** .59** .68**
| 7. State anxiety T1 | | | | | | | | | | | | .47** .45** .43** .52** .38** .41**
| 8. State anxiety T2 | | | | | | | | | | | | .42** .57** .51** .47** .49** .50** .53**
| 9. State anxiety T3 | | | | | | | | | | | | .41** .48** .52** .38** .42** .57** .49** .56**
| 10. Prenatal life events | | | | | | | | | | | | .33** .36** .44** .37** .36** .31** .25** .26** .26**
| 11. Life event distress | | | | | | | | | | | | .24** .24** .30** .23** .28** .27** .22** .17** .26** .33**
| 12. Obstetric risk | | | | | | | | | | | | .07 .09 .03 .03 -.05 .03 .12 .08 .07 .09 .13**
| 13. Cigarettes | | | | | | | | | | | | .20** .20** .15* .20** .11 .19* .12* .11 .12* .07 .08 .08
| 14. Caffeine | | | | | | | | | | | | .18** .13* .11 .13* .08 .16** .06 .06 .13* .06 .06 .02
| 15. Unhealthy eating | | | | | | | | | | | | .27** .25* .21* .24** .22** .19** .23** .22** .21** .11 .07 .08
| 16. Physical strain | | | | | | | | | | | | .07 .08 .11 .13* .14* .23** .08 .06 .10 .12* .12 - .04
| 17. Healthy eating | | | | | | | | | | | | .13* -.12* -.07 -.25** -.26** -.25** -.26** -.26** -.20** -.23** -.01 -.09 .09
| 18. Vitamins | | | | | | | | | | | | .15 -.16* -.15* -.22** -.10 -.14* -.11 -.21** -.20* -.06 -.05 -.06
| 19. Exercise | | | | | | | | | | | | .13* -.14* -.09 -.20* -.15* -.11 -.21** -.17** -.19* .01 -.10 -.09
| 20. Gestational age (weeks) | | | | | | | | | | | | .15* -.20* -.16** -.05 -.02 -.05 -.13* -.09 -.14* -.03 -.12 -.27**
| 21. Birth weight (grams) | | | | | | | | | | | | -.07 -.10 -.12* .01 -.01 -.09 -.08 -.07 -.12* -.03 .02 -.17**
| 22. >37 weeks (0 = No; 1 = Yes) | | | | | | | | | | | | -.17** -.14* -.14* -.07 -.03 -.13* -.10 -.12* -.13* -.10 -.06 -.10
| 23. >2,500 grams (0 = No; 1 = Yes) | | | | | | | | | | | | -.05 -.01 -.03 .10 .09 -.01 -.01 -.06 -.04 -.01 -.02 -.13**

Mean* | | | | | | | | | | | | .72 .59 .55 .63 .38 5.39 9.57 7.57 7.65 5.09 2.78 2.08
| SD | | | | | | | | | | | | .35 .32 .30 3.30 3.06 3.13 6.65 5.93 5.72 3.37 3.93 1.50
| Alpha | | | | | | | | | | | | .59 .71 .79 .78 .79 .82 .88 .89 .87 .88 .71 .51

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<th>Variable name</th>
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</table>
| 13. Cigarettes | | | | | | | | | | | | .36**
| 14. Caffeine | | | | | | | | | | | | .06 .23**
| 15. Unhealthy eating | | | | | | | | | | | | .14* .20** .17**
| 16. Physical strain | | | | | | | | | | | | -.19** -.14* -.15* -.13*
| 17. Healthy eating | | | | | | | | | | | | -.02 -.13* -.16** -.17** -.31**
| 18. Vitamins | | | | | | | | | | | | -.08 -.04 -.17** .15* .33* .03
| 19. Exercise | | | | | | | | | | | | -.12* -.01 .08 .06 -.04 .02 .09
| 20. Gestational age (weeks) | | | | | | | | | | | | -.21** -.06 -.01 .03 .01 -.03 .03 .57**
| 21. Birth weight (grams) | | | | | | | | | | | | -.13* -.02 -.03 .04 -.07 -.08 .01 .47** .32**
| 22. >37 weeks (0 = No; 1 = Yes) | | | | | | | | | | | | -.15* -.02 .12* .06 -.08 -.11 .01 .33** .38** .57**
| 23. >2,500 grams (0 = No; 1 = Yes) | | | | | | | | | | | | .80 1.73 1.69 1.69 2.90 3.38 1.26 38.90 3,357 1.92 1.96

Mean* | | | | | | | | | | | | .12 1.03 .63 .74 .63 .99 .91 1.60 501 .26 .19
| Alpha | | | | | | | | | | | | .61 .73 .71 .77

*Means for pregnancy-specific stress and health behavior variables are item means; means for other stress variables and obstetric risk are scale means. * p < .05, ** p < .01.
exercise (2 items—stretching or calisthenics & exercise), physical strain (3 items—lifting heavy objects, overstretching, & standing for long periods), and unhealthy eating (3 items—snack foods, fatty or oily foods, & overeating). Prior studies using this measure (DeLuca & Lobel, 1995; Lobel et al., 2000) have found predicted associations with outcomes. Although it is likely that social desirability concerns affect pregnant women’s reports of their health behaviors, recent research finds that self-report measurement of cigarette smoking during pregnancy is reliable and accurate, and highly correlated with serum cotinine levels (McDonald, Perkins, & Walker, 2005; Okah, Cai, Dew, & Hoff, 2005). Similarly, physical activity recall measures show strong correlations with objective measures of activity in pregnant women (Lindseth & Vari, 2005; Timperio, Salmon, & Crawford, 2003) and there is some evidence that pregnant women reliably report their eating behaviors (Verbeke & De Bourdeaudhuij, 2007).

Assessment of Obstetric Risk and Birth Outcomes

Obstetric risk was statistically controlled because it is a predictor of birth outcomes, typically associated with health behaviors, and sometimes with PNMS (Lobel, 1994). A 36-item index adapted from the Problem Oriented Perinatal Risk Assessment System (Hobel, 1979) and shown to have excellent predictive validity in prior studies (Lobel et al., 2000; Wadhwa et al., 1993) was used to assign risk scores. It assesses six categories: unusual conditions of pregnancy, gynecological and obstetric history, complications of past pregnancies, family history, medical history, and current pregnancy complaints. Items are dichotomously coded (present/absent), then summed.

The primary birth outcome variables were continuously coded: gestational age at delivery (weeks) and birth weight (g). Because rates of clinically defined adverse birth outcomes (age <37 weeks and weight <2,500 g) have low incidence, large samples are often needed to assess the impact of predictors on these. Also, although dichotomous variables may have more immediate clinical interpretability, associations with childhood and adult outcomes exist even across the normal range of birth weight and gestational age (Breslau, Chilcoat, DelDotto, Andreski, & Brown, 1996; Matte, Bresnaahan, Begg, & Susser, 2001; Raikkonen et al., 2007; Richards, Hardy, Kuh, & Wadsworth, 2001; Sorensen et al., 1997). Thus, we focused on continuous birth outcomes in this study, but also examined the impact of PNMS on dichotomous birth outcomes: preterm delivery (yes/no) and low birth weight (yes/no).

Statistical Analysis

AMOS 5.0 software for SEM (Arbuckle, 2003; Byrne, 2001) was used to construct a single latent variable from the four measures of PNMS, to compare the ability of pregnancy-specific stress to predict gestational age and birth weight relative to the composite latent variable and to the individual measures of general stress, and to examine whether health behaviors explain an association between PNMS and birth outcomes. Any maternal characteristic significantly correlated with birth outcomes was to be included in models predicting birth outcomes. SEM is ideal for use in this study because of its ability to accommodate multiple, correlated outcomes (i.e., gestational age and birth weight) and its facility with latent variables. Results are comparable to analyzing several regression equations simultaneously (Byrne, 2001).

Results

Sample Description

Correlation coefficients, means, standard deviations, and internal consistency coefficients appear in Table 2. As compared with prior samples of pregnant women studied by our research team, participants in the present study had similar scores on the measures of perceived stress and life event distress, slightly higher state anxiety scores, and reported more prenatal life events (Lobel et al., 1992; 2000). Perceived stress and state anxiety scores in this and our previous studies of pregnant women are higher than population norms reported for nonpregnant women (Cohen & Williamson, 1988; Spielberger, 1983, 1995). With respect to pregnancy-specific stress, average item responses correspond to a rating between “not at all” and “somewhat.” Approximately 22% of women reported smoking “sometimes,” “fairly often,” or “very often.” On average, they reported exercising “almost never,” and “sometimes” consuming caffeine, eating unhealthily, and experiencing physical strain. Participants reported eating healthy meals “fairly often” and taking prenatal vitamins between “fairly” and “very” often. Finally, 60% of the sample had two or more obstetric risk factors. The low internal consistency of the obstetric risk measure confirms that items comprising this index are substantially independent and that scores are not artifactually elevated.

No maternal characteristic other than obstetric risk was associated with birth outcomes, so only this variable was added to the structural equation models. As expected, all of the stress variables were significantly intercorrelated, underscoring the appropriateness of modeling these as a latent factor. There were also significant intercorrelations among some of the health behaviors, such as between vitamin use and healthy eating. Finally, as expected, the two birth outcomes were highly intercorrelated, corroborating that gestational age should be modeled as a predictor of birth weight.

Model Testing: PNMS, Gestational Age, and Birth Weight

The first model confirmed that the four measures of PNMS (pregnancy-specific stress, perceived stress, state anxiety, and life events) could be represented by a single, higher-order latent factor, replicating prior studies establishing the coherence of a PNMS factor based on these components. The component factors repre-

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2 A variety of fit indices were examined. A nonsignificant chi-square indicates no difference between model and data, but because this fit index is sensitive to sample size and to violation of normality assumptions (the value in both cases tends to be large), we also used the Comparative Fit Index (CFI), with scores closer to 1.0 indicating good fit, and the Root Mean Square Error of Approximation (RMSEA), for which values of less than .05 are desired. Lagrange Multiplier test values were also calculated; only conceptually consistent model improvements with a value above 4.0 were considered (Byrne, 2001). For model comparison, the Akaike Information Criterion (AIC; Akaike, 1987) and the Bayesian Information Criterion (BIC; Raftery, 1993; Schwarz, 1978) were used; smaller values indicate better fit. These indices are affected by the number of parameters in models and therefore are only appropriate when comparing models with equivalent degree of complexity.
senting pregnancy-specific stress, perceived stress, and state anxiety were comprised of the average scores on these measures at the three prenatal time points; the life events latent factor consisted of number of events and average life event distress. All path coefficients were statistically significant (p’s < .05). This model of the higher-order latent PNMS factor exhibited good fit, $\chi^2 = 70.83$, $df = 38, p = .001$; CFI = .98; RMSEA = .06 (.03–.08). Based on Lagrange Multiplier test values, we allowed correlations between the residuals of perceived stress and state anxiety measured at the first time point and at the third time point.

A model examining the impact of this latent PNMS factor on birth outcomes was then examined. Results indicated that the path from the latent stress factor to gestational age ($B = -.13, p = .04$) was significant, but the latent factor did not predict birth weight (see Figure 1). Obstetric risk was also a predictor of gestational age, which in turn predicted birth weight. The model explained 7.2% of variance in gestational age and 31% of variance in birth weight.

To examine whether pregnancy-specific stress was an independent predictor of gestational age, we removed it from the latent PNMS factor and examined its effects separately, retaining its correlation with the PNMS latent factor (now comprised of the remaining three general stress variables). The resulting model confirmed that pregnancy-specific stress is a significant, independent predictor of gestational age ($B = -.16, p = .008$). With pregnancy-specific stress predicting gestational age, the latent PNMS factor no longer predicted gestational age, so we removed this path from the model. The model (see Figure 2) explained 8% of variance in weeks gestation and 31.6% of variance in birth weight. A nonsignificant $\chi^2$ difference test comparing the models with and without a path from the latent PNMS factor to gestational age indicated that the model was not improved by retaining the path, $\chi^2_{\text{diff}} = 2.50, df = 1, p > .05$. Furthermore, imposing an equality constraint on the two path coefficients representing associations with gestational age from pregnancy-specific stress and from latent PNMS produced a significant $\chi^2$ difference test, indicating significant departure from a model with these coefficients unconstrained, $\chi^2_{\text{diff}} = 4.69, df = 1, p < .05$, and signifying that these coefficients are not of equal magnitude. These tests confirm the validity of removing the path from the latent PNMS factor to gestational age.

We used the same method of model-testing for each of the remaining components of the PNMS latent factor: removing the component from the latent factor, allowing it to correlate with the latent factor (composed of the three remaining stress variables), and examining whether the component itself predicted birth outcomes. Each of these models was a good fit, but they indicated that perceived stress and life events were neither significant predictors of gestational age nor birth weight. However, state anxiety did predict gestational age ($B = -.13, p = .04$) when it was separated from (but still correlated with) the latent PNMS factor. This model explained 7.2% of the variance in weeks gestation and 31.6% of variance in birth weight. We conducted a $\chi^2$ difference test comparing this model with and without adding a path from the latent PNMS factor to gestational age. Results indicated that the model was not improved by including the path from latent PNMS. Imposing an equality constraint on the two path coefficients representing associations with gestational age from state anxiety and from latent PNMS produced a nonsignificant $\chi^2$ difference test, indicating that the coefficients for these paths are not significantly different. These tests suggest that the path from state anxiety to gestational age is not a vital component of the model.

Figure 1. Structural equation model examining the impact of the latent PNMS factor and obstetric risk on birth weight and gestational age at delivery, $\chi^2 = 116.81$, $df = 71, p = .001$; CFI = .97; RMSEA = .05 (.03–.06). All path coefficients displayed are statistically significant (p < .05). For simplicity, error values and correlations among some of the measured stress indicators are not shown.
AIC and BIC\(^2\) were calculated to compare the above models examining pregnancy-specific stress and state anxiety as unique predictors of birth outcome. AIC and BIC were 182.03 and 305.49, respectively, for the model examining pregnancy-specific stress, and 184.81 and 308.27, respectively, for the model examining state anxiety, suggesting that the former is a slightly better-fitting model.

Finally, we examined two pared-down models to examine the independent predictive validity of state anxiety and pregnancy-specific stress without other stress variables in the model. In the first, the state anxiety latent factor was modeled as a predictor of birth outcomes, without pregnancy-specific stress, perceived stress, or life events in the model. This model fit well, \(\chi^2 = 9.84, df = 9, p = .36; \text{CFI} = 1.0; \text{RMSEA} = .02 \) \((.00-.07)\). However, state anxiety only marginally predicted weeks gestation, \(B = -.12, p = .06\). The second model, examining pregnancy-specific stress and birth outcomes without state anxiety, perceived stress, or life events (see Figure 3), also fit well. Pregnancy-specific stress was a significant predictor of gestational age in this model, \(B = -.18, p = .004\). The model explained 9\% of variance in gestational age and 32\% of variance in birth weight.

### The Role of Health Behaviors

The next set of structural equation models examined whether pregnancy-specific stress was associated with prenatal health behaviors and if so, whether any of the latter predicted birth weight or gestational age at delivery. Bivariate correlations (see Table 2) indicated that six of the seven health behaviors (i.e., all but physical strain) were associated with pregnancy-specific stress at two or three time points. Therefore, these six health behavior variables were included in the structural equation model. The resulting model, shown in Figure 4, indicates that pregnancy-specific stress significantly predicts cigarette smoking, caffeine consumption, and unhealthy eating, and is inversely associated with healthy eating, prenatal vitamin use, and exercise. Additionally, cigarette smoking predicts lower birth weight. The direct association between pregnancy-specific stress and gestational age \((B = -.18)\) remains significant in this model. The model fits well. There are also significant correlations among some of the health behaviors. All of these are in predictable directions (e.g., healthy eating is associated with prenatal vitamin use). This model accounts for 10\% of the variance in gestational age at delivery and 33\% of the variance in birth weight.

### Predicting Dichotomous Birth Outcomes

We replaced the continuous birth outcome variables in the preceding model with dichotomous outcomes (normal/low birth weight and full-/preterm delivery). Obstetric risk did not significantly predict full-/preterm delivery \((B = -.11)\), so this path was removed from the model. The resulting model fit well (see Figure 5). Comparing Figures 4 and 5 reveals that the magnitude of path coefficients is essentially the same; pregnancy-specific stress is as strongly associated with gestational age \((B = -.18)\) as with full-term delivery \((B = -.18)\). However, as compared with the model predicting continuous outcomes, this model does not account for as much variance in the timing of delivery \((R^2 = .03\) for full-/preterm delivery vs. .10 for continuously measured gestational age). Both models account for the same portion (33\%) of

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*Figure 2.* Structural equation model examining the impact of pregnancy-specific stress and obstetric risk on birth weight and gestational age at delivery, including the correlation between latent PNMS and pregnancy-specific stress, \(\chi^2 = 114.03, df = 71, p = .001; \text{CFI} = .97; \text{RMSEA} = .05 \) \((.03-.06)\). All path coefficients displayed are statistically significant \((p < .05)\). For simplicity, error values and correlations among some of the measured stress indicators are not shown.
variance in birth weight—whether continuously measured or dichotomized as normal/low.

Finally, to quantify the impact of pregnancy-specific stress and obstetric risk, we examined the gestational age at delivery of infants born to women highest and lowest in pregnancy-specific stress and highest and lowest in obstetric medical risk (splitting these variables at their median). Women with low stress and low risk delivered at $M = 276$ days ($SD = 8.4$), low stress/high risk women delivered at $M = 271$ days ($SD = 11.2$), low risk/high stress women delivered at $M = 272$ days ($SD = 11.2$), and women with high obstetric risk and high stress delivered at $M = 267$ days ($SD = 12.6$).

**Discussion**

Results of this study indicate that pregnancy-specific stress is a better predictor of birth outcome than state anxiety, perceived stress, or life event stress, or than a higher-order latent factor constructed from all four types of stress. Pregnancy-specific stress was associated with earlier delivery and with clinically defined preterm delivery in an ethnically and socioeconomically diverse sample of women. Although the majority of women did not deliver preterm, delivery was nine days earlier for those with high obstetric risk and high pregnancy-specific stress than for women low in risk and stress. Pregnancy-specific stress was also associated with

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**Figure 3.** Structural equation model examining the impact of pregnancy-specific stress and obstetric risk on birth weight and gestational age at delivery, $\chi^2 = 10.29$, $df = 9$, $p = .33$; CFI = 1.0; RMSEA = .02 (.00–.07).

**Figure 4.** Structural equation model examining the impact of pregnancy-specific stress, health behaviors, and obstetric risk on birth weight and gestational age at delivery, $\chi^2 = 64.40$, $df = 49$, $p = .07$; CFI = .98; RMSEA = .03 (.00–.05). All path coefficients displayed are statistically significant ($p < .05$). For simplicity, error values and correlations among some of the health behaviors are not shown.
a variety of prenatal health behaviors involving eating, exercise, and cigarette smoking. Of these, cigarette smoking predicted lower birth weight. These results suggest that pregnancy-specific stress may be a direct contributor to early delivery, and through its association with cigarette smoking, an indirect contributor to low birth weight. Furthermore, associations of pregnancy-specific stress with birth outcome exist after controlling for obstetric risk, illustrating that the impact of women’s psychological condition is independent of their medical condition during pregnancy.

State anxiety, which has been used in many prior studies to operationally define prenatal stress, predicted gestational age in this study when its correlation with the latent stress factor was modeled, but only to a small degree, and post hoc tests indicated that this association was a nonsignificant contributor to the model. Similarly, when it was the only stress variable in the model, state anxiety only marginally predicted gestational age. In contrast, pregnancy-specific stress was a significant predictor of gestational age in several models, including the model in which its correlation with other stress variables was controlled, and when it was modeled as the sole stress variable predicting gestational age. These findings suggest that the impact of pregnancy-specific stress on birth outcome is stronger than and independent of state anxiety and the other general types of stress measured in this study.

Why might pregnancy-specific stress be a better predictor of birth outcome than general stress? Pregnancy-specific stress may be a more potent type of stress. Other researchers have suggested, for example, that pregnancy-specific stress triggers greater physiological arousal than general stress (DiPietro et al., 2002, 2004; Huizink et al., 2004). Unlike general stress, pregnancy-specific stress involves stressors and responses that are context specific. Therefore, pregnancy-specific stress may have more proximal impact on the outcome of pregnancy. Measures of pregnancy-specific stress may also be a more valid means of assessing what women are experiencing during pregnancy than measures which capture general emotional state or conditions.

Results of this study offer some insight into the processes through which pregnancy-specific stress may affect birth outcome. The direct associations observed between pregnancy-specific stress and gestational age are most likely attributable to vascular, immunological, and neuroendocrine changes that have been implicated by prior research. For example, prenatal stress has been linked in several studies with higher levels of corticotropin-releasing hormone (Austin & Leader, 2000; Hobel, Dunkel-Schetter, Roesch, Castro, & Arora, 1999; Mancuso, Dunkel-Schetter, Rini, Roesch, & Hobel, 2004; Wadhwa et al., 2004) which triggers release of prostaglandins, facilitates the actions of oxytocin, stimulates contractions of the myometrium during labor, and through these mechanisms may contribute to earlier delivery (Hobel et al., 1999). Associations between pregnancy-specific stress and birth weight in this study may be better explained by changes in health behaviors, namely cigarette smoking, which affects birth weight by causing uterine blood vessel spasm and reducing uterine blood flow, thereby retarding fetal growth (Scott, 2003). Highly stressed women may resort to smoking as a means of coping. Study findings may underestimate the impact of smoking, however, if participants underreported their smoking frequency due to social desirability concerns. Although recent evidence suggests that pregnant women accurately report the amount they smoke (McDonald et al., 2005), self-report measures of cigarette smoking and other health behaviors are not ideal. This study provides a foundation for further research examining the association of prenatal stress with objective indicators of health behaviors such as serum cotinine and fitness tests.

The present study did not examine whether the impact of pregnancy-specific stress and general stress differ according to when they occur during pregnancy, but this question is worthy of

![Figure 5. Structural equation model examining the impact of pregnancy-specific stress and health behaviors on normal birth weight and full-term delivery. $\chi^2 = 52.88$, $df = 39$, $p = .07$; CFI = .98; RMSEA = .04 (.00–.06). All path coefficients displayed are statistically significant ($p < .05$). For simplicity, error values and correlations among some of the health behaviors are not shown.](image-url)
Further investigation, particularly given recent evidence suggesting that responses to stress may change across pregnancy (Glynn, Wadhwa, Dunkel-Schetter, Chicz-Demet, & Sandman, 2001; Glynn, Dunkel-Schetter, Wadhwa, & Sandman, 2004). Another caveat to the results of the present study is that women excluded from analyses because they did not complete study measures were more likely to be poor and to be non-White than women included, raising the possibility that findings are not generalizable to other groups of pregnant women. Furthermore, although a model was successfully fit that implicated pregnancy-specific stress as a predictor of clinically defined adverse birth outcomes, the sample size did not permit a strong test of the impact of PNMS on these outcomes, which have low prevalence. Larger samples may be needed to definitively assess the impact of pregnancy-specific stress on preterm delivery and low birth weight. However, because small differences in gestational age and birth weight, even within normal ranges, have been shown to predict later outcomes such as IQ, cognitive function, and adult depression (e.g., Behrman & Butler, 2007; Matte et al., 2001; Raikkonen et al., 2007; Sorensen et al., 1997), the stress effects on continuously measured birth outcomes observed in this study are probably not consequential.

Study results underscore the value of further research to determine whether a brief measure of pregnancy-specific stress such as the PDQ can be used in clinical settings to successfully identify and intervene with pregnant women at greatest risk of delivering early or of engaging in behaviors that reduce birth weight. Interventions might focus on educating such women about pregnancy, providing support, and enhancing self-care (e.g., Ickovics et al., 2007). Educating pregnant women about the symptoms and changes that they can expect, and about other aspects of pregnancy, birth, and parenting is likely to decrease pregnancy-specific stress. We found that knowledge was associated with lower stress in another study of pregnant women (Lobel, Dias, & Meyer, 2005). Results of the present research suggest that alleviating pregnancy-specific stress may reduce women’s risk of preterm delivery and the chances that they will smoke, thereby decreasing their risk of low birth weight. Coupled with the results of prior studies, these findings demonstrate that the opportunity to protect children’s health likely begins in utero by improving the psychosocial well-being of their mothers.

References


Appendix

Revised Prenatal Distress Questionnaire Items

Are you feeling bothered, upset, or worried at this point in your pregnancy:

Repeated at each timepoint:
... about the effect of ongoing health problems such as high blood pressure or diabetes on your pregnancy?
... about feeling tired and having low energy during your pregnancy?
... about paying for your medical care during pregnancy?
... about changes in your weight and body shape during pregnancy?
... about whether you might have an unhealthy baby?
... about physical symptoms of pregnancy such as vomiting, swollen feet, or backaches?
... about the quality of your medical care during pregnancy?
... about working or caring for your family during your pregnancy?
... about whether the baby might be affected by alcohol, cigarettes, or drugs that you have taken?

Added at second and third timepoint:
... about whether the baby might come too early?
... about changes in your relationships with other people due to having a baby?
... about paying for the baby’s clothes, food, or medical care?

Added at third timepoint:
... about taking care of a newborn baby?
... about pain during labor and delivery?
... about what will happen during labor and delivery?
... about working at a job after the baby comes?
... about getting day care, babysitters, or other help to watch the baby after it comes?

Note. Response scale is Not at all (0), Somewhat (1), or Very much (2).