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Prenatal Maternal Stress and Prematurity: A Prospective Study of Socioeconomically Disadvantaged Women

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Developed and tested a biopsychosocial model of birthweight and gestational age at delivery using structural equation modeling procedures. The model tested the effects of medical risk and prenatal stress on these indicators of prematurity after controlling for whether a woman had ever given birth (parity). Subjects were 130 women of low socioeconomic status interviewed throughout pregnancy in conjunction with prenatal care visits to a public clinic. The majority of women were Latino or African-American. Half were interviewed in Spanish. Lower birthweight was predicted by earlier delivery and by prenatal stress. Earlier delivery was predicted by medical risk and by prenatal stress. Parity was not related to time of delivery or to birthweight. Implications of results for the development of biopsychosocial research on pregnancy and on stress are discussed.

Key words: stress, birthweight, pregnancy, prematurity, biopsychosocial

Preterm delivery and low birthweight are major contributors to infant mortality and morbidity (Institute of Medicine, 1985). Their causes, however, are not well established. Most of the research has looked separately at medical or psychosocial contributors to adverse birth outcomes. Medical risk factors predict only about one half to two thirds of all adverse pregnancy outcomes (Institute of Medicine, 1985; Wilson & Schifrin, 1980). In the last two decades, psychosocial studies have linked higher levels of maternal state anxiety and stressful life events during pregnancy to adverse birth outcomes, but the studies have been inconclusive (Istvan, 1986). Of the studies that have examined effects of prenatal life events on infant prematurity, approximately half have found no significant relationship between stressful life events and lower birthweight (e.g., Ching & N. Newton, 1982; Larsson, Spangberg, Theorell, & Wager, 1986) or between life events and earlier delivery (e.g., Ching & N. Newton, 1982; Larsson et al., 1986; Omer, Friedlander, Palti, & Shekel, 1986; C. C. Williams, R. A. Williams, Griswold, & Holmes, 1975). The other half of the studies found that earlier delivery is significantly associated with the number (e.g., Berkowitz & Kasl, 1983; R. W. Newton & Hunt, 1984; R. W. Newton, Webster, Binu, Maskrey, & Phillips, 1979; J. L. Schwartz, 1977) or impact (e.g., Nethercut & Adler, 1983) of stressful life events. Trait anxiety was not found to be related to birthweight or to preterm delivery in two studies (Burstein, Kinch, & Stern, 1974; Levi, Lundberg, Hanson, & Frankenhaeuser, 1989). Finally, in two studies measuring state anxiety, anxiety was significantly and negatively correlated with infant birthweight in one study (Falorni, Fornasarig, & Stefanile, 1979), but not in the other (Brooke, H. R. Anderson, Bland, Peacock, & Stewart, 1989).

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The goal of the present study was to integrate biomedical and psychosocial approaches to develop a biopsychosocial model of prematurity. *Prematurity* refers here either to preterm delivery or to low birthweight. Preterm delivery—delivery before 37 weeks gestation—is a major contributor to lower birthweight because a fetus that is born early may not have had sufficient time in utero to complete its growth. Low birthweight is less than 2,500 grams. Past research has often overlooked the relationship between weeks gestation at delivery and birthweight (e.g., Falorni et al., 1979; Larsson et al., 1986). In addition to being limited in this way, previous research on contributors to adverse birth outcomes has been hampered by several factors, including the use of conceptually weak measures of prenatal psychosocial variables, chiefly stress; the misidentification of medical complications during pregnancy as birth outcomes; and the use of inappropriate statistical techniques (cf. Istvan, 1986). Variation in the way stress has been used across pregnancy studies also makes it difficult to draw conclusions (see Lobel, 1992).

Irrespective of the problems in this literature, maternal stress is a plausible contributor to preterm delivery and low birthweight. There is evidence that increases in maternal stress have uterine, cervical, and fetal effects (e.g., Fox, 1979; Lederman, Lederman, Work, & McCann, 1981). Elevated levels of epinephrine and norepinephrine, which are produced by high levels of stress, have been shown to reduce blood flow and oxygen to the fetus (Bragonier, Cushner, & Hobel, 1984). Stress during pregnancy may inhibit fetal growth or weight gain by this mechanism. There is also some evidence that peaks of epinephrine precipitate labor (Institute of Medicine, 1985). Thus, preterm delivery might be caused by sudden or large surges of epinephrine caused by high stress. The present study used structural equation modeling (SEM) to test the hypotheses that maternal stress and medical condition are independently related to lower birthweight and gestational age at delivery as part of a biopsychosocial model of birth outcomes.

CONCEPTUALIZING STRESS

In order for stress to have a detectable effect on complex and multiply determined outcomes such as birthweight and time of delivery, this construct must be operationalized very effectively. Elsewhere, we (Lobel & Dunkel-Schetter, 1990) described in detail our approach to conceptualizing stress and the methods we used in the current sample to develop a latent factor representing prenatal maternal stress. In short, SEM techniques were used to develop and test our conceptualization of stress, which incorporates the three most prominent approaches to stress definition—stimulus, perceptual, and emotional response definitions (Hobfoll, 1989; Lazarus & Folkman, 1984). Most studies of stress in pregnancy have applied exclusively stimulus or response approaches to stress definition, using either life events measures or anxiety measures, respectively. However, in the studies that have examined joint effects of life events, anxiety, and other distress variables, adverse effects on birth outcome have been most strongly documented (Molfese et al., 1987; Nethercut & Adler, 1983; Norbeck & Tilden, 1983; Nuckolls, Cassel, & Kaplan, 1972; but see Norbeck & N. J. Anderson, 1989), suggesting that research designs incorporating multiple measures of prenatal stress may enable researchers to better identify health effects (cf. Lobel, 1992). SEM is a powerful tool for examining the multivariate structure of complex constructs such as stress, and it has been used in recent research to clarify the structure of other latent variables such as social support (Newcomb, 1990) and loneliness (Russell, Kao, & Cutrona, 1987). SEM provides a method to separate the conceptually important common component (i.e., the latent factor) of measured variables from the measurement error that each contains (Newcomb, 1990).

Because no single measure exists that assesses the stimulus, perceptual, and emotional response components of stress, our goal was to model stress as a latent factor with measures of each component. Life events during pregnancy represented the stimulus or environmental component of stress. To represent perceptions of stress, two types of appraisals were assessed: subjects' perceptions of general levels of stress in their lives (Cohen, Kamarck, & Mermelstein, 1983) and their appraisals of how stressful life events had been. To assess the emotional response component of stress, we measured anxiety, both because it has been examined in many prior studies of pregnancy and because it is an emotion plausibly involved in the physiology of pregnancy and birth (Reading, 1983). State anxiety and perceived stress were measured at every prenatal clinic visit and were averaged over pregnancy—improving the psychometric quality of these measures compared to single assessments. This procedure was also selected because levels of anxiety and perceived stress were found to be stable across pregnancy in early analyses (see Lobel & Dunkel-Schetter, 1990).

Socioeconomic, ethnic and racial, and age differences in birthweight or gestational age at delivery might be expected based on past research (Cramer, 1987; Powell-Griner, 1988; Rogers, 1989; Samuels, 1986). African-American women, poor or uneducated women, and women less than 18 years old or more than 35 years old have higher rates of low birthweight in the United States (Becerra, Hogue, Atrash, & Pérez, 1991; Buescher et al., 1988; Institute of Medicine, 1985; Shiono, Klebanoff, Graubard, Berendes, & Rhoads, 1986; R. L. Williams, Binkin, & Clingman, 1986). Because women in the current sample were relatively homogeneous in socioeconomic class and because sampling excluded teenagers, we did not expect effects of social class or age, although we did test for them. We anticipated mean differences by ethnicity in birthweight, gestational age at time of delivery, and possibly stress, but we did not have any basis for hypothesizing different *relationships between* stress and birth outcomes for different ethnic groups. The underlying processes whereby stress and risk influence prematurity were presumed to be similar in these groups. Furthermore, ethnicity and race, age, marital status, and socioeconomic status may affect birth outcomes through their effects on stress and medical risk, which were the primary focus of this study.

METHOD

Subjects

The sample consisted of 130 women receiving prenatal care in the public clinic of a university-affiliated teaching hospital that offers medical care on a sliding pay scale. All the women had delivered a live infant at the study hospital and were participants in the UCLA Psychosocial Factors in Pregnancy Project, a large-scale investigation of prenatal psychosocial factors and birth outcomes. To participate in the study, subjects were required to be at least 18 years of age, 15 weeks or less gestation, and able to speak English or Spanish.[1] About half the women attending the clinic are Spanish speaking. Approximately 5% of the clinic population was ineligible due to age or language. Of all eligible women who were approached from 1984 to 1987, 88% agreed to participate. During the 3 years of data collection, an additional 134 clinic patients completed at least one interview but did not continue care at the clinic and are therefore not included in this report. Reasons include spontaneous abortions ($n = 26$), therapeutic abortions ($n = 3$), transfer to private care or to other medical facilities ($n = 10$), moving out of the city ($n = 11$), failure to return for further prenatal care or delivery for unknown reasons ($n = 26$), and no return for postpartum care for unknown reasons with attempts at telephone contact unsuccessful ($n = 58$). Analyses of 65 women with partial data showed that they were not significantly different from the sample with respect to prenatal state anxiety, prenatal perceived stress, education, parity, marital status, or age. However, the sample was more likely to be Latino, was at lower medical risk, delivered slightly earlier, and had babies that weighed slightly more on average than the babies of women not in the sample (all $ps < .05$).

Subjects ranged in age from 18 to 42 years ($M = 27.7$ years, $SD = 5.0$ years) and had an average of 10.8 years of education ($SD = 3.3$ years). On average, subjects were 12.4 weeks pregnant ($SD = 3.2$ weeks) upon entry into the study. Eighty-three women in the sample were Latino, 26 were African-American, and 16 were Anglo. Thirty-five percent of the sample were born in the United States; 61% were born in Mexico, El Salvador, Guatemala, or other Latin American countries; and most of the remainder were born in Europe or Asia. One fourth of the women had lived in the United States for 7 years or less. More than half the sample (55%) were interviewed in Spanish. Fifty-eight percent of the sample were married. The majority (78%) were living with the baby's father at the time of entry into the study. Approximately 1 in 5 subjects (21.5%) reported that they received no monetary support from the baby's father.

[1]Near the end of data collection, the weeks gestation eligibility requirement was relaxed to allow medically high-risk women up to 20 weeks gestation to participate in the study. This change was initiated to increase the number of high-risk subjects in the study.

Measures

The selection of measures was made with particular concern for the clinic population's cultural and linguistic diversity and low level of education as well as with the necessity to administer interviews quickly and in a crowded clinic setting.[2] Standard scales and specially developed sets of structured questions were used to assess the major constructs and study variables. Six different interview protocols were developed: five prenatal interviews and one postpartum interview. A core set of instruments was repeated in Interviews 1 through 4. For the present analyses, perceived chronic stress and state anxiety from the core set of repeated instruments were used; life events measures were taken from the postpartum interview. In addition, sociodemographic characteristics recorded at the first prenatal interview were used. Further details about the measures of perceived stress, state anxiety, and prenatal life events—including their internal consistency, descriptive statistics, and comparisons to relevant norms—can be found in Lobel and Dunkel-Schetter (1990).

Perceived stress. A five-item abbreviated version of the Perceived Stress Scale (PSS; Cohen et al., 1983; see also Cohen & Williamson, 1988) was used to assess general or nonspecific stress. Items assessed how often in the past 7 days women felt unable to control important things, how often they felt they coped well with changes, how often they felt they had too many difficulties to overcome, how often they felt things were going well, and how often they felt they could handle their problems. Each item was rated on a 5-point scale ranging from *never* (0) to *almost always* (4). Positively worded items were reverse scored, and the five ratings were summed. PSS scores were averaged across interviews to create a single prenatal perceived stress index for each subject. Scores on this index represent chronic stress or strain.

State anxiety. The 20-item State Anxiety form of Spielberger's (1983) State–Trait Anxiety Inventory (STAI) was used to assess state anxiety. Items were rated on a 4-point scale ranging from *not at all* (1) to *very much* (4). State anxiety scores were averaged across interviews, as with the PSS, to create a single prenatal state anxiety score for each subject.

Prenatal life events. A measure of stressful life events, adapted from the Los Angeles Epidemiological Catchment Area Study (Golding, 1989), was administered during the postpartum interview. Subjects answered items on 22 life events that they may have experienced or that had happened to a close family member or friend during pregnancy. The specific life events included moving, being robbed, being deported or having trouble with immigration, and having someone close die. In addition, women rated each event that occurred on how undesirable or negative it was from *not at all* (1) to *very much* (4). Two indices were computed from the life events instrument: number of life events during pregnancy and a mean life event distress score. The latter was computed by averaging the distress rating reported for each event. Subjects reporting no events were assigned a life event distress score of zero.

[2]All measures were translated by a bilingual team representing six countries of origin to produce Spanish and English versions that were pretested extensively in the clinic.

Medical risk and parity. Although medical risk has been used as a dichotomous variable in many previous studies (i.e., high vs. low risk), a continuous measure was developed for this study that took both prepregnancy and pregnancy conditions into account. A list of 66 explicit criteria considered as risk contributing was developed after reviewing the medical risk literature and consulting with obstetrics experts. The medical risk instrument was patterned after sections of the Problem Oriented Perinatal Risk Assessment System (Hobel, 1982; Hobel, Hyvarinen, Okada, & Oh, 1973; Hobel, Youkeles, & Forsythe, 1979).[3] Six categories of maternal risk criteria were included based on major medical risk classification instruments (Selwyn, 1982): (a) subject's medical history (e.g., renal disease or epilepsy), (b) family medical history (e.g., diabetes or hypertension), (c) subject's gynecological and obstetric history (e.g., previous stillbirth or previous second-trimester spontaneous abortion), (d) complications of past pregnancies (e.g., placenta abruptio or preeclampsia), (e) unusual features of current pregnancy (e.g., multiple gestation or Rh negative status), and (f) current pregnancy risk factors and complications (e.g., edema or incompetent cervix). Tobacco use, alcohol use, and inadequate weight gain were included in the last category. A subject's medical risk score was the total number of her risk-contributing conditions.

Because women giving birth for the first time have been shown in some studies to experience more adverse birth outcomes (e.g., Erickson, 1976; Zax, Sameroff, & Farnum, 1975), effects of this variable (parity) were controlled. About one third of the subjects in this sample (31.5%) were giving birth for the first time.

Birth outcomes. Newborns are weighed in the delivery room immediately after birth. Birthweight was used as a continuous dependent variable in analyses because categorical birth outcomes such as normal versus low birthweight (less than 2,500 g) are less reliable and afford poorer statistical power in data analyses. Also, although a newborn may be labeled *normal* by virtue of birthweight or time of delivery, this label tells little about the functional maturity of the newborn (Pritchard & MacDonald, 1980). For example, some newborns weighing 2,500 g or more and some born after 37 weeks are functionally immature.

Gestational age at time of delivery was obtained from medical charts. Medical charts contain many different calculations of gestational age, including those based on self-report of last menstrual period, physician estimates based on pelvic examinations, and, sometimes, sonograms. Our scanning of the medical charts indicated that, for many women, there was a 1-week discrepancy in the estimates of gestational age at delivery. Therefore, time of delivery was coded as clearly full term (38 or more weeks gestational age at birth), marginally preterm (36 or 37 weeks gestational age), or clearly preterm (fewer than 36 weeks gestational age).

Procedure

Interviewers. Twelve bilingual Latino women were trained as interviewers in group sessions and individually on-site by the investigators with the assistance of a survey interviewing consultant, an obstetric nurse, a cultural anthropologist, and clinic staff.

[3]The medical risk instrument is available from the authors.

Sequence and timing of interviews. Women were interviewed at each clinic visit throughout pregnancy and once postpartum. Interviews 1 through 5 were administered in sequence beginning with Interview 1 on the day of entrance into the study. Each subsequent prenatal interview was administered at least 10 days after the preceding one to space interviews for those receiving frequent care. Also, a woman had to be at least 26 weeks gestation for Interview 4 and at least 30 weeks gestation for Interview 5. Women who came to the clinic for care before they were eligible for Interview 4 or 5, or women who had completed the entire sequence of Interviews 1 to 5, were interviewed with only the core set of repeated measures.

Medical charts. Medical risk factors and labor and delivery variables were abstracted from subjects' medical charts by nurses with experience in labor and delivery. To calculate interrater reliability, the medical charts of 45 randomly selected subjects were coded a second time by an independent coder, an obstetric nurse. Agreement averaged 92% and ranged from 86% to 100% across five variables appearing in different sections of the medical chart.

RESULTS

Descriptive Information on Major Study Variables

The highest number of risk conditions that any woman in the sample experienced was 14, and most of the subjects (93.8%) experienced at least one risk-contributing condition. Mean medical risk was 3.5 conditions (SD = 2.6 conditions), with a median score of 3 conditions.

Birthweight ranged from 1,000 g to 4,470 g (M = 3,371 g, SD = 634 g). No infants in the sample weighed more than 4,500 g—a commonly used cutoff for abnormally high birthweight. One hundred eight subjects had pregnancies coded as clearly full term (38 weeks or more gestational age), 16 subjects were marginally preterm (36 or 37 weeks), and 6 subjects were clearly preterm (fewer than 36 weeks). As expected, the correlation between time of delivery and birthweight was substantial ($r = .60, p < .001$).

The mean number of administrations of the core measures was 7 (SD = 1.7, range = 2 to 11). Subjects experienced more life events relative to community sample norms and to mean scores in other studies of pregnant women. They were moderately distressed on the life events distress measure but not highly anxious on the STAI. Perceived chronic stress was also slightly low compared to relevant norms (see Lobel & Dunkel-Schetter, 1990).

To determine whether there were differences between Latino, African-American, or Anglo subjects on any of the independent or dependent variables, a series of analyses of variance was run, followed by post hoc tests for two-group comparisons. The ethnic groups were not different with respect to parity, number of life events, life event distress, state anxiety, perceived stress, time of delivery, or birthweight. Although not significantly different, the pattern of birthweight for each ethnic group corresponds to the pattern often observed: Birthweight was highest for Anglos (M = 3,500 g), lowest for African-Americans (M = 3,290 g), and intermediate for Latinas (M = 3,371 g). Also, Anglos (M = 4.8) were at greater medical risk compared to Latinas (M = 3.1), $F(1, 97) = 5.99$, $p < .05$ (M = 3.9 for African-American women).

Marital status and education were unrelated to all the independent and dependent variables reported here. Age was unrelated to all variables except parity: younger subjects were more likely to be having their first child ($p < .001$).

Testing the Biopsychosocial Model of Birthweight and Time of Delivery

The primary hypotheses of the study were tested by the use of SEM; such modeling yields statistics that are equivalent to the results of regression analyses, and it has several specific advantages in this application. First, the statistical procedures can accommodate a latent factor; second, it is possible to have correlated dependent variables included in a single model; and third, SEM results are robust with skewed dependent variables.

Modeling procedures. Quantitative experts (e.g., J. C. Anderson & Gerbing, 1988; Newcomb, 1990) recommended a stepwise approach to testing structural equation models that involves first testing a "measurement model," or confirmatory factor analysis of latent variables, and then testing a "structural model" of relationships among the independent and dependent variables. Each path in a model to be tested corresponds to a hypothesis. For example, because we hypothesized that parity would be related to the birth outcomes, paths between parity and each of the outcomes were included in the model. Leaving a path out of a model indicates an expectation that no relationship exists between two variables.

Data analyses were undertaken in three stages. The first stage, testing the measurement model of stress, is reported in detail in Lobel and Dunkel-Schetter (1990). A two-factor model of stress resulted from data reduction using SEM. Anxiety and the two measures of perceived stress during pregnancy were part of a single underlying latent factor, whereas the actual number of major life events occurring during pregnancy represented a second, distinct variable. In the current study, hypotheses about stress are tested with the latent stress construct, although number of life events is also tested for comparison.[4]

In the second stage of analyses, the model of birthweight incorporating the hypothesized relationships of stress, medical risk, and parity to birthweight was tested. We included a correlational path between parity and stress because women having their first child were expected to experience greater prenatal stress.

In the third stage of analyses, we tested the model of time of delivery, which incorporated the hypothesized relationships of stress, medical risk, and parity to time of delivery, as well as the relationship between time of delivery and birthweight. To avoid theoretically unguided "model fitting," conservative a priori criteria were established for modifying the model at each step.[5]

[4]Number of life events was left in the covariance matrix to which the model was fit and was treated as a variable with no hypothesized relationships to other variables.

[5]Criteria during each of the three steps were the following. To produce the most conservative, constrained model (i.e., fewest paths), Wald tests (see Bentler, 1985) were used initially to identify nonsignificant paths. The path whose removal increased the chi square by the smallest magnitude was dropped first. The model was then reestimated, and Wald test results were reexamined. This process was repeated until all paths remaining in the model were significant. At this point, the results of a Lagrange multiplier test (see Bentler, 1985) were used to add any statistically indicated yet theoretically meaningful paths one at a time; again, the model was reevaluated after each modification.

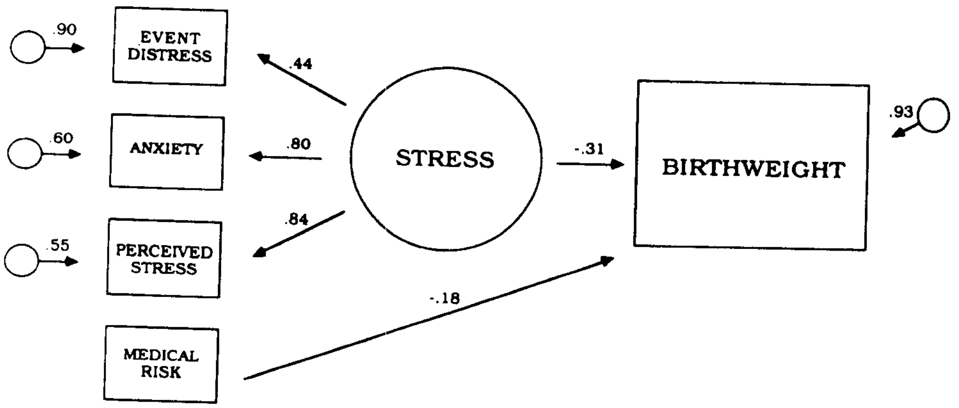

FIGURE 1 Model of birthweight.

Model of birthweight. The initial model of birthweight fit the data well (χ^2 = 10.65, p = .56, df = 12); that is, the hypothesized model and the observations do not differ significantly. The Comparative Fit Index (CFI; see Bentler, 1985) was 1.0 of a possible 1.0, which indicates that the initial model of birthweight is a significantly better fit to the data than a model with no relationships among variables. The results of Wald tests, however, suggested that two of the paths in the model were nonsignificant: the relationships of parity to stress and to birthweight. These paths were dropped. The resultant, modified model of birthweight, depicted in Figure 1, yielded a chi square of 2.72 (p = .74, df = 5), and the CFI remained 1.0, indicating that the modified model is a good fit to the data. As is customary in SEM, the latent variables are circled and the measured variables are denoted by rectangles (see Figure 1).[6]

The model indicates that medical risk and stress each predict lower birthweight (standardized regression coefficients = -.18 and -.31, respectively). Notably, medical risk and stress are not correlated. Also, the results of the Lagrange multiplier tests suggest that there are no additional significant paths to be added. Thus, the associations between number of life events and all the variables in the model are not significant. For this modified model of birthweight, R^2 = .14.

Model of birthweight and time of delivery. In the final stage of analyses, time of delivery was added to the model with pathways from its hypothesized predictors (stress, medical risk, and parity). The effect of time of delivery on birthweight was also included as a path. The initial model fit with a chi square of 22.66 (p = .20, df = 18, CFI = .97). According to Wald test results, there were two nonsignificant paths in this model. Thus, paths between medical risk and birthweight and between parity and time of delivery were dropped. After these modifications, the chi square for the resultant model was 5.79 (p = .67, df = 8, CFI = 1.0). None of the Wald or Lagrange multiplier tests was significant at this point. Thus, number of life events has no impact on birthweight or time of delivery, and it is not significantly related to medical risk or to the latent stress factor.

[6]Paths between latent variables and measured variables represent factor loadings. Residuals are represented as small circles pointing to the measured variables. The remaining one-headed arrows—those that are not factor loadings—represent regression effects.

The full model, which now contains the latent stress variable, predictors of birthweight, and predictors of time of delivery, is depicted in Figure 2. It indicates that stress significantly predicts both delivery (standardized regression coefficient = -.23) and birthweight (standardized regression coefficient = -.18), independent of medical risk. The relationship between stress and birthweight is both direct and indirect, through its contribution to gestational age at delivery. Medical risk predicts gestational age at delivery but has no direct relationship to birthweight. However, there is an indirect effect of medical risk on birthweight through gestational age at delivery (standardized regression coefficient = -.25). Thirty-nine percent of the variance in birthweight is accounted for by this model, and time of delivery is the strongest predictor of birthweight (standardized regression coefficient = .55), as would be expected.

Correlations between the biopsychosocial predictors, time of delivery, and birthweight were computed separately for Latinas, Anglos, and African-Americans and were compared to the correlation matrix for the entire sample. All correlation matrices were similar, and no reversals in direction of any correlation were found. A few of the correlations were smaller within an ethnic group than in the entire sample, possibly due to the differences in sample size and in the distribution of medical risk, stress, and birth outcome variables within these subgroups.

Group analyses of birth outcome. For ease of understanding the clinical implications of the modeling results, logistic regression analyses were run on dichotomized birth outcomes. These yield statistically equivalent results, although they are not as powerful as the SEM analyses in this application. Subjects were divided into those whose pregnancies did and did not result in low birthweight and preterm delivery. For each subject, delivery was coded as full term (n = 108) or preterm (n = 22, including marginally and clearly preterm deliveries), and birthweight was coded as normal (n = 120) or low (n = 10). Stress was scored for each subject by a standardized sum of state anxiety, perceived stress, and life event distress. The results of the logistic regression analyses corroborate the results of the SEM. The stress factor significantly predicts both low birthweight (standardized logistic regression coefficient = -.85, p < .01) and preterm delivery (standardized logistic regression coefficient = .30, p < .03). Medical risk is related to preterm delivery (standardized coefficient = .28, p < .03) but not to low birthweight. Medical risk and stress have almost equivalent relationships to preterm delivery.

DISCUSSION

In this study of low-income, predominantly ethnic minority women receiving care in a prenatal clinic, stress during pregnancy contributed significantly and independently to earlier delivery and lower birthweight. That is, women experiencing greater stress gave birth to babies that weighed less, regardless of when they delivered. The associations of stress with birthweight and gestational age at delivery were independent of the significant association between medical risk and gestational age. Furthermore, medical risk and stress had associations to gestational age that were similar in magnitude. Consistent with past research (Selwyn, 1982), medical risk had no direct relationship to birthweight. All these relationships were with birthweight as a continuous variable and with time of delivery coded in one of three categories. In addition, stress and medical risk also significantly predicted the dichotomous outcomes of whether a baby was normal or low in birthweight and whether a delivery was full term or preterm. Parity (i.e., first birth), number of life events, marital status, education, and age were not related to birthweight or gestational age, stress, medical risk, or the measured components of stress.

The latent stress factor developed in this study is highly phenomenological and affect based. It might be labeled *distress*, rather than *stress*, to differentiate it from objectively occurring stressful conditions or the mere number of prenatal life events. Number of life events was not a significant component of the stress factor, and it was not related to birthweight or time of delivery. This latter result is consistent with evidence that life events have adverse effects only when appraised as stressful (cf. Sarason, Johnson, & Siegel, 1978; Thoits, 1983). However, it is also possible that life events were unreliably reported because these data were collected retrospectively. Although reporting biases can be a problem when life events are assessed after an adverse outcome (Thoits, 1983), event distress, which was retrospectively measured, was not more highly related to birth outcomes than the prospectively measured stress variables, and number of events was not related at all.

The measures of state anxiety and perceived stress used here are known to be sensitive to change. Therefore, if any fluctuations in stress occurred in this study, they should have been evident. However, the conditions that created stress for women in this study, such as poverty and immigration problems, were not likely to change during the 7 to 8 months of pregnancy that were studied. Furthermore, the high degree of stability on the prenatal stress and anxiety measures suggests that the stress factor may be reflecting not only the stable conditions of these women's lives but also their psychological predispositions, such as control beliefs, coping styles, or other individual differences. Supporting this reasoning is the fact that stress was correlated with trait anxiety ($r = .69$). Yet, trait anxiety was not related to birthweight or to gestational age ($rs = -.11$ and $-.10$, respectively)—consistent with past studies. A future task is to untangle the extent to which personality and environmental factors each contribute to the type of stress that influenced birth outcomes in this study. Attention should also be focused on the effects of social support on birth outcomes (Collins, Dunkel-Schetter, Scrimshaw, & Lobel, 1992).

Counter to expectation, medical risk was not significantly associated with stress. Knowing that one is at medical high risk for an adverse birth outcome should contribute to perceptions of greater stress. However, women in the current study were not consistently informed of their medical risk status in the prenatal clinic due to various aspects of the health care delivery system, including language barriers and time constraints (cf. Engle, Scrimshaw, Zambrana, & Dunkel-Schetter, 1990). Most subjects were Spanish speaking, and most physicians did not speak Spanish. Therefore, many high-risk women were not aware that they were at risk for an adverse birth outcome, and most were not aware of the full extent of their medical risk status or the reasons for it. In other settings, stress and medical risk may be significantly related. For example, higher socioeconomic status women receiving private health care are probably more aware of their risk conditions. However, the different relationships of stress and medical risk to birth outcomes, observed here, could be overlooked if these two risk-contributing factors are combined into a global or comprehensive risk index.

Although the correlational nature of our data do not permit causal inferences, there are reasons to suspect that stress is a contributor to earlier delivery and lower birthweight. Two of the three stress measures were assessed prospectively. Moreover, there are behavioral and physiological mechanisms to support a causal relationship of stress to birthweight and time of delivery. Stress may produce adverse birth outcomes through effects on health behaviors and self-care during pregnancy. For example, people under stress are more likely to engage in poorer health behaviors and are less compliant with medical recommendations (e.g., Caldwell et al.,

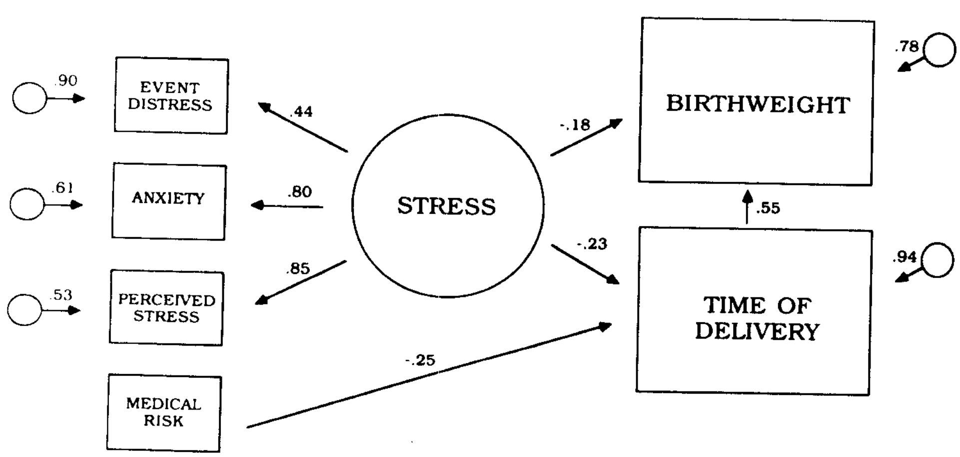

FIGURE 2 Model of birthweight and time of delivery.

1983). A highly stressed pregnant woman is unlikely to have the motivation, energy, time, and resources to observe sound diet, rest, exercise, and prenatal care practices. She may cope with stress by smoking or using alcohol and other substances (see Conway, Vickers, Ward, & Rahe, 1981; Krantz, Grunberg, & Baum, 1985), and these behaviors are known to be associated with adverse birth outcomes (e.g., Shiono, Klebanoff, & Rhoads, 1986). Alcohol, tobacco, and illicit drug use were extremely low in the current sample, but other unmeasured behaviors such as eating habits and nutrition may have contributed to the relationship between stress and adverse birth outcome.

A host of physiological factors have been implicated as the pathways linking stress and pregnancy outcomes, including hormones (e.g., progesterone, estrogen, and oxytocin), calcium ions, adrenergic agents and receptors, catecholamines, and blood flow from the uterus to the placenta (Bragonier et al., 1984; Institute of Medicine, 1985; McAnarney & Stevens-Simon, 1990; Pritchard & MacDonald, 1980). Catecholaminergic responses to environmental stressors and emotional stress during pregnancy and birth have been widely documented in animal and human studies. Catecholamine elevations have been linked to uterine and cervical changes and to fetal effects (e.g., Fox, 1979; Lederman et al., 1981; Levinson & Shnider, 1979; Morishima, Pedersen, & Finster, 1978; Myers, 1975). Catecholaminergic-sensitive prenatal periods may exist that result in adverse birth outcomes due to the particular processes that are impeded. For example, stress-related catecholaminergic elevations early in pregnancy during fetal development might result in structural abnormalities, whereas stress later in pregnancy might be associated with lower birthweight because growth occurs primarily during the latter two trimesters (see Moore, 1982). Also, because high levels of epinephrine may initiate labor (Institute of Medicine, 1985), sudden stress elevations late in pregnancy might produce preterm delivery. Another possibility is that chronic maternal stress results in lower birthweight because sustained catecholamine activity leads to decreased uterine blood flow and fetal asphyxia (Lederman et al., 1981; Levinson & Shnider, 1979). Mixed evidence about the effects of chronic stress on birth outcomes exists in studies on women in high-stress occupations and especially in studies on women whose work requires frequent standing (e.g., Grunebaum, Minkoff, & Blake, 1987; Mamelle, Laumon, & Lazar, 1984; Klebanoff, Shiono, & Rhoads, 1990; McDonald et al., 1988; Phelan, 1988; R. W. Schwartz, 1985). Effects of chronic versus episodic stress during sensitive periods are difficult to differentiate in the current study because stress was stable throughout pregnancy. However, the results provide a justification for follow-up research investigating the physiological and behavioral mechanisms linking perceived stress and prematurity within each trimester of pregnancy.

How generalizable are these results to other populations of pregnant women? With respect to overall rates of preterm delivery, low birthweight, and their patterns of medical risk, this sample is largely representative of U.S. women. However, the sample is small compared to epidemiological studies, and the number of African-American and Anglo women included is particularly small relative to the number of Latinas, making ethnic differences difficult to detect reliably. Moreover, there is evidence that disparities in education, income, and stress level may be important contributors to ethnic differences in birth outcome (e.g., Binsacca, Ellis, Martin, & Petitti, 1987; Cramer, 1987), and subjects in the current study were quite homogeneous with respect to these factors. In addition, the study selected women who initiated prenatal care early in pregnancy, and prenatal care has an important influence on birth outcomes—one that has been confounded with ethnic group membership in past studies (Ginzberg, 1991; Lia-Hoagberg et al., 1990). A study in progress is designed to examine mediators of birthweight differences, such as prenatal care among African-American, Mexican-American, and Mexican immigrant women (Zambrana, Dunkel-Schetter, & Scrimshaw, 1991, 1992). In sum, the biopsychosocial model of birthweight and time of delivery developed in this study appears to apply to African-Americans, Latinos, and Anglos equally well, but replication in larger samples is needed.

Implications and Conclusions

Several features of the present study helped to increase the likelihood that a biopsychosocial model would emerge. First, assessment of the psychological variables was strengthened by using multiple indicators of stress, by repeating assessments over pregnancy, and by using aggregated prenatal stress scores. This was especially advantageous due to the sample size. Second, specific risk and outcome variables were selected and precisely scored, as has not been the case in many previous studies that have assessed multiple birth outcomes simultaneously and categorized women grossly into groups with "normal" or "abnormal" outcomes (e.g., Jones, 1978; Norbeck & Tilden, 1983; Nuckolls et al., 1972). Because distinct physiological and behavioral factors may be involved in producing different birth outcomes, stress is likely to influence some outcomes to different degrees and through different processes (Dunkel-Schetter, Lobel, & Scrimshaw, 1992). Third, the study benefited from the use of SEM procedures—a statistically sophisticated tool for model testing.

The study provides evidence that specific birth outcomes are related to psychosocial factors after controlling for the contributions of medical factors. That psychosocial and medical variables have significant and independent effects in this study lends further support for systems theories of health (e.g., Kasl, 1983; Leventhal & Tomarken, 1987; G. E. Schwartz, 1982). Furthermore, these results add to the growing body of evidence about the relationship of stress to various aspects of health and disease. Continued research and intervention in this area are of paramount importance because the United States has one of the highest rates of low infant birthweight of any industrialized country and, as a consequence, high incidence of infant mortality and morbidity, especially among ethnic minorities and the socioeconomically disadvantaged (Institute of Medicine, 1985). Many researchers believe that higher levels of stress in these groups contribute to their higher rates of low birthweight, but previous studies have been inconclusive on the whole. The results of the current study suggest that prenatal stress has significant associations with both birthweight and gestational age at delivery, independent of traditional medical risk factors. The findings provide an important framework for continuing biopsychosocial research on birth outcomes, and they help to clarify the factors that affect the health and well-being of pregnant women and their babies.

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