ARTICLE

Prepregnancy Health Status and the Risk of Preterm Delivery

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Background: Despite extensive evaluation, our understanding of risk factors for premature delivery is incomplete.

Objective: To examine whether a woman's health status and risk factors before pregnancy are associated with a woman's risk of preterm delivery, independent of risk factors that occur during pregnancy.

Design, Setting, and Participants: Prospective cohort of pregnant women in the San Francisco Bay area who delivered a singleton infant (n=1619).

Main Outcome Measure: Preterm delivery (<37 weeks' gestational age).

Results: Sociodemographic characteristics alone explained 13.0% of the risk of preterm delivery, whereas risk factors that occurred before pregnancy explained 39.8% and risk factors that occurred during pregnancy explained 47.1%. After we adjusted for sociodemographic characteristics, prepregnancy risk factors, and pregnancy risk factors, women who reported poor physical function during the month before conception were nearly twice as likely to experience a preterm delivery (odds ratio, 1.97; 95% confidence interval, 1.18-3.30) as women with better physical function.

Conclusion: A broader focus on the health of women prior to pregnancy may improve rates of preterm delivery.

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PRETERM DELIVERY IS ONE OF the most important causes of perinatal morbidity and mortality and childhood morbidity in the United States.[1,2] In addition, ethnic disparities in prematurity are a significant public health problem.[2,3] The incidence of preterm births has risen over the last 15 years and is at least twice as high among African American women as among white women.[2,3] Reducing disparities in prematurity has been identified as a national public health priority.[4]

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For these reasons, risk factors for preterm delivery have been extensively examined, and several have been identified, including maternal age,[5] socioeconomic status,[6,7] marital status,[8,9] parity,[10] smoking,[11] mental health,[12,13] alcohol and substance use,[14] the adequacy of prenatal care,[15,16] physical activity,[17-19] chronic illness (eg, asthma[20-23] and diabetes[24,25]), and intrauterine infection.[26-28] Despite such extensive evaluation, our understanding of the etiology of preterm delivery remains incomplete. Similarly, interventions designed to reduce preterm delivery have focused on the prenatal period. For example, the expansion of public health coverage for pregnant women was implemented to improve access to prenatal care and reduce rates of prematurity. Unfortunately, these programs have had limited effect on these outcomes.[29-31]

These findings suggest that our focus on the prenatal period may be too narrow. By the time a woman is pregnant, it may be too late to modify important health behaviors, treat chronic illness, or improve her health status. A broader perspective on a woman's health status before pregnancy may be necessary to improve our understanding of the factors associated with preterm delivery. The goal of this study was to examine the relationship between a woman's prepregnancy health status and her risk of subsequent preterm delivery.

METHODS

SAMPLE

Project WISH (Women and Infants Starting Healthy) is a longitudinal cohort of pregnant women who received their prenatal care at a practice or clinic affiliated with 1 of 6 delivery hospitals in the San Francisco Bay area. Women were eligible to participate in Project WISH if they (1) received prenatal care at 1 of the practices or clinics associated with these delivery hospitals and planned to deliver at 1 of these hospitals; (2) were at least 18 years old at the time of recruitment; (3) spoke English, Spanish, or Cantonese; (3) sought prenatal care before 16 weeks' gestational age; and (4) could be contacted by telephone.

Potentially eligible women were sent an informational letter explaining the study and requesting their participation. This mailing included a prestamped, preaddressed "opt-out" postcard that a woman could return if she did not wish to be contacted. If no "opt-out" postcard was returned within 2 weeks of the mailing, attempts were made to contact the woman by telephone. When a woman was reached, verbal informed consent was obtained using a standard script. Women were enrolled between May 2001 and July 2002. The research protocol was reviewed and approved by the institutional review boards of the participating institutions.

ASSESSMENT

Women who agreed to participate were asked to complete 4 telephone surveys: (1) before 20 weeks' gestation, (2) at 24 to 28 weeks' gestation, (3) at 32 to 36 weeks' gestation, and (4) 8 to 12 weeks' postpartum. During each interview, women were asked to report their physical functioning using the Medical Outcome Study (MOS) Short Form-36 (SF-36).[32] The MOS SF-36 contains subscales to measure 8 dimensions of health, including physical function, physical role function, bodily pain, general health, vitality, social function, emotional role function, and mental health. This instrument has been extensively evaluated in many populations and has been shown to have adequate psychometric properties, including validity and reliability. Scores for each subscale range from 0 to 100, with a higher score indicating better function. During each interview, women also were asked to complete the short-form Center for Epidemiologic Studies–Depression Scale (CES-D) to screen for depressive symptoms.[33] During the first interview (median gestational age at the time of this interview, 16 weeks), participants were asked to report their health status, using the MOS SF-36 and the CES-D, during the month before they became pregnant. During subsequent interviews, they were asked to report their health status during the prior 4 weeks.

Other information ascertained in the first interview included age, race, ethnicity, country of birth, marital status, education, prepregnancy chronic medical conditions (including anemia, asthma or other chronic lung diseases, diabetes, hypertension, epilepsy, HIV, cancer, and rheumatologic, thyroid, kidney, liver, and heart disease), parity, weight and height during the month before pregnancy, the frequency and duration of exercise during the month before pregnancy, and tobacco use during the 3 months before conception and during pregnancy. Additional data collected during the subsequent pregnancy interviews included the diagnosis or treatment of obstetric conditions during pregnancy (including preeclampsia or eclampsia, gestational diabetes, placenta previa, placental abruption, oligohydramnios, polyhydramnios, intrauterine growth restriction, isoimmunization, incompetent cervix, and current smoking). Following delivery, the medical records of women and their infants were reviewed to obtain data about the length of gestation; birth weight; the adequacy of prenatal care[34]; the use of tobacco, alcohol, and illicit drugs; and the chronic medical conditions and pregnancy-associated conditions previously noted.

VARIABLES

Preterm delivery (<37 weeks' gestational age at the time of delivery) was the outcome variable for these analyses. Independent variables included self-reported age (categorized in 5-year intervals), self-reported race/ethnicity (white, Latina, African American, and Asian American), self-reported country of birth (United States–born vs other), self-reported marital status (married or living with a partner vs other family structures), self-reported level of education (less than high school, high school graduate or some college, college graduate or higher), parity recorded in the medical record (nulliparous vs parous), self-reported exercise prior to pregnancy (none vs some), prepregnancy body mass index (BMI) (calculated as weight in kilograms divided by height in meters squared) as recorded in the medical record or by self-report if the chart data were not available (BMI: underweight, <18.5 kg/m^2; normal, 18.5 kg/m^2 to 24.9 kg/m^2; overweight, 25 kg/m^2 to 29.9 kg/m^2 and >30 kg/ m^2), the chronic medical conditions previously listed if noted in the medical record or by self-report, the pregnancy-associated conditions previously listed if noted in the medical record or by self-report, smoking status both before pregnancy and during pregnancy based on medical record review or self-report, and the adequacy of prenatal care based on medical record review.[34] A woman was considered to have depressive symptoms if her score on the short-form version of the CES-D was higher than 10, consistent with the definition for this version of the instrument.[33]

ANALYSES

This analysis was restricted to women with a singleton delivery. Variables for the multivariate models were selected on the basis of a priori hypotheses or bivariate associations. The perinatal health framework was used as a conceptual model for these analyses.[35] This framework recognizes the influence of distal determinants of health, including demographic and socioeconomic characteristics; proximal determinants, including biomedical conditions and behavioral factors; and the interface between the preconceptional and the prenatal periods. We therefore examined a series of 3 multivariate logistic regression models: (1) a model that examined only sociodemographic characteristics (age, race, ethnicity, place of birth, level of education, and parity); (2) a model that included sociodemographic determinants plus prepregnancy health status and risk factors (prepregnancy BMI, physical function, depressive symptoms, chronic medical conditions, smoking, and exercise); and (3) a model that also included risk factors that occurred during pregnancy (adequacy of prenatal care, physical function during pregnancy, depressive symptoms during pregnancy, pregnancy-associated conditions, smoking during pregnancy, and use of illicit drugs during pregnancy). We then estimated the relative contribution of sociodemographic, prepregnancy, and pregnancy factors to the variation in premature birth by the marginal change in the model χ^2 as each group of factors as it was added and removed from the full model.[36] The c statistic is a measure of the concordance between the predicted and observed outcomes. Values closer to 1 indicate a better model fit.[37]

Because many of the women were at the upper limit of the physical function scale before pregnancy, we chose to examine poor function, defined as below the 25th percentile for women of reproductive age from national normative data.[32] This

Table 1. Description of the Sample (n=1619)*

	Term Delivery (n = 1490)	Preterm Delivery (n = 129)	Unadjusted Odds Ratio for Preterm Delivery (95% Confidence Interval)
Median age (range), y	30 (18-45)	31 (18-44)	NA
Nulliparous†	45.4	45.7	1.01 (0.71-1.45)
Born in the United States	58.1	55.0	0.88 (0.61-1.27)
Married or living with a partner	88.6	84.5	0.70 (0.43-1.16)
Race/ethnicity			
White	32.6	24.8	1
African American	16.9	24.8	1.94 (1.16-3.24)
Latina	35.6	37.2	1.38 (0.87-2.19)
Asian American	14.9	13.2	1.17 (0.63-2.14)
Educational attainment†			
Less than high school	16.0	19.4	1.61 (0.96-2.71)
High school graduate/some college	41.8	48.8	1.55 (1.03-2.34)
College graduate	42.2	31.8	1
BMI before pregnancy			
Underweight (BMI<18.5)	3.1	6.2	2.36 (1.07-5.23)
Normal (BMI, 18.5-24.9)	54.0	45.0	1
Overweight (BMI, 25.0-29.9)	24.6	20.9	1.02 (0.63-1.64)
Obese (BMI≥30.0)	18.3	27.9	1.83 (1.18-2.84)
Exercise during the month before pregnancy			
None	23.4	29.5	1.37 (0.92-2.04)
Cigarette use			
Smoked at least 1 cigarette per day during the 3 mo before pregnancy	8.7	18.6	2.39 (1.48-3.86)
Smoked during pregnancy	5.5	10.9	2.09 (1.15-3.80)
Used illicit drugs during pregnancy	6.4	10.1	1.65 (0.89-3.03)
Chronic medical conditions before pregnancy			
Hypertension	8.6	24.8	3.51 (2.26-5.44)
Other chronic conditions‡	40.4	52.7	1.64 (1.15-2.36)
Poor physical function before pregnancy	9.6	21.7	2.61 (1.66-4.11)
Depressive symptoms before pregnancy	10.9	17.1	1.69 (1.04-2.74)
Inadequate prenatal care	8.5	12.4	1.53 (0.88-2.67)
Pregnancy complications			
Gestational diabetes	5.0	9.3	1.93 (1.02-3.66)
Preeclampsia or eclampsia	9.3	28.7	3.94 (2.59-6.00)
Other pregnancy complications§	8.9	20.2	2.58 (1.62-4.10)
Mean physical function during pregnancy‖	59.5	53.2	¶
Depressive symptoms during pregnancy	24.2	34.9	1.68 (1.15-2.46)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); NA, not applicable.
*Data are presented as percentages unless otherwise indicated.
†There were missing data for parity (n=2) and educational attainment (n=1).
‡Other chronic conditions include anemia, asthma or other lung diseases, thyroid disease, diabetes, rheumatologic diseases, epilepsy, kidney disease, liver disease, heart disease, cancer, and human immunodeficiency virus infection.
§Other pregnancy complications include placental abruption, oligohydramnios, polyhydramnios, isoimmunization, intrauterine growth restriction, incompetent cervix, cervical cerclage, or placenta previa.
‖A continuous score from 0 to 100.
¶$P<.002$ for comparison of preterm with term delivery.

represented a physical function score of 85 or lower. Women with a score above this threshold were considered to have normal function. Because a greater range of physical function was reported during pregnancy, physical function during pregnancy was analyzed as a continuous score. Multivariate models also accounted for the site of care.

RESULTS

RESPONSE AND RETENTION RATES

Of the 2854 women who were potentially eligible to participate in this study, 1809 participated and 1045 refused (actively or passively) for a response rate of 63%. Of these women, 1648 (91%) subsequently delivered an infant at 1 of the participating hospitals (the remainder had a spontaneous abortion or therapeutic abortion or delivered elsewhere). Twenty-three women with a multiple-gestation birth and 6 women who described their race and ethnicity as Native American were excluded from this analysis, leaving a sample of 1619. Of these women, 1581 (98%) completed subsequent surveys during pregnancy. Respondents at baseline and nonrespondents were of similar age. Nonrespondents were more likely ($P<.05$) than respondents to be Asian American (23.9% vs 14.5%) and less likely to be African American (11.3% vs 18.3%), Latina (30.5% vs 35.3%), or white (20.6% vs 31.6%).

CHARACTERISTICS OF THE SAMPLE

The rate of preterm delivery was 8.0% (**Table 1**). The majority of women had a prior pregnancy, were born in

the United States, and were married or living with a partner. The cohort was ethnically and socioeconomically diverse. Approximately one quarter of the sample did not exercise prior to pregnancy. In unadjusted analyses, African American women were more likely than white women to have a preterm delivery. Education, BMI, tobacco use, chronic medical problems prior to pregnancy, pregnancy complications, poor physical function prior to pregnancy, and depressive symptoms prior to or during pregnancy were each associated with the unadjusted odds of preterm delivery.

RISK FACTORS FOR PRETERM DELIVERY

After adjustment for age and other sociodemographic characteristics (**Table 2**, Model 1), African American women were more likely than white women to experience a preterm delivery (odds ratio [OR], 1.94; 95% confidence interval [CI], 1.07-3.51). There were no significant differences between whites and Latinas or Asian Americans in the rate of preterm delivery. After adjustment for prepregnancy risk factors (Model 2), the difference in the risk of preterm delivery between African American and white women diminished in magnitude (OR, 1.72; CI, 0.93-3.17). Several indicators of prepregnancy health status were associated with an increased risk of preterm delivery, including underweight BMI (OR, 2.38; CI, 1.04-5.48), a history of chronic hypertension (OR, 3.12; CI, 1.94-5.02), poor prepregnancy physical function (OR, 2.31; CI, 1.41-3.77), and smoking before pregnancy (OR, 2.20; CI, 1.29-3.75). Depressive symptoms before pregnancy were not associated with the risk of preterm delivery. Most of these prepregnancy factors remained significantly associated with the risk of preterm delivery after adjusting for risk factors that occurred during pregnancy (Model 3). Smoking, pregnancy-associated hypertension, and other pregnancy-associated complications were significantly associated with an increased risk of preterm delivery.

Using the model that included demographic, prepregnancy, and pregnancy factors (Model 3), we estimated the relative contributions of each group of factors to the variation in the risk of preterm delivery: demographic characteristics alone contributed 13.0% of the variation in the risk of preterm delivery, whereas prepregnancy characteristics contributed 39.8% and risk factors that occurred during pregnancy contributed 47.1%.

COMMENT

The results of this large prospective study offer a broader perspective on maternal risk factors for preterm delivery. We observed that several prepregnancy risk factors were as important as pregnancy-specific risk factors in explaining a woman's risk of preterm delivery. While prenatal care and other interventions during pregnancy can address conditions that occur during pregnancy, they are not designed to address the cumulative burden of poor physical function before pregnancy. Interventions and policies directed at improving access to care during pregnancy may fall short of the goal of reducing preterm delivery because they cannot address this legacy of poor health status and health behaviors.

Other studies support our finding that it is important to consider a broader perspective of risk factors for preterm delivery. Our finding that a low prepregnancy BMI is associated with an increased risk of preterm delivery, perhaps related to inadequate nutritional status, has been previously observed.[38] Women who themselves were of low birth weight are at an increased risk for having a low-birthweight infant.[39] Although the factors that mediate this continuity of risk are unknown, low birth weight is associated with the subsequent development of impaired glucose tolerance and hypertension in adulthood,[40,41] and both of these conditions are risk factors for adverse birth outcomes.[24,25]

In addition to examining the association of chronic conditions and health behaviors with the risk of preterm delivery, we examined patient-reported measures of physical function and depressive symptoms. Patient-reported measures of health status are increasingly being incorporated into clinical care and research and were developed to complement more traditional provider-determined physiologic and clinical outcomes.[42-44] The results of the current study extend our earlier finding that poor self-reported physical function is associated with the occurrence of preterm labor.[45] Conversely, report of depressive symptoms before or during pregnancy was not associated with the risk of preterm delivery. Further work should consider whether self-reported physical function could be used prospectively to identify women who would benefit from preconception interventions to prevent prematurity.

Our findings have several potential limitations. First, women retrospectively recalled their prepregnancy health status during early pregnancy. Importantly, this information was obtained early in pregnancy, well before delivery. The prepregnancy health status reported by these women was, if anything, better than that reported in normative data for women of reproductive age.[32] In addition, the retrospective recall of these health-status measures have been shown to be reliable during a 1-year period.[46] Second, the associations observed are not causal. Both prepregnancy health status and the risk of preterm delivery may be associated with an earlier exposure, perhaps in utero.[40,47] Third, the initial response rate of 63% may limit the generalizability of our findings. This response rate is similar to that observed in other pregnancy cohorts.[48] Retention in our cohort was very high. Finally, we only examined maternal risk factors that occurred during the immediate preconception period. Future work should examine the role of maternal risk factors from a life-course perspective.[35]

These findings suggest that interventions to reduce the rate of preterm delivery may need to start before pregnancy. Presently, preconception care is strongly endorsed only for women with specific medical conditions, notably diabetes.[49] Since almost half of the pregnancies in the United States are unintended,[50] improving birth outcomes may require improving the health status of all women without regard to their plans for conception. Several studies have examined the effect of public health insurance programs that provide health care coverage during pregnancy. While some of these studies demonstrate an increase in enrollment,[51] the effects of these pro-

Table 2. Factors Associated With the Risk of Preterm Birth*

	Model 1†	Model 2‡	Model 3§
Race			
White	1	1	1
African American	1.94 (1.07-3.51)	1.72 (0.93-3.17)	1.57 (0.84-2.94)
Latina	1.11 (0.58-2.11)	1.21 (0.63-2.34)	1.03 (0.53-2.02)
Asian American	1.07 (0.55-2.12)	1.01 (0.50-2.01)	0.87 (0.42-1.77)
Place of birth			
United States–born	0.85 (0.51-1.41)	0.71 (0.42-1.21)	0.61 (0.35-1.05)
Foreign-born	1	1	1
Education			
Did not complete high school	1.82 (0.92-3.59)	1.10 (0.54-2.25)	1.22 (0.60-2.51)
High school graduate or some college	1.68 (1.01-2.79)	1.18 (0.70-1.99)	1.15 (0.68-1.96)
College graduate or higher	1	1	1
Parity			
Nulliparous	1.26 (0.85-1.87)	1.19 (0.79-1.79)	1.14 (0.75-1.73)
Parous	1	1	1
Body mass index before pregnancy			
Underweight	NA	2.38 (1.04-5.48)	2.30 (0.96-5.53)
Normal weight	NA	1	1
Overweight	NA	0.81 (0.49-1.34)	0.77 (0.46-1.28)
Obese	NA	1.14 (0.69-1.89)	0.97 (0.58-1.65)
Physical function before pregnancy			
Poor	NA	2.31 (1.41-3.77)	1.97 (1.18-3.30)
Not poor	NA	1	1
Depressive symptoms before pregnancy			
Yes	NA	1.21 (0.71-2.08)	1.09 (0.60-1.96)
No	NA	1	1
Hypertension before pregnancy			
Yes	NA	3.12 (1.94-5.02)	1.77 (1.02-3.06)
No	NA	1	1
Other chronic medical conditions before pregnancy			
Yes	NA	1.46 (1.00-2.13)	1.47 (0.99-2.17)
No	NA	1	1
Smoker			
Yes	NA	2.20 (1.29-3.75)	2.02 (1.14-3.59)
No	NA	1	1
Exercised during the month before pregnancy			
Yes	NA	1	1
No	NA	1.21 (0.79-1.86)	1.24 (0.79-1.92)
Gestational diabetes			
Yes	NA	NA	1.51 (0.73-3.11)
No	NA	NA	1
Pregnancy-associated hypertension			
Yes	NA	NA	3.17 (1.87-5.37)
No	NA	NA	1
Other pregnancy complications			
Yes	NA	NA	2.24 (1.33-3.78)
No	NA	NA	1
Adequacy of prenatal care			
Inadequate	NA	NA	1.71 (0.94-3.13)
Intermediate or adequate	NA	NA	1
C statistic	0.61	0.68	0.74

Abbreviation: NA, not applicable.
*Data are presented as odds ratio (95% confidence interval).
†Adjusted for age, country of birth, race/ethnicity, level of education, parity, and site of care.
‡Adjusted for age, country of birth, race/ethnicity, level of education, parity, site of care, body mass index, physical function prior to pregnancy, depressive symptoms prior to pregnancy, chronic medical conditions, level of exercise during the month prior to pregnancy, and smoking status prior to pregnancy.
§Adjusted for age, country of birth, race/ethnicity, level of education, parity, site of care, body mass index, physical function prior to pregnancy, depressive symptoms prior to pregnancy, chronic health conditions prior to pregnancy, level of exercise during the month prior to pregnancy, smoking status prior to pregnancy, smoking status during pregnancy, physical function during pregnancy, depressive symptoms during pregnancy, eclampsia or preeclampsia during pregnancy, gestational diabetes, other pregnancy complications, use of illicit drugs during pregnancy, and inadequate prenatal care.

grams on birth outcomes have been limited.[29-31] The care of women of reproductive age in the United States is fragmented; women generally seek care for family planning, obstetrics, and general medical care from different providers, often with poor coordination of care.[52] The provision of health insurance coverage to all women of reproductive age, for example, may result in greater improvements in the rate of preterm delivery than cov-

erage directed at women only once they become pregnant. Sweden's universal health care access program, for example, has been associated with fewer social disparities in birth outcomes.[53]

In conclusion, this study suggests that maternal health status prior to pregnancy is associated with the risk of preterm delivery. Improving the rates of preterm delivery may require attention to the health status of women before pregnancy.

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