Maternal Underweight Status and Inadequate Rate of Weight Gain During the Third Trimester of Pregnancy Increases the Risk of Preterm Delivery[1,2]

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ABSTRACT This study examines the differences in the pattern of weight gain according to trimesters of pregnancy for women who delivered term vs. preterm and analyzes the independent effect of prepregnancy weight status and rate of weight gain on delivering preterm. The differential effects of these variables on the etiological pathways of prematurity (preterm labor and preterm rupture of the amniotic membranes) were also examined. Data were collected prospectively from 7589 pregnant women receiving care in public health clinics in the West Los Angeles area. Eighty percent of women identified themselves as being of Hispanic origin. Multivariate logistic regression techniques were used to isolate the role of each nutritional variable from other factors that may influence birth outcome. Women who delivered preterm had patterns of weight gain similar to women delivering term infants. Underweight status (body mass index <19.8 kg/m^2) before pregnancy nearly doubled the likelihood of delivering preterm [adjusted odds ratio (AOR) 1.98, 95% confidence interval (CI) = 1.33, 2.98). Inadequate weight gain in the third trimester defined as <0.34, 0.35, 0.30 and 0.30 kg/wk for underweight, normal weight, overweight and obese women, respectively, increased the risk by a similar magnitude (AOR 1.91, 95% CI = 1.40, 2.61). Slight differentiation of these risk factors occurred when analyzing the etiological pathways of preterm birth. Preconceptional nutrition counseling and promotion of adequate weight gain during the third trimester of pregnancy should be components of public health programs designed to decrease the prevalence of preterm birth. J. Nutr. 126: 146–153, 1996.

INDEXING KEY WORDS:

- *prematurity* • *pregnancy*
- *anthropometry* • *Hispanic women*

Prepregnancy weight status and the rate of weight gained during pregnancy have been associated with adverse pregnancy outcomes. Underweight status before pregnancy defined in various ways [i.e., <45 kg, <54 kg, <90% of ideal body weight for height using the Metropolitan Life Tables, or body mass index (BMI, kg/m^2)[4] <19.8] has been shown to nearly double the risk of delivering preterm (Ferraz et al. 1990, Kalkwarf 1991, Kaminski et al. 1973, Kramer 1987, Scholl et al. 1989). Recently, several large-scale epidemiological studies have shown that inadequate weight gain in the second half of pregnancy (after 20–24 wk of gestation) is associated with a preterm birth (Abrams et al. 1989, Hediger et al. 1989, Kalkwarf 1991, Wen et al. 1990). However, these studies have not adequately controlled for several potential confounders, such as maternal physical and emotional stress and/or iron status, which have been shown to be associated with a preterm birth (Lieberman et al. 1987, Muscati et al. 1988). In addition, a preterm birth has routinely been defined as delivering before 37 wk regardless of the predisposing factor, i.e., preterm labor, preterm premature rupture of the amniotic membranes (preterm PROM)[5] or medical induction. In failing to separate the etiological pathways, valuable information that could aid in our understanding of the pathophysiology of a preterm birth may be lost.

The aims of this study were as follows: *1*) to investigate the differences in prepregnancy weight status

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[4] Abbreviations used: AOR, adjusted odds ratio; BMI, body mass index; CI, confidence interval; PROM, premature rupture of amniotic membranes; RR, relative risk.

[5] Preterm PROM is a delivery before 37 completed weeks with spontaneous rupture of the amniotic membranes occurring before the onset of labor.

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and the pattern of weight gain between women who deliver term vs. preterm; 2) to test the hypothesis that inadequate weight gain in the third trimester, based on a definition that was prepregnancy weight status specific, is predictive of a preterm birth; and 3) to determine whether the effect of prepregnancy weight status and inadequate weight gain differed according to the etiological pathways of a preterm birth. In addition, we wanted to estimate the public health impact of resolving underweight status and poor rate of weight gain in this population.

MATERIALS AND METHODS

Data were collected prospectively from 9651 pregnant women receiving prenatal care in the public health clinics in the West Los Angeles area from 1983 to 1987. Women in this cohort were eligible to participate in the Prematurity Prevention Project (Hobel et al. 1994, Ross et al. 1994). The original research project and this substudy were approved by the Institutional Review Boards at Harbor/UCLA Medical Center and the University of North Carolina School of Public Health. Beginning with the first prenatal visit, information on all women attending the selected clinics was entered into the project's data base. The database contains information from discrete medical, nutritional and psychosocial assessments. Women were asked their country of origin, number of years living in the United States and racial identity as part of the psychosocial assessment.

Sample

For the present analysis, women with their first pregnancy in the project were eligible (915 women had >1 pregnancy during the study period and 1030 women were lost to follow-up[6]). From this sample of 7706, we excluded 12 cases because of mismatched prenatal and birth outcome files, 1 case because of an unreasonable gestational age (62 wk) and cases where pregnancies resulted in stillbirths (n = 52) or multiple births (n = 52). This reduced the eligible sample size to 7589 of which 517 were preterm births. For the analysis of the pathways leading to a preterm birth, women were divided into three subgroups: term, preterm PROM and preterm labor. Medical inductions, whether term or preterm, were excluded from this analysis (n = 220 of which 21 were preterm) because of the wide array of medical problems that occur in these women. There were 107 preterm deliveries for which the details of the timing of membrane rupture or start of labor contractions were unavailable. We excluded these deliveries in the pathway analysis to maximize the likelihood of being able to distinguish risk factors for preterm PROM and preterm labor. The sample sizes of 6873 term, 95 preterm PROM and 294 preterm labor deliveries were the initial samples eligible for the pathway analysis.

Birth outcome measure

Length of gestation was determined from the onset of the last menstrual period or obstetrical estimate based on ultrasound results. Upon completion of the study, the charts of all infants born before 38 wk were reviewed for accuracy of gestational age. At that time a gestational age value was assigned, which took into account the concordance between fundal height measurements, ultrasound results and Dubowitz scores. Preterm labor was defined as a delivery before thirty-seven completed weeks with the onset of labor as the precipitating event, before membrane rupture and preterm PROM as a delivery before thirty-seven completed weeks with spontaneous rupture of the amniotic membranes before the onset of labor. A term birth was defined as delivery after thirty-seven completed weeks of gestation.

Newborns were classified as growth-retarded (birth weight less than the sex-specific 10th percentile for a given gestational age) using reference values from the state of California (Williams et al. 1982).

Primary exposure variables

Prepregnancy weight was based on self-report obtained at the initial visit. Weight status groups were defined using the BMI cutoff points recommended by the Institute of Medicine (1990) (<19.8 kg/m^2 underweight, 19.8–26 kg/m^2 normal weight, 26–29 kg/m^2 overweight, and >29 kg/m^2 obese). Maternal weight was measured at each prenatal visit. Weight gain was expressed as the total amount of weight gained in the first trimester and as the rate of weight gained per week (kg/wk) in the second and third trimesters for all women. Previous descriptive analyses on weight gain in this population indicated that the pattern of weight gain was linear from 10 wk of gestation until delivery (Siega-Riz et al. 1994). Because the gain is linear, weekly weight gain comparisons for term and preterm deliveries are valid. Women were classified as having inadequate third trimester weight gain if their rate of weight gain was less than the 25th percentile of gain in each prepregnancy weight status group (0.34 kg/wk, underweight; 0.35 kg/wk, normal weight; 0.30 kg/wk, overweight and obese women). Details for the justification of this definition of in-

[6] Women lost to follow-up left the prenatal care setting after a minimum of two visits, one of which included a physical exam, but no birth outcome information was available. Descriptive analysis showed women lost to follow-up were slightly younger and more highly educated than those who completed the study.

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TABLE 1

Selected characteristics of women with missing prepregnant BMI, Hematocrit at 28–32 wk or rate of weight gain during the third trimester compared with women with complete data

	Missing data			
	Prepregnant BMI[1]	Hematocrit	Rate of weight gain	None
Sample size, *n*	1482	1207	1402	4352
Age, *y*	25.0 ± 5.6[2]	25.3 ± 5.7	25.4 ± 5.8	24.8 ± 5.5
Education, *y*	6.9 ± 3.6	8.2 ± 3.9	8.6 ± 3.9	8.2 ± 3.7
Primiparous, %	32.3	30.6	29.1	36.8
Prepregnant BMI	NA	24.6 ± 4.8	24.4 ± 4.9	24.4 ± 4.5
Initial hematocrit	0.35	0.36	0.36	0.35
Rate of weight gain 2nd trimester, *kg/wk*	1.11 ± 0.99	1.17 ± 0.98	1.14 ± 1.0	1.17 ± 0.85
Gestational age, *wk*				
First visit	20.3 ± 7.0	17.7 ± 6.8	16.6 ± 6.3	18.9 ± 7.4
Last visit	34.2 ± 5.9	31.5 ± 8.2	23.6 ± 6.5	36.8 ± 2.6
Delivery	39.8 ± 2.1	39.7 ± 2.3	39.2 ± 3.5	40.1 ± 1.8
Infant				
Weight, *g*	3439 ± 553	3411 ± 570	3298 ± 711	3455 ± 517
Length, *cm*	50.8 ± 2.7	50.5 ± 3.5	49.9 ± 4.4	51.1 ± 10.1
Preterm, %	7.1	7.7	15.4	4.6

[1] BMI = body mass index, kg/m^2.
[2] Values are means ± SD.

adequate weight gain and reliability of the prepregnancy weight variable for this population are given in a previously published report (Siega-Riz et al. 1994).

Selected covariates

Anemia, defined as a hematocrit less than 0.33 taken at 28–32 wk of gestation, was found in approximately 10% of the population. Anemia at this point in gestation is significantly predictive of a preterm birth [crude relative risk (RR) = 1.83; 95% confidence interval (CI) = 1.21, 2.77]. Univariate results also demonstrated a significant relationship between anemia and underweight status before pregnancy (crude RR = 1.35; 95% CI = 1.09, 1.69). The relationship between anemia and inadequate weight gain during the third trimester (crude RR = 1.17; 95% CI = 0.98, 1.39) was not significant, but previous analysis showed that women with anemia had a significantly lower rate of weight gain in the third trimester compared with women with a hematocrit in the normal range (0.33–0.40) (Siega-Riz, Adair & Hobel unpublished data).

Stress has been previously reported in the literature to affect maternal weight gain (Muscati et al. 1988). To obtain a measure of physical and emotional stress for this population, each question from the psychosocial questionnaire administered at entry into prenatal care was tested for an association with the main exposures and birth outcome. Only two questions, which represent a form of emotional stress, were associated with inadequate weight gain and preterm birth. These included wantedness of the pregnancy (crude RR = 0.66; 95% CI = 0.45, 0.95 for preterm birth and crude RR = 0.78; 95% CI = 0.60, 1.02 for inadequate weight gain) and currently living with the father of the baby (crude RR = 0.77 95%; CI = 0.65, 0.92 for preterm birth and crude RR = 0.86; 95% CI = 0.77, 0.96 for inadequate weight gain). These univariate results indicated that wanting to be pregnant and living with the baby's father were protective against both inadequate weight gain during the third trimester and having a preterm birth. Because inadequate weight gain, underweight status, stress and poor iron status may co-occur, we included separate terms representing the two stress questions and anemia in the models to adjust for confounding.

A variable representing the combination of maternal age and parity was also used in the models. Women who were primiparous <19 y, primiparous 19–34 y, primiparous >35 y, multiparous <19 y and multiparous >35 y were compared with women who were multiparous in their prime childbearing ages (19–34 y).

Missing data

Not all women with a known pregnancy outcome had complete data for the independent variables of interest. In **Table 1,** selected characteristics for women who were missing a prepregnant BMI, hematocrit at 28–32 wk or rate of weight gain in the third trimester were compared with women with data available for these variables. Women missing a rate of weight gain had a higher percentage of preterm births and, on the average, started prenatal care the earliest. Women

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missing a prepregnant BMI had less education. Losses of cases with missing information may lead to biased estimates of the effects of different risk factors, because excluded women may differ in both measurable and unmeasurable ways from those with complete information. We tested for selectivity bias by developing a model in which the likelihood of having missing data was estimated from baseline maternal sociodemographic factors (i.e., race, age, parity and marital status), gestational age of the first prenatal visit and gestational age at the last prenatal visit. This model was jointly estimated with the equation of primary interest (preterm births) (Limdep, Version 6, Econometrics Software, Bellport, NY). This procedure has been previously described by Maddala (1983) and Meng and Schmidt (1985). These results showed that the correlation between error terms from the two equations was not statistically significant, indicating that exclusion of cases with missing data did not bias estimates in the preterm birth models. In fact, the results using this strategy and the logistic results based on women with complete data were similar, indicating the robustness of our findings. Therefore, for the multivariate analysis and simulations, we used the sample with nonmissing BMI, weight gain and hematocrit data ($n = 4352$).

Statistical analysis

Student's t test for continuous variables and chi-square statistics for categorical variables were used to determine significant differences between mothers who delivered term and preterm (SAS/STAT, Version 6, SAS Institute, Cary, NC). To compare the weight gain distribution between term and the types of preterm birth, total weight gained by gestational age was plotted, and regression lines were fitted to the data (Harvard Graphics, Version 3.0, SPC Software, Mountain View, CA). The Mantel Extension was used to test whether the odds in successive BMI groups associated with preterm births increased or decreased when compared with a baseline group (Schlessman 1983). For this purpose, the women with a BMI greater than 29 kg/m^2 (obese group) served as the baseline group because their exposure rate was the lowest. Multivariate logistic regression (Hosmer and Lemeshow 1989) was used to isolate the role of prepregnant weight status and adequacy of weight gain from other factors that may influence birth outcome (Stata, Version 3.1, Stata Corporation, College Station, TX). Bivariate analysis and information from the literature were used to help define the form of the variables. Two sets of models were developed separately, one for preterm vs. term births in general and a second for the types of preterm birth vs. term births. To determine whether the effect of prepregnant weight status differed according iron status, an interaction term was tested in the models and retained if the P value was <0.10.

To facilitate interpretation of the multivariate results and to estimate the public health impact of our findings, predicted probabilities of the outcome were calculated only for women included in the multivariate analysis. The effects of selected risk factors commonly found in public health prenatal clinics (i.e., an underweight teenager with anemia and inadequate rate of weight gain) were simulated by assigning values to these variables. The remainder of the variables are evaluated at the mean value for the population. The probability of delivering preterm is then computed for each simulation.

RESULTS

The population who received prenatal care from the West Los Angeles public health clinic was predominantly Hispanic (80%), married (61%), in prime child-bearing ages 18–34 (91%) and of low educational level (52% <8 years of education); 50% entered prenatal care between 10 and 20 wk of gestation. The prevalence of preterm births and intrauterine growth retardation in this population was 6.6 and 6.0%, respectively.

Women who delivered preterm were significantly lower in prepregnancy weight and as a result had a lower mean prepregnant BMI than women who delivered term (**Table 2**). In addition, mothers of preterm infants were less frequently married, more likely to smoke, to be African-Americans and had more occurrences of uterine bleeding and blood pressure abnormalities (chronic hypertension and/or pregnancy-induced hypertension) than mothers of term infants.

Weight gain patterns

Women who delivered preterm gained the same amount of weight in the first trimester and had a similar rate of weight gain in the second trimester as women who delivered term (refer to Table 2). However, differences in rate of weight gain were seen in the third trimester. Women who delivered term gained, on average, 30 g more per week than women who delivered preterm. The weight gain curves for term vs. the types of preterm deliveries, preterm labor and preterm PROM are shown in **Figure 1.** Regression lines fitted to the data illustrate the similarities in the rate of weight gain among all three groups.

Multivariate results

Results of the multivariate model comparing term and preterm births are shown in **Table 3.** While controlling for several covariates, an underweight status

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TABLE 2

Characteristics of preterm and term deliveries from the Prematurity Prevention Project (1983–1987)[1]

Characteristic	n	Preterm (n = 517)	n	Term (n = 7072)
Maternal age, y	517	24.9 ± 0.25	7072	24.9 ± 0.06
Age at menarche, y	504	12.1 ± 0.25	6877	11.9 ± 0.06
Primiparous, %	517	36.9	7065	34.4
Prepregnant weight, kg	419	57.6 ± 0.53	5780	59.0• ± 0.15
Height, cm	508	155.7 ± 0.33	6942	155.2 ± 0.07
Body mass index, kg/m^2	412	23.7 ± 0.22	5695	24.5• ± 0.06
Weight gain				
1st trimester, kg	148	1.4 ± 0.22	2112	1.2 ± 0.06
13–26 wk, kg/wk	393	0.51 ± 0.02	5405	0.53 ± 0.005
26 wk–delivery, kg/wk	301	0.50 ± 0.02	5886	0.53• ± 0.004
Hematocrit				
Initial	482	0.35	6638	0.35
Reevaluation	404	0.35	5797	0.36
Marital status, %				
Married	513	55.6	7026	62.8•
Single		41.9		35.2
Working at the initial visit, %	474	20.9	6717	21.8
Race, %	503		7026	
Hispanic		76.1		82.8
White (non-Hispanic)		8.7		8.9
African-American		10.3		4.9•
Asian		4.0		3.3
Maternal education, %				
<8 y	455	44.3	6311	52.4
>12 y		13.4		9.3
Entry into prenatal care, %	517		7069	
<13 wk		20.8		23.3
13–26 wk		66.3		61.7
>26 wk		12.9		15.0
Smoking, %	511	5.4	7028	3.8
Uterine bleeding, %	517	6.4	7072	0.3•
Vaginitis, %	513	20.3	7040	17.7
Diabetes, %	517	2.3	7072	2.9
Hypertension, %[2]	517	4.8	7072	2.5•
Edema, %	517	7.8	7072	14.8•

[1] Values are means ± SEM.
[2] Chronic or pregnancy-induced hypertension.
• Different from preterm, $P < 0.05$.

before pregnancy significantly doubled the risk of delivering preterm. There was a significant trend of increasing risk for preterm births associated with decreasing BMI ($\chi^2 = 15.4$, $P < 0.001$). Inadequate weight gain in the third trimester increased the risk of preterm birth by 90%. History of a preterm birth was not included in the model because underlying maternal characteristics that may have predicted a preterm birth previously are also represented in the present model. The two questions representing emotional stress were no longer confounders in the multivariate model and were thus dropped from the final model. Anemia status remained in the final model with an adjusted risk estimate of 1.89 and 95% CI = 1.26, 2.83. The interaction term testing a differential effect of prepregnancy weight status according to iron status was not significant.

We calculated the predicted probability of delivering preterm for a high risk profile commonly seen in the public health prenatal clinics. For a teenager who is underweight with a poor rate of weight gain in the third trimester and anemia after 28 wk of gestation, the probability of delivering preterm is 24%. If her prepregnancy weight status could have been improved (i.e., BMI to normal, 19.8–26 kg/m^2), the probability of preterm birth would be 13.7%, representing a reduction in risk of 43%. Furthermore, if her rate of weight gain in the third trimester was adequate, her chances of delivering preterm would be reduced by at least 67%. In another simulation, we resolved underweight status and inadequate weight for the entire population (all women in the multivariate analyses). This resulted in a 26% reduction in risk of preterm birth. In a more practical scenario, we resolved just

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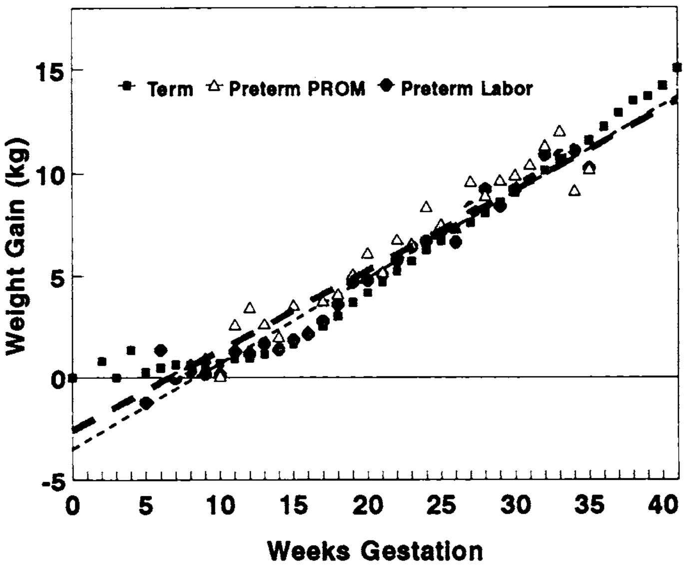

FIGURE 1 Gestational weight gain curves of women in the Prematurity Prevention Project who delivered term vs. type of preterm birth. Regression lines fitted to the data. PROM, premature rupture of amniotic membranes.

inadequate weight gain for the entire population and found a 17% drop in the rate of preterm birth.

Table 4 presents results from the multinomial model comparing the two types of preterm births (preterm labor and preterm PROM) with term births. An underweight status before pregnancy was predictive of both preterm labor and preterm PROM, with the effect on preterm PROM being slighter greater. The trend of increasing risk of preterm birth with decreasing BMI was seen for preterm labor deliveries only (χ^2 = 11.3, $P < 0.001$). An inadequate rate of weight gain in the third trimester increased the risk of preterm labor by 75% and more than doubled the risk of preterm PROM. Covariates kept in this model were the same as in the model of preterm vs. term births. The interaction term tested in the previous model was insignificant in this comparison as well.

DISCUSSION

An underweight status before pregnancy continues to be a positive predictor of preterm births. Its effect did not differ between the pathways. The trend for increasing risk of preterm birth with decreasing prepregnancy weight status has been documented in other populations of predominantly non-Hispanic origin (Garn 1991). However, we are the first to show that this trend appears for preterm labor deliveries and not for PROM deliveries. There was a slight increase in risk of preterm PROM for women of obese pregnancy weight status. However, our sample size for the preterm PROM group is small, and results should be interpreted with caution. Furthermore, our results indicate that to produce correct estimates of the relationship between prepregnancy weight status and preterm birth one must control for the confounding effects of anemia.

The biological basis for the adverse effect of prepregnancy underweight status can be twofold. First, expansion of the maternal fluid compartment may be dependent on age and size of the mother. Women with lower prepregnant weights may have less capacity for fluid expansion. In a case-control study of women who came in with preterm labor, researchers found cases had a significantly higher prevalence of underweight status before pregnancy and greater absence of edema than women who never had preterm labor (Frentzen et al. 1987). We also found a greater absence of edema

TABLE 3

Effects of prepregnant BMI and adequacy of weight gain during the third trimester on preterm births among women in the Prematurity Prevention Project[1]

Variable	n	Preterm births	AOR[2]	95% CI
		%		
Prepregnant BMI				
Normal 19.8–26 kg/m^2	2626	4.1	—	—
Under <19.8 kg/m^2	499	8.0	1.98	1.33, 2.98
Over 26–29 kg/m^2	641	4.4	1.16	0.75, 1.80
Obese >29 kg/m^2	586	4.0	1.07	0.67, 1.70
Rate of weight gain				
Adequate	3312	3.8	—	—
Inadequate[3]	1040	6.9	1.91	1.40, 2.61

[1] Adjusted for iron status, parity combined with maternal age, ethnicity, hypertension (chronic or pregnancy induced), smoking status and week prenatal care began.

[2] AOR = adjusted odds ratio; CI = confidence interval.

[3] <0.34, 0.35, 0.30 and 0.30 kg/wk for underweight, normal weight, overweight and obese women, respectively.

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TABLE 4

Effects of prepregnant BMI and adequacy of weight gain during the third trimester on the types of preterm delivery among women in the Prematurity Prevention Project[1,2]

Variable	Preterm labor			Preterm PROM		
	Prevalence	AOR[3]	95% CI	Prevalence	AOR	95% CI
	%			%		
Prepregnant BMI						
Under <19.8 *kg/m*^{2}	21	1.96	1.17, 3.27	25	2.70	1.19, 612
Over 26–29 *kg/m*^{2}	16	1.33	0.77, 2.30	3	0.22	0.02, 1.66
Obese >29 *kg/m*^{2}	8	0.73	0.36, 1.50	14	1.30	0.47, 3.53
Rate of weight gain						
Inadequate[4]	34	1.75	1.15, 2.64	42	2.70	1.35, 5.42

[1] Sample sizes: 4020 term, 36 preterm PROM, and 111 preterm labor. Compared with prevalences of 11% underweight, 60% normal weight, 15% overweight, 13% obese and 23% inadequate weight gain for women who delivered term.

[2] Adjusted for iron status, parity combined with maternal age, ethnicity, hypertension (chronic or pregnancy induced), smoking status and week prenatal care began.

[3] AOR = adjusted odds ratio; CI = confidence interval.

[4] <0.34, 0.35, 0.30 and 0.30 kg/wk for underweight, normal weight, overweight and obese women, respectively.

among women who delivered preterm compared with term. Furthermore, Goodlin et al. (1981) has shown that 60% of women in their sample with preterm labor or PROM had plasma volume measurements <3 SD below the mean of normal pregnant women. Second, underweight status also serves as an indicator of chronic undernutrition, which may have occurred as early as childhood. Therefore, in women of underweight status, macro- and micronutrient supplies are potentially limited. The availability of these nutrients may be essential during the beginning stages of embryonic and placenta development.

We confirm the results of several large-scale epidemiological studies that show that inadequate weight gain during the second half of pregnancy is associated with a preterm birth (Abrams et al. 1989, Hediger et al. 1989, Kalkwarf 1991, Wen et al. 1990). An important contribution of this study was the definition of adequacy based on prepregnancy weight status, the consideration of various confounders and the ability to narrow down the time frame to the 26th wk of gestation until delivery. There is no clear biological mechanism to support a causal role of poor gestational weight gain, but weight gain may be a marker of risk for preterm births. Inadequate weight gain may well be a reflection of a poor dietary intake during pregnancy (Luke et al. 1981, Scholl et al. 1991, Scholl et al. 1993).

Frentzen et al. (1987) has proposed that there is a relationship between a suboptimal nutritional state, combined with skipped or inadequate meals, and the local production of prostaglandin, which eventually triggers the events leading to a preterm birth. There is evidence from animal studies that supports this theory (Binienda et al. 1989, Fowden and Silver 1983, Silver and Fowden 1982), and our results would appear to indicate that this may be true. However, more studies are needed concerning the effect of different meal patterns on birth outcomes.

Maternal stress, as measured in this study, did not confound the relationship between inadequate weight gain and preterm births in the multivariate analysis. This finding may have occurred because our study used one questionnaire that combined several constructs of psychosocial well-being and did not use an established scale to measure stress. Hickey and colleagues (1995) have shown through the use of several indices of psychosocial well-being that poor scores in high trait anxiety, increased levels of depression, low mastery and low self-esteem are highly predictive of lower maternal weight gains among white women delivering term. These associations should be explored in the future for preterm deliveries.

A uniqueness of this study is the large sample size of Hispanic women. Our sample came from a population of predominantly low income, recent Hispanic immigrants attending public health clinics in the West Los Angeles area. Though these results may not be generalizable to all women, it provides valuable information on a minority population that is growing rapidly in the United States.

The results presented here lend support to the importance of maternal nutritional status before conception and during pregnancy on delivering preterm. The nutritional status of women is a modifiable risk factor that can be mediated through interventions designed to alter energy intakes and expenditures. Our predicted probabilities demonstrated that a high risk woman's chance of delivering preterm could be cut substantially with normal weight status before pregnancy and adequate gestational weight gain. In addition, a 17% reduction in the risk of preterm birth would occur in

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this predominantly Hispanic population if inadequate weight gain alone was resolved. These simulations provide an approximation of the magnitude of the effect if the nutritional risk factors were resolved independently of any other risk factor. In reality, any nutrition intervention is likely to have multiple effects that could change the overall risk of preterm birth. Considering the fact that prematurity is a major contributor to infant mortality, such reductions in preterm birth could have a significant public health impact on the infant mortality rate.

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