Implications of the Institute of Medicine Weight Gain Recommendations for Preventing Adverse Pregnancy Outcomes in Black and White Women

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ABSTRACT

Objectives. This study examined the relation between gestational weight gain and risk of delivering a small-for-gestational-age or large-for-gestational-age infant by race, along with the implications of gaining weight according to the Institute of Medicine guidelines.

Methods. Logistic regression methods were used to identify risk factors for small- and large-for-gestational-age births among 2617 Black and 1253 White women delivering at the Johns Hopkins Hospital between 1987 and 1989.

Results. Rate of total weight gain was related to risk of small- and large-for-gestational-age births; the relationship differed according to maternal body mass index but not race. No differences in outcome by race were evident for women with low body mass indexes; among those with average or high indexes, however, Black women were at higher risk of small-for-gestational-age births and at lower risk of large-for-gestational-age births.

Conclusions. Having Black women gain at the upper end of the recommended range is unlikely to produce measurable reductions in small-for-gestational-age births. Some beneficial reductions in the risk of large-for-gestational-age births may occur if weight gain recommendations are lowered for average-weight and overweight White women. (*Am J Public Health*. 1998;88:1168–1174)

Introduction

In 1990, the Institute of Medicine published guidelines for gestational weight gain based on a woman's prepregnancy body mass index (weight in kilograms divided by height in meters squared).[1] Women entering pregnancy with a body mass index of less than 19.8 kg/m^2 should gain 12.7 to 18.2 kg, those with an index between 19.8 and 26.0 kg/m^2 should gain 11.4 to 15.9 kg, and those with an index between 26.1 and 29 kg/m^2 should gain 6.8 to 11.4 kg. For women with a body mass index of more than 29.0 kg/m^2, only a lower threshold of 6.0 kg was specified. It was also recommended that adolescents and Black women gain at the upper end of the recommended ranges.

The Institute of Medicine urged researchers to investigate the usefulness of the weight gain recommendations for preventing adverse pregnancy outcomes across populations and within specific ethnic groups.[1] Since then, studies have evaluated the institute's recommendations for decreasing the risk of low as well as high birthweight and cesarean delivery.[2–6] Questions remain, however, regarding the benefits of race-specific weight gain recommendations.

We have shown previously that only one third of women delivering at Johns Hopkins Hospital gain the recommended amounts of weight during pregnancy, with Black women more likely to undergain and White women more likely to overgain.[7] To understand the implications of these findings, we examined the relation between weight gain and pregnancy outcome among Black and White women delivering at that hospital. We addressed 4 questions: (1) Does weight gain influence the risk of delivering a small-for-gestational-age or large-for-gestational-age infant? (2) Do risks differ by prepregnancy body mass index or race? (3) Should Black women be advised to gain at the upper ends of the recommended weight gain ranges? and (4) What would be the impact on the incidences of small- and large-for-gestational-age births if women gained the recommended amounts of weight, and how would this compare with other interventions such as smoking prevention or optimizing prepregnancy body mass index?

Methods

The Johns Hopkins Hospital obstetric database contains information on deliveries of all live-born infants at the hospital between 1987 and 1989. The data were abstracted from clinical records at discharge by trained personnel. For analyses, we identified all Black or White women giving birth over the 3-year period who had singleton pregnancies of at least 28 weeks' duration and who provided information on prepregnancy weight, height, and total gestational weight gain. Of 6566 pregnancies, 2421 were excluded as a result of missing values for these variables, 98 were excluded owing to improbable information, and 24 were excluded owing to non-Black/non-White ethnicity. A computer program randomly chose one delivery per woman to remain in the sample, resulting in a final sample of 3870 independent deliveries.

Analyses comparing births included in the sample with those excluded showed

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This paper was accepted February 17, 1998.

many statistical differences resulting from the large sample size but only a few differences of practical significance. There were no differences in maternal race. However, excluded women were more likely to be multiparous service patients with little or no prenatal care, and they were twice as likely to deliver a small- or large-for-gestational-age infant. Thus, the analytic sample was at somewhat lower risk than the general Johns Hopkins Hospital obstetric population.

Maternal height and prepregnancy weight were self-reported. Women were classified into categories according to their body mass index: less than 19.8 kg/m^2 (thin), 19.8 to 26.0 kg/m^2 (average), 26.1 to 29.0 kg/m^2 (overweight), or more than 29.0 kg/m^2 (very overweight).[1] Because few overweight women delivered small-for-gestational-age infants (n = 19), overweight and very overweight women were combined for analyses. This was reasonable because the 2 groups had similar recommended weight gains,[5,6] and preliminary analyses indicated that the groups were comparable in terms of weight gain[7] and the relation between weight gain and pregnancy outcome. Women were weighed at each visit, and total weight gain was calculated as the difference between prepregnancy weight and final recorded weight before delivery. For analyses, we used rate of weight gain, calculated as total weight gain (in grams) divided by duration of pregnancy (date of delivery minus date of last menses).

Birthweights were compared with a reference distribution of birthweights by week of gestation.[8] Infants considered small for their gestational age had birthweights at less than the 10th percentile for their week of gestation and sex. Infants considered large for their gestational age had birthweights above the 90th percentile for their week of gestation; girls and boys were not considered separately, because sex-specific values were not available.[8] Infants with birthweights between the 10th and 90th percentiles were considered to be of adequate weight for gestation. Examining outcomes in terms of fetal growth adequacy as it related to rate of weight gain adjusted up front for duration of pregnancy. Duration of pregnancy did not remain in the final regression models, thus validating the use of this adjustment strategy.

Other variables considered during analyses included maternal race, age, parity, years of schooling, smoking, provider type, diabetes, hypertension, and the sex of the fetus. Maternal race was self-reported. Smoking (yes/no) was defined on the basis of maternal reporting of at least one cigarette per day. For diabetes and hypertension, preexisting and gestation-related cases were combined. Provider types were managed care, service, and private.

Characteristics of women delivering small- or large-for-gestational-age infants were compared with those of women delivering adequate-weight-for-gestational-age infants via *t* tests and χ^2 tests. Analyses were stratified by prepregnancy body mass index and race. Distributions of continuous variables were also categorized into quantiles and recompared across categories of pregnancy outcome. Exploratory analyses indicated, for example, that maternal age should be kept as a continuous variable and that it was reasonable to treat smoking as a dichotomous variable. Furthermore, over the range of observed weight gains, the effect of increasing weight gain on the frequency of each pregnancy outcome within body mass index strata was constant or incremental and did not differ in magnitude or statistical significance by race.

Logistic regression models were developed to identify determinants of delivering a small- or large-for-gestational-age infant, as opposed to an adequate-weight-for-gestational-age infant, within each prepregnancy body mass index stratum. Because of the body mass index range within each stratum, body mass index was also included as a continuous variable. Full models were fitted, and these models included most known risk factors for small- and large-for-gestational-age births.[1] Factors were retained in each model with $P < .05$ as the criterion for significance; for consistency, however, risk factors significant in one model were retained in the other 2 models. Interaction terms, including product terms for each variable with race and weight gain, were tested for inclusion in the models ($P < .15$). Few interaction terms were identified, and, because their contribution to the overall χ^2 value was marginal and had little influence on the interpretation of the findings, interactions were dropped from the final models. Odds ratios and their 95% confidence intervals (CIs) were calculated from the 6 final models.

To describe the impact of variation in weight gain on the probability of delivering a small- or large-for-gestational-age infant, we graphed the probability of each outcome associated with weight gain in each of the models. Each outcome probability was the exponentiation of the logistic model formula, which was linear in the parameter estimates (multiplied by given values of the set of maternal or other characteristics influencing the likelihood of the outcome and divided by one plus the exponentiation of this quantity). We focused on predicted probability because the line's placement illustrated the overall probability of the outcome and the slope represented the expected impact of unit changes in weight gain. Differences in placement of the lines across strata also illustrated the effect of varying prepregnancy body mass index values. For presentation, we converted rate of weight gain to expected total weight gain at term by multiplying each rate by the average pregnancy duration of the sample (38.5 weeks).

We calculated the proportion of small- and large-for-gestational-age infants attributable to each of several modifiable risk factors[9] and estimated the expected impact on the incidences of such births if women gained weight within the recommended ranges for their body mass index. We also considered the impact of eradicating maternal smoking during pregnancy and decreasing the proportion of women entering pregnancy with body mass indexes of less than 19.8 kg/m^2 or greater than 26.0 kg/m^2. Estimates were made for each race and body mass index stratum separately. These estimates were then summed to allow consideration of differences in exposure by race and body mass index strata and to illustrate the differential impact on incidence by race associated with modifying prepregnancy body mass indexes.

Results

Within each body mass index stratum, Black women were younger and more likely to be service patients, to smoke during pregnancy, and to gain less total weight than White women (Table 1). Also, Black women were about twice as likely to deliver a small-for-gestational-age infant and one third as likely to deliver a large-for-gestational-age infant.

The unadjusted change in the relative odds of small- or large-for-gestational-age births associated with weight gain was constant within each body mass index stratum but varied across strata. Among thin women, each additional 50 g per week of weight gain (2.2 kg over the pregnancy) diminished the risk of a small-for-gestational-age birth by 18% (95% CI = 6%, 31%), whereas among overweight women, each additional 50 g per week diminished this risk only by 5% (95% CI = 0%, 14%). The risk of large-for-gestational-age births increased by 22% (10% to 34%) for each additional 50 g per week among thin women but only by 12% (6% to 17%) among overweight women. Across all strata, the effect of weight gain on pregnancy outcomes was not significantly different for Black and White women ($P > .15$).

Adjusted risks of delivering a small- or large-for-gestational-age infant (vs an infant

TABLE 1—Characteristics of 3870 Women Delivering at Johns Hopkins Hospital, According to Prepregnancy Body Mass Index (BMI) and Race

Characteristic	BMI < 19.8 kg/m²		BMI 19.8–26.0 kg/m²		BMI > 26.0 kg/m²	
	Black	White	Black	White	Black	White
No.	523	267	1479	796	615	190
Age, y, mean ± SD	21.7 ± 4.8	27.1 ± 6.6	22.7 ± 5.3	29.8 ± 5.8	24.9 ± 6.0	28.2 ± 5.5
Primiparous, %	52.4	55.4	50.1	48.0	36.9	46.9
Provider type, %						
Private	4.6	62.3	6.3	72.8	8.0	59.7
Managed care	8.3	9.7	11.4	6.0	10.8	10.5
Service	87.1	28.0	82.3	21.2	81.2	29.8
Height (in)	64.3 ± 2.8	65.3 ± 2.6	63.6 ± 2.7	64.5 ± 2.7	63.7 ± 2.7	64.6 ± 3.0
BMI, kg/m², mean ± SD	18.4 ± 1.0	18.5 ± 1.0	22.7 ± 1.8	22.1 ± 1.8	31.2 ± 4.8	31.2 ± 5.2
Total weight gain, kg, mean ± SD	13.3 ± 5.7	14.6 ± 5.1	13.6 ± 6.7	15.3 ± 5.4	12.4 ± 7.7	14.5 ± 7.3
Rate of weight gain, g/wk, mean ± SD	345 ± 142	376 ± 123	351 ± 171	395 ± 136	319 ± 198	372 ± 187
Smoking, %	32.8	20.6	35.4	20.0	28.8	25.4
Hypertension, %	4.3	3.0	6.0	5.7	11.9	17.0
Duration of pregnancy, wk, mean ± SD	38.2 ± 2.3	38.7 ± 2.4	38.4 ± 2.3	38.8 ± 2.2	38.8 ± 2.3	38.9 ± 2.3
Fetal growth, %						
SGA	9.9	5.6	6.6	3.1	7.0	5.3
AGA	86.9	85.0	89.2	83.8	85.2	65.2
LGA	3.2	9.4	4.2	13.1	7.8	29.5

Note. SGA = small for gestational age; AGA = adequate for gestational age; LGA = large for gestational age.

of adequate weight for gestational age) were calculated within each body mass index stratum (Table 2). After adjustment, increasing rates of weight gain still reduced the risk of small-for-gestational-age births and increased the risk of large-for-gestational-age births within each stratum. Maternal race no longer influenced the risk of either type of birth among thin women after adjustment, but it still differentiated risk among women with average and high body mass indexes.

Figure 1 shows the predicted probabilities of delivering small- and large-for-gestational-age infants associated with expected total weight gain at term for Black and White women in each body mass index stratum. First, within each stratum, increasing weight gain was associated with a decreased risk of delivering a small-for-gestational-age infant and an increased risk of delivering a large-for-gestational-age infant. For example, among thin women, the risk of delivering a small-for-gestational-age infant declined from 8.3% to 3.3% among Black women and from 7.7% to 3.0% among White women over the range of weight gain, while the risk of delivering a large-for-gestational-age infant increased from 1.0% to 4.7% among Black women and from 1.4% to 6.6% among White women. Second, the effect of weight gain varied by maternal body mass index. In comparison with the risk of small-for-gestational-age births for White women with low body mass indexes (described earlier), risks declined from 3.7% to 1.6% for White women with average body mass indexes and from 5.6% to 2.9% for White women with high indexes. Third, there were no differences in incidence by race for women with low body mass indexes. However, at higher body mass indexes, racial disparities in risk of small-for-gestational-age births increased, and more so for large-for-gestational-age births.

Effects of prepregnancy body mass index on pregnancy outcomes can be seen by examining how the predicted probabilities of small- and large-for-gestational-age births vary across the 3 graphs (Figure 1). Among White women, a body mass index of 19.8 to 26.0 kg/m² (vs an index of less than 19.8 kg/m²) was associated with a lower overall risk of delivering a small-for-gestational-age infant (2.7% vs 5.4% for a total weight gain of 12.5 kg), but an index of greater than 26.0 kg/m² did not diminish further the risk of such a birth (4.2% for a weight gain of 12.5 kg). Among Black women, the incidence of small-for-gestational-age births remained stable, changing from 5.9% to 5.4% and 6.0% as body mass index increased. The risk of large-for-gestational-age births was influenced more by prepregnancy body mass index. Again, for White women, the change in risk was greater, with the incidence (for a 12.5-kg gain) increasing from 2.6% to 6.8% to 12.0% across body mass index strata; for Black women, the incidence increased from 1.8% to 3.6% to 6.4%.

Predicted changes in the incidences of small- and large-for-gestational-age births associated with changes in weight gain were calculated and compared with the expected changes in incidence associated with optimizing prepregnancy body mass index or eradicating maternal smoking (Table 3). Trade-offs exist for preventing small- and large-for-gestational-age births associated with changes in weight gain, body mass index, and smoking. Reducing the proportion of women gaining less weight than recommended (undergain) would probably result in an 11% to 16% reduction in small-for-gestational-age births but, concomitantly, a 17% to 26% increase in large-for-gestational-age births. Conversely, reducing the proportion of women gaining more weight than recommended (overgain) would decrease the latter but increase the former. Having Black women enter pregnancy with average body mass indexes would have a minimal impact on small-for-gestational-age births. Preventing undergain and smoking would have the greatest impact on reducing such births among Black women, whereas preventing low body mass index and smoking would have the greatest impact on reducing these births among White women. Reductions in large-for-gestational-age births could be achieved by preventing high body mass indexes and overgain during pregnancy.

Discussion

Rate of gestational weight gain was related in a constant fashion to the likelihood of delivering a small- or large-for-gestational-age infant as compared with an adequate-weight-for-gestational-age infant. The influ-

TABLE 2—Adjusted Odds Ratios for Small- or Large-for-Gestational-Age Births (vs Adequate-Weight-for-Gestational-Age Births), According to Maternal Prepregnancy Body Mass Index (BMI)

	Odds Ratio (95% Confidence Interval)					
	Small for Gestational Age			Large for Gestational Age		
Characteristic	BMI < 19.8	BMI 19.8–26.0	BMI > 26.0	BMI < 19.8	BMI 19.8–26.0	BMI > 26.0
Black race	1.09 (0.58, 2.06)	2.03 (1.19, 3.48)	1.46 (0.61, 3.46)	0.70 (0.28, 1.72)	0.51 (0.32, 0.83)	0.50 (0.29, 0.86)
Multiparity	0.65 (0.36, 1.18)	0.53 (0.35, 0.80)	0.53 (0.27, 1.02)	2.54 (1.26, 5.13)	1.62 (1.15, 2.26)	1.59 (1.00, 2.54)
Any smoking	2.32 (1.34, 4.00)	3.40 (2.31, 5.02)	2.33 (1.27, 4.29)	0.74 (0.30, 1.87)	0.68 (0.44, 1.06)	0.55 (0.31, 0.96)
Height (per 2.8 in)	0.68 (0.51, 0.89)	0.73 (0.59, 0.89)	0.80 (0.59, 1.09)	1.95 (1.34, 2.86)	1.40 (1.17, 1.68)	1.12 (0.90, 1.39)
Body mass index (per kg/m^2)	0.83 (0.65, 1.07)	1.00 (0.90, 1.11)	0.98 (0.92, 1.06)	1.27 (0.87, 1.84)	1.12 (1.02, 1.22)	1.09 (1.04, 1.13)
Rate of weight gain (per 50 g/wk)	0.87 (0.78, 0.97)	0.90 (0.84, 0.96)	0.93 (0.86 1.01)	1.25 (1.11, 1.41)	1.14 (1.08, 1.20)	1.13 (1.07, 1.20)
Age (per 6 years)	0.95 (0.51, 1.76)	1.37 (1.11, 1.70)	0.86 (0.61, 1.22)	...	...	...
Provider type						
Managed care[a]	0.86 (0.32, 2.28)	2.44 (1.48, 4.03)	0.44 (0.13, 1.45)	...	...	...
Private[a]	...	...	...	2.55 (0.99, 6.54)	2.25 (1.39, 3.63)	1.69 (0.95, 3.01)
Hypertension	1.91 (0.62, 5.94)	1.93 (0.97, 3.81)	2.22 (1.06, 4.66)	...	...	...
Female infant	...	...	...	0.57 (0.28, 1.17)	1.43 (1.02, 1.99)	0.74 (0.47, 1.15)

Note. Presented are the adjusted odds ratios for each variable in each of 6 final models (2 outcomes × 3 prepregnancy BMI categories).
[a]As compared with all other provider types.

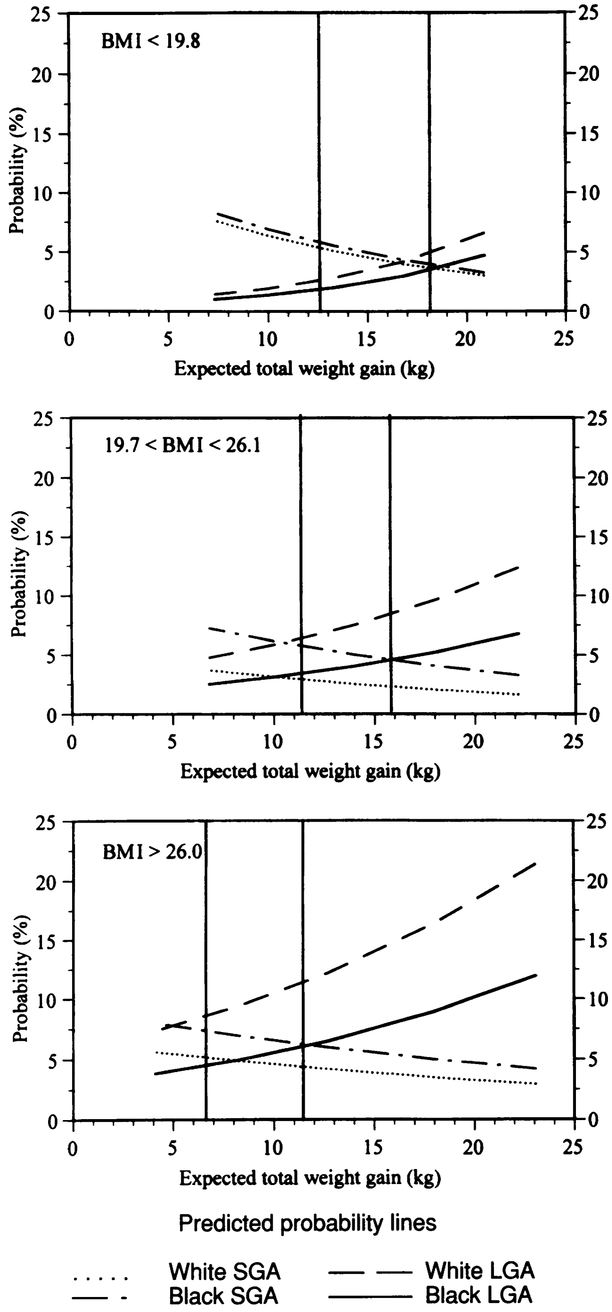
ence of weight gain on the risk of small- and large-for-gestational-age births was modified by maternal body mass index, confirming the findings of the Institute of Medicine and other investigators.[1,2,4,5] The relation between weight gain and risk of small- or large-for-gestational-age births did not differ by maternal race in any of the body mass index strata, but the effect of maternal race on pregnancy outcome did differ across these strata. After adjustment for confounding factors, maternal race no longer influenced risk among thin women; among those with body mass indexes greater than 19.8 kg/m^2, however, Black women were still more likely to deliver a small-for-gestational-age infant and less likely to deliver a large-for-gestational-age infant.

Before the implications of these findings are considered, several limitations of the data should be addressed. First, we relied on self-reported prepregnancy weight. Previous research indicates excellent agreement between actual and self-reported heights and weights, with greater underreporting of weight at higher body mass index levels but no difference in agreement by race.[10–12] Thus, errors in body mass index probably diminish the effect of body mass index on pregnancy outcomes—particularly for heavier women—but would not differentially affect results by race. Underreporting of higher prepregnancy weights may also explain the observed similarities between overweight and very overweight women and provide further justification for our grouping these women together. Second, despite these considerations, our inability to analyze outcomes for overweight and very overweight women separately is a limitation. Third, we calculated weight gain using reported prepregnancy weight and last weight recorded before delivery. At Johns Hopkins Hospital, women delivering at term were probably weighed within 1 week of delivery; thus, for most women, gestational weight gains are fairly precise. However, women delivering preterm infants may have been weighed 2 weeks or more before delivery, leading to an underestimation of weight gain and a potential overestimation of the risks of lower weight gains. Underreporting of body mass index among heavier women would lead to an overestimation of weight gain and an overestimation of the benefits of higher weight gains. Fourth, the exclusion of 37% of women owing to missing data resulted in a slightly lower-risk sample of women than the general Johns Hopkins Hospital obstetric population. Fifth, the analyses were based on the weight gains of women delivering before publication of the Institute of Medicine recommendations, but this would affect the results only if weight gain advice influenced the relation between weight gain and pregnancy outcome. These limitations are not unique to our data but reflect the reality of analyzing routinely collected obstetric data, as well as the circumstances under which medical decisions are made regarding the appropriateness of weight gain and the risk of adverse outcomes.

The results indicate that as weight gains increase, the risk of small-for-gestational-age births declines and the risk of large-for-gestational-age births increases, each in an incremental fashion. Thus, recommended weight gains do not confer minimal risks for such births but, rather, represent some acceptably low level of risk for these outcomes. Furthermore, because these risks change over the same range of weight gain (Figure 1), there are direct trade-offs between small- and large-for-gestational-age births to consider when setting weight gain recommendations.

The health implications of small- and large-for-gestational-age births are not equivalent, but both represent suboptimal pregnancy outcomes. Both small- and large-for-gestational-age infants are at increased risk for perinatal mortality.[13] Furthermore, they are at increased risk for fetal distress during delivery and for respiratory distress, hypoglycemia, and hyperbilirubinemia postnatally.[14,15] Large-for-gestational-age infants are more likely to suffer traumas during delivery that may be handicapping or lethal.[16] The birth process and the extrauterine environment are more life threatening for small- and large-for-gestational-age infants, and effective obstetric and perinatal management is crucial to their health and survival. Small- and large-for-gestational-age infants are more frequently delivered by cesarean, and we previously demonstrated a U-shaped relation between size at birth and cesarean delivery at Johns Hopkins Hospital.[17] Therefore, trying to minimize the risk of both small- and large-for-gestational-age births may reduce surgical risks for women. Although it is debatable whether cesarean delivery represents a suboptimal pregnancy outcome, some obstetricians are concerned that higher weight gains will increase cesarean delivery rates unnecessarily.[3,18]

With these considerations in mind, the 3% to 5% likelihood of both small- and large-for-gestational-age births associated with recommended weight gains for women with low



Note. Probabilities were predicted from parameters of the logistic regression models described in the text and presented (as odds ratios) in Table 2. The probabilities are graphed across the observed 10th–90th percentiles of weight gain within each BMI stratum. All covariates were set to their average values or frequencies within each BMI stratum (races pooled), except for maternal race, which was set to 0 or 1 in order to predict race-specific probabilities. See Table 1 for approximate values; exact values are available from the authors. The vertical lines represent the Institute of Medicine recommended weight gain ranges.[1]

FIGURE 1—Probabilities of small-for-gestational-age (SGA) and large-for-gestational-age (LGA) births associated with expected total weight gain at term for Black and White women of varying prepregnancy body mass index (BMI) (kg/m^2).

body mass indexes seems reasonable. To further reduce the risk of small-for-gestational-age births, higher weight gains could be recommended, because the risk of delivering a large-for-gestational-age infant would not increase very much. Among those with average and high body mass indexes, the risks of both types of birth for Black women also seem reasonable and are in line with the risks for women with low indexes. For White women, however, the risks of large-for-gestational-age births are substantially higher, and risks of small-for-gestational-age births are quite low. Thus, weight gain recommendations for White women could perhaps be lowered to diminish the risk of large-for-gestational-age births without greatly increasing the risk of small-for-gestational-age births.

The Institute of Medicine suggested that Black women gain at the upper end of the recommended ranges. We can see why that might be; in this study, Black women were at higher risk of small-for-gestational-age births and lower risk of large-for-gestational-age births than White women. Differences by race were body mass index dependent, because, after adjustment, we found racial differences in risk only among women with average and high body mass indexes. Furthermore, the racial differences were more pronounced for large- than for small-for-gestational-age births. Thus, racial differences in fetal growth relate more to average and overweight Black women being less likely than White women to deliver a large-for-gestational-age baby than to average and thin Black women being more likely than White women to deliver a small-for-gestational-age baby.

Racial differences in the incidence of small- and large-for-gestational-age births among women with average and high body mass indexes were not explained by weight gain or any other factor we examined during analyses. We found no significant interactions between maternal race and weight gain, indicating that the influences of weight gain on the risk of such births were similar for Black and White women. Cogswell et al.[5] also found no interaction between race and weight gain in their analyses of the pregnancy outcomes of more than 53 000 average-weight and overweight women. Our findings do indicate that the effects of body mass index on pregnancy outcomes vary by race. Interestingly, data from Johns Hopkins Hospital reported more than 20 years ago support the findings that (1) the effect of weight gain on pregnancy outcome is similar for Black and White women and (2) the magnitude of the effect of body mass index on pregnancy outcome is smaller for Black women than for White women.[19]

Because race did not influence the risk of small- or large-for-gestational-age births among women with body mass indexes of less than 19.8 kg/m^2, there is little reason to make separate weight gain recommendations by race for these women. Higher weight gains for Black women with average or high body mass indexes could help prevent

TABLE 3—Expected Change in Incidence of Small- and Large-for-Gestational-Age Births in Black and White Women Attributable to Changes in Selected Modifiable Risk Factors

	Small for Gestational Age		Large for Gestational Age	
	Black	White	Black	White
Sample incidence, %	7.35	3.97	4.85	14.80
Risk factor change[a]				
No undergain	−1.17 (−16)	−0.44 (−11)	+1.28 (+26)	+2.58 (+17)
No overgain	+0.97 (+13)	+0.60 (+15)	−0.77 (−16)	−2.87 (−19)
No BMI < 19.8 kg/m^2	−0.15 (−2)	−0.64 (−16)	+0.82 (+17)	+3.70 (+25)
No BMI > 26.0 kg/m^2	+0.15 (+2)	+0.32 (+8)	−0.73 (−15)	−1.48 (−10)
No smoking	−2.77 (−38)	−1.10 (−28)	+0.75 (+16)	+1.62 (+11)

Note. Values are based on calculations of attributable risk[12] using exposure data reported in Table 1 and odds ratios reported in Table 2 or available from the authors. BMI = body mass index. The sign of the change indicates the proportion of cases that would be averted (−) or would no longer be averted (+) if there were changes in each modifiable risk factor for Black women and White women, respectively. Undergain and overgain refer to weight gains less than or more than the Institute of Medicine recommended ranges for gestational weight gain.[1]

[a]Expected absolute change (as % of baseline) in incidence.

adverse outcomes, not because the relation between weight gain and pregnancy outcome is different for Black women but because weight gain can be manipulated to equalize the risk of small-for-gestational-age births for Black and White women at acceptably low levels. However, based on our results, Black women with average body mass indexes would have to gain nearly 25 kg to lower their risk of small-for-gestational-age births to that (approximately 3%) of White women gaining 11.5 kg (the lower limit of the recommendation). Similarly, Black women with high body mass indexes would have to gain nearly 18 kg to lower their risk of small-for-gestational-age births to about 5%, the risk for White women gaining only 7.0 kg.

Should weight gain recommendations be raised for Black women? Our results provide little support for advocating that Black women gain at the upper end of the recommendations. First, we observed no difference in risk of adverse outcomes by race among thin women. Second, having average-weight or overweight Black women gain at the upper end of the recommendations is not likely to translate into tangible benefits. For example, the predicted incidence of small-for-gestational-age births for Black women with average body mass indexes gaining at the lower limit of the recommendations (11.5 kg) is 5.7%, whereas the predicted incidence if they gain at the upper end of that range (16 kg, or a 4.5-kg additional gain) is 4.5%. Weight gains for Black women that equalize the risk of small-for-gestational-age births for Black and White women would be high. Although the concomitant increase in the risk of large-for-gestational-age births may be tolerable, such high gains are probably not achievable and may heighten concern about the surgical risks associated with increased maternal weight, as well as postpartum weight retention, obesity, and related health risks.[17,20–22]

Should weight gain recommendations be lowered for White women? This could be justified for women with average or high body mass indexes, whose likelihood of delivering a large-for-gestational-age infant is high and whose likelihood of delivering a small-for-gestational-age infant is low. We hesitate to draw this conclusion from our data alone; rather, we suggest that our approach is a reasonable one to begin addressing this issue. It would be important to conduct similar analyses using larger samples representative of pregnant women in the United States and to separate overweight and very overweight women. The distributions of women by body mass indexes and race in our sample and the representative sample of women participating in the 1988 National Maternal and Infant Health Survey are quite similar[23,24]; however, racial differences in weight gain were somewhat greater in the latter, and the general socioeconomic profile of the Johns Hopkins Hospital sample (regardless of race) implies higher risks for adverse pregnancy outcomes than among US women in general.[7,24]

Given that the relation between weight gain and fetal growth does not seem to vary by race, should we be setting race-specific recommendations for weight gain? Instead of urging Black women to gain different amounts than White women, perhaps we should intensify efforts to illuminate the basis for differential risk of small- and large-for-gestational-age births, which is unexplained by currently measured variables. Furthermore, additional research is needed to understand the relation between body mass index and fetal growth, which does appear to be race specific. □

References

1. Institute of Medicine, Subcommittee on Nutritional Status and Weight Gain during Pregnancy. *Nutrition During Pregnancy.* Washington, DC: National Academy of Sciences; 1990.
2. Parker JD, Abrams B. Prenatal weight gain advice: an examination of the recent prenatal weight gain recommendations of the Institute of Medicine. *Obstet Gynecol.* 1992;79:664–669.
3. Johnson JWC, Longmate JA, Frentzen B. Excessive maternal weight and pregnancy outcome. *Am J Obstet Gynecol.* 1992;167:353–372.
4. Hickey CA, Cliver SP, Goldenberg RL, Kohatsu J, Hoffman HJ. Prenatal weight gain, term birth weight, and fetal growth retardation among high-risk multiparous black and white women. *Obstet Gynecol.* 1993;81:529–535.
5. Cogswell ME, Serdula MK, Hungerford DW, Yip R. Gestational weight gain among average-weight and overweight women—what is excessive? *Am J Obstet Gynecol.* 1995;172:705–712.
6. Edwards LE, Hellerstedt WL, Alton IR, Story M, Himes JH. Pregnancy complications and birth outcomes in obese and normal-weight women: effects of gestational weight change. *Obstet Gynecol.* 1996;87:389–394.
7. Caulfield LE, Witter FR, Stoltzfus RJ. Determinants of gestational weight gain outside the recommended ranges among black and white women. *Obstet Gynecol.* 1996;87:760–766.
8. Alexander GR, Himes JH, Kaufman RB, Mor J, Kogan M. A United States national reference for fetal growth. *Obstet Gynecol.* 1996;87:163–168.
9. Kahn HA. Attributable risk. In: *An Introduction to Epidemiologic Methods.* New York, NY: Oxford University Press Inc; 1983.
10. Stewart AL. The reliability and validity of self-reported weight and height. *J Chronic Dis.* 1982;35:295–309.
11. Stevens-Simon C, McAnarney ER, Coulter MP. How accurately do pregnant adolescents estimate their weight prior to pregnancy? *J Adolesc Health Care.* 1986;7:250–254.
12. Rowland ML. Self-reported weight and height. *Am J Clin Nutr.* 1990;52:1125–1133.
13. Williams RL, Creasy RK, Cunningham GC, Hawes WE, Norris FD, Tashiro M. Fetal growth and perinatal viability in California. *Obstet Gynecol.* 1982;59:624–632.
14. Caulfield LE, Haas JD, Belizán JM, Rasmussen KM, Edmonston B. Differences in early postnatal morbidity risk by pattern of fetal growth in Argentina. *Paediatr Perinat Epidemiol.* 1991;5:263–275.
15. Stevenson DK, Hopper AO, Cohen RS, Bucalo LR, Kerner JA, Sunshine P. Macrosomia: causes and consequences. *J Pediatr.* 1982;100:515–520.
16. Boyd ME, Usher RH, McLean FH. Fetal macrosomia: prediction, risks, proposed management. *Obstet Gynecol.* 1983;61:715–722.
17. Witter FR, Caulfield LE, Stoltzfus RJ. Influence of maternal anthropometric status and

birth weight on the risk of cesarean delivery. *Obstet Gynecol.* 1995;85:947–951.
18. Brost BC, Goldenberg RL, Mercer BM, et al. The Preterm Prediction Study: association of cesarean delivery with increases in maternal weight and body mass index. *Am J Obstet Gynecol.* 1997;177:333–341.
19. Eastman NJ, Jackson E. Weight relationships in pregnancy. *Obstet Gynecol Surv.* 1968;23:1003–1025.
20. Abrams B, Parker J. Overweight and pregnancy complications. *Int J Obes.* 1988;12:293–303.
21. Parker JD, Abrams BA. Differences in postpartum weight retention between black and white mothers. *Obstet Gynecol.* 1993;81:768–774.
22. Taffel SM, Keppel KG, Jones GK. Medical advice on maternal weight gain and actual weight gain: results from the 1988 National Maternal and Infant Health Survey. *Ann N Y Acad Sci.* 1993;678:293–305.
23. Frisbie WP, Biegler M, de Turk P, Forbes D, Pullum SG. Racial and ethnic differences in determinants of intrauterine growth retardation and other compromised birth outcomes. *Am J Public Health.* 1997;87:1977–1983.
24. Keppel KG, Taffel SM. Pregnancy-related weight gain and retention: implications of the 1990 Institute of Medicine guidelines. *Am J Public Health.* 1993;83:1100–1103.