

## SPECIAL ARTICLE

## FAMILIAL AGGREGATION OF LOW BIRTH WEIGHT AMONG WHITES AND BLACKS IN THE UNITED STATES

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**Abstract Background.** Studies have shown that the birth weight of infants is correlated with the birth weights of their siblings and their mothers. We investigated whether the birth weights of mothers and index children were jointly associated with the risk of low birth weight in the siblings of the index children.

**Methods.** We used data on the live-birth cohort of the 1988 National Maternal and Infant Health Survey. The analysis included 1691 white and 1461 black mothers, each of whom had two or more live-born, singleton children. Multiple logistic regression with generalized-estimation equations was used to assess the risk of low birth weight among an index child's siblings. Four groups were studied: that in which neither the mother nor the index child had low birth weight (group 1), that in which only the mother had low birth weight (group 2), that in which only the index child had low birth weight (group 3), and that in which both the mother and the index child had low birth weight (group 4). There was adjustment for other maternal and infant covariates.

AMONG 3.9 million infants born in the United States in 1988, approximately 270,000 had low birth weight (<2500 g).<sup>1</sup> Low birth weight is the single most important determinant of neonatal mortality and a major determinant of postnatal infant mortality, as well as morbidity during infancy and childhood.<sup>2,3</sup> Previous investigations of low birth weight have largely focused on individual pregnancies and factors associated with that period.<sup>2,4,5</sup> Relatively little work has been done to study the familial aggregation of low birth weight among whites and blacks in the United States.

Studies have shown that women tend to bear children whose birth weights are similar to each other. The correlation coefficients for birth weight among siblings range from 0.36 to 0.62 (median, approximately 0.50).<sup>6</sup> This similarity persists even after adjustment for the length of gestation.<sup>7</sup> The correlation among siblings is affected by characteristics of both the mother and the infant.<sup>8</sup> Other studies suggest that a mother's own birth weight is also an important determinant of the birth weights of her infants. Infants born to mothers who had low birth weight themselves have a lower mean birth

**Results.** In groups 1, 2, 3, and 4, respectively, 3.6, 8.3, 21.2, and 38.9 percent of white siblings had low birth weights, as compared with 8.0, 19.0, 31.1, and 57.1 percent of black siblings. When group 1 was used as the reference group, the adjusted odds ratios (and 95 percent confidence intervals) for low birth weight in groups 2, 3, and 4 were 2.5 (1.4 to 4.3), 6.8 (4.7 to 9.8), and 15.4 (9.2 to 25.5), respectively, among white siblings and 2.6 (1.8 to 3.8), 4.7 (3.5 to 6.4), and 13.9 (9.2 to 20.9) among black siblings. These associations were consistently found for birth weights below 1500 g and those ranging from 1500 to 2499 g in both races and after stratification for the mother's age, parity, education, cigarette-smoking status, and weight and height before pregnancy and the infant's sex.

**Conclusions.** Although the possibility of selection and recall biases cannot be excluded with certainty, our data suggest a strong familial aggregation of low birth weight among both whites and blacks in the United States. (N Engl J Med 1995;333:1744-9.)

weight and are more likely to have low birth weight than those born to mothers with normal birth weights, even after adjustment for relevant covariates.<sup>9-12</sup> The correlation between the birth weight of a mother and those of her children (0.15 to 0.25)<sup>12</sup> is lower than that between the birth weights of siblings.

We studied mothers, white and black, who were included in the live-birth cohort of the National Maternal and Infant Health Survey, conducted in 1988, who had had two or more live-born, singleton infants at the time of the survey. Our primary goals were to assess the association between the birth weights of the mother and the index child and the risk of low birth weight among the siblings of that child and to see whether the association was influenced by characteristics of the mother and the infant, including the mother's race, age, parity, education, weight and height before the index pregnancy, and cigarette-smoking status, as well as the infant's sex. Furthermore, we evaluated whether the association involving these birth weights was mediated by the rate of intrauterine growth or the duration of gestation.

## METHODS

## Study Population

A detailed description of the National Maternal and Infant Health Survey has been published elsewhere.<sup>13</sup> Briefly, the survey was conducted by the National Center for Health Statistics to study factors related to the outcomes of pregnancy in the United States in 1988. The survey involved a representative, nationwide sample including 9953 women who had live births, 5332 women whose infants died within the first year, and 3309 women who lost their fetuses in 1988. This study was based on the survey's live-birth cohort, in which the re-

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sponse rate was 74.4 percent. The survey oversampled blacks and infants with very low or moderately low birth weights. Approximately half the respondents sampled were black, and 30 percent of the infants had low birth weights. The data used in this analysis were taken from birth certificates and questionnaires completed by the mothers.

The present study included white and black women who had had two or more singleton live births by 1988 and for whom there were no missing data on the birth weights of the mothers and their infants, or on other specified covariates. Of the 9953 women in the cohort, 9055 were black or white; 2192 (24 percent) did not report their own birth weights. Among the 6863 remaining women, 3219 (47 percent) had had two or more singleton live births by the time of the survey. Sixty-seven of these women were excluded because data on either the mother or the infants were missing or because the infants had birth weights below 500 g. These additional exclusions reduced the final sample to 3152 women.

Only singleton live births were considered in the analysis. An index child was defined as the child who served to bring a family (or group of siblings) into the sample and who was studied independently of all the other index children.<sup>14</sup> Thus, in this study the index child was defined as the index child included in the 1988 survey — that is, the youngest child in the family. The outcomes of interest were the birth weights of infants and their gestational ages. Low birth weight was defined as birth weight under 2500 g and was subdivided into very low birth weight (<1500 g) and moderately low birth weight (1500 to 2499 g). Preterm birth was defined as the birth of an infant at a gestational age under 37 weeks. An infant with intrauterine growth retardation was defined as one having a birth weight below the 10th percentile for gestational age among all singleton infants born to mothers of the same race in the live-birth cohort of the 1988 survey.

The major covariates studied included the following characteristics of the mother: race (white or black), age (less than 20, 20 to 29, or 30 or more years), parity (one, two, three, or four or more offspring), education (less than 12, exactly 12, or more than 12 years), place of birth (in the United States or elsewhere), cigarette smoking (yes or no) during the pregnancy that led to the birth of the infant in question, and weight and height before that pregnancy. In addition, the covariates included the year and season of the infant's birth and the infant's sex. We also considered two intervals: the interval between the birth of the infant in question and the birth of the index child and the interval between pregnancies, as defined elsewhere.<sup>15</sup> Of these intervals, only the former was included in the final models, because the latter did not affect the outcomes of interest. In this analysis, the factors that could vary from one pregnancy to the next in a given mother included age, parity, and cigarette smoking; the remaining factors were assumed to remain constant over time. Although this assumption may not be accurate with respect to the mother's education and prepregnancy weight, that information was available only for the index pregnancy.

### Statistical Analysis

Multiple logistic-regression analysis was used to assess the combined association of the birth weights of the mother and the index child with the risk of low birth weight in the index child's older siblings, after adjustment for covariates. The analysis included multiple offspring of the same mother rather than only one child for each mother, as was done in previous studies. This approach not only increased the statistical power of the study but

also provided an opportunity to study a sequence of births. The standard errors were estimated by a method using generalized-estimation equations to accommodate correlations among siblings in birth weight and gestational age.<sup>16</sup> A similar approach was used in assessing the risk of very low or moderately low birth weight, preterm birth, and intrauterine growth retardation. When very low birth weight and moderately low birth weight were considered, the reference group used was that of infants with birth weights of 2500 g or more.

The risks of low birth weight, intrauterine growth retardation, and prematurity among the siblings of the index children were studied in four groups defined as follows, according to the birth weights of the mother and the index child: the group in which neither the mother nor the index child had low birth weight (group 1), the group in which only the mother had low birth weight (group 2), the group in which only the index child had low birth weight (group 3), and the group in which both the mother and the index child had low birth weight (group 4). Our assessment of the interaction between the mother's birth weight and that of the index child was based on the assumption that there was no interaction on an additive scale. The statistical significance of this interactive effect was tested with the z statistic as described by Hogan and colleagues.<sup>17</sup> When we addressed reductions in the frequency of disease, identifying deviations from additive effects appeared to be the most reasonable approach.<sup>18</sup>

No weighting was used, since all the analyses were stratified according to race and the birth weight of the index child. The analyses were also performed with stratification according to the mother's age,

**Table 1. Characteristics of White and Black Mothers Surveyed in 1988, after Classification into Four Study Groups According to the Birth Weights of the Mother and the Index Child.\***

CHARACTERISTIC	GROUP 1	GROUP 2	GROUP 3	GROUP 4
<b>White mothers</b>				
No. of mothers	1202	139	273	77
Age (%)				
<20 yr	1.9	3.6	5.1	5.2
20–29 yr	57.0	52.5	54.2	50.7
≥30 yr	41.1	43.9	40.7	44.2
No. of live births (%)				
2	60.6	56.8	57.5	57.1
3	26.5	29.5	27.5	36.4
≥4	12.9	13.7	15.0	6.5
Education (%)				
<12 yr	12.8	16.6	23.1	27.3
12 yr	40.4	48.9	38.8	35.1
>12 yr	46.8	34.5	38.1	37.7
Smoking (%)				
No	77.6	66.9	56.8	44.2
Yes	22.4	33.1	43.2	55.8
Weight before pregnancy (kg)	62.7±13.2	59.0±11.5	60.6±14.0	55.9±11.4
Height (cm)	164.7±6.8	161.5±6.9	162.9±7.4	161.0±6.8
<b>Black mothers</b>				
No. of mothers	884	180	283	114
Age (%)				
<20 yr	11.3	7.8	14.1	14.9
20–29 yr	64.1	64.4	57.6	62.3
≥30 yr	24.6	27.8	28.3	22.8
No. of live births (%)				
2	50.1	50.0	51.9	45.6
3	30.3	23.9	28.3	29.8
≥4	19.6	26.1	19.8	24.6
Education (%)				
<12 yr	24.1	25.0	26.9	32.5
12 yr	42.7	40.0	45.6	40.4
>12 yr	33.3	35.0	27.6	27.2
Smoking (%)				
No	79.1	71.1	64.0	60.5
Yes	20.9	28.9	36.0	39.5
Weight before pregnancy (kg)	64.6±14.6	62.1±14.3	62.2±13.9	57.8±11.6
Height (cm)	164.6±7.2	163.3±7.1	163.8±6.7	162.0±7.1

\*In group 1, neither the mother nor the index child had low birth weight (weight <2500 g); in group 2, only the mother had low birth weight; in group 3, only the index child had low birth weight; and in group 4, both the mother and the index child had low birth weight. The index child was the youngest child in the family, as in the 1988 survey. Plus–minus values are means ±SD.

Table 2. Birth Outcomes among the Siblings of the Index Children, after Classification into Four Study Groups According to the Birth Weights of the Mother and the Index Child.\*

OUTCOME	GROUP 1	GROUP 2	GROUP 3	GROUP 4
<b>White siblings</b>				
No. of siblings	1902	228	419	113
Mean birth weight (g)	3451±532	3327±557	2938±738	2639±760
Birth weight (%)				
<1500 g	0.5	0.4	6.0	8.0
1500–2499 g	3.1	7.9	15.3	31.0
<2500 g	3.6	8.3	21.3	39.0
Mean gestation (wk)	39.8±2.1	39.5±3.3	37.9±3.9	37.5±4.2
Gestation <37 wk (%)	4.7	7.5	23.2	29.2
Intrauterine growth retardation (%)	4.8	6.2	11.0	29.2
<b>Black siblings</b>				
No. of siblings	1530	305	483	205
Mean birth weight (g)	3204±561	3002±649	2759±760	2449±672
Birth weight (%)				
<1500 g	1.8	2.3	8.5	8.3
1500–2499 g	6.1	16.7	22.6	48.8
<2500 g	7.9	19.0	31.1	57.1
Mean gestation (wk)	39.4±2.8	39.0±3.7	37.3±5.7	36.6±5.1
Gestation <37 wk (%)	6.5	9.5	24.8	35.6
Intrauterine growth retardation (%)	4.7	14.5	14.7	28.4

\*In group 1, neither the mother nor the index child had low birth weight (weight <2500 g); in group 2, only the mother

parity, education, cigarette-smoking status, and weight and height before the pregnancy and the infant's sex, to test whether these factors modified the association between the birth weights of the mother and the index child and the risk of low birth weight among the siblings of the index child. All P values were two-tailed.

## RESULTS

In all, our study included 1691 white mothers and 1461 black mothers with 4353 and 3984 singleton, live-born children, respectively, including the index children. Table 1 shows race-specific characteristics of the mothers, grouped according to the birth weights of the mother and the index child. The characteristics of the mothers differed among groups. Among the white mothers, those in group 4 (both mother and child with low birth weight) were more likely than those in group 1 (neither mother nor child with low birth weight) to be teenagers, were less well educated, and were more likely to have smoked during the pregnancy; the mothers in group 4 also weighed less before pregnancy and had shorter stature. The characteristics of the mothers in groups 2 and 3 were intermediate, but the characteristics of group 3 resembled those of group 4 more closely. Similar patterns were found among the black mothers, but black mothers in general were more likely than white mothers to be teenagers and to have had fewer years of education.

The crude correlation between the birth weight of the index child and the birth weights of that child's siblings was 0.42 for whites ( $P<0.001$ ) and 0.40 for blacks ( $P=0.001$ ). The correlations increased to 0.45 and 0.49, respectively, among siblings born consecutively. The crude correlation between the birth weight

of the mother and the birth weights of the index child's siblings was 0.23 for whites ( $P=0.001$ ) and 0.20 for blacks ( $P=0.001$ ).

There were large differences among study groups in the mean birth weights of the siblings of the index child. The percentages of siblings with very low birth weight, moderately low birth weight, and overall low birth weight also varied greatly according to study group (Table 2), with the lowest rates found in group 1 and the highest rates found in group 4. The rates for groups 2 and 3 were intermediate, but group 3 had higher rates of these conditions than group 2.

The mean gestational age, the percentage of preterm births, and the percentage of infants born with intrauterine growth retardation among the siblings of the index child were also examined according to study group (Table 2). The birth weight of the index child was much more

closely correlated with the mean gestational age and the percentage of preterm births than was the mother's birth weight. Nevertheless, the rates of preterm delivery were considerably higher in group 4 than in group 3. The mother's birth weight and the index child's birth weight were both associated with the rates of intrauterine growth retardation. The rates in group 4 were much higher than those in groups 2 and 3.

These associations were quantified further in logistic-regression models. The crude odds ratios for low birth weight in groups 2, 3, and 4, with group 1 as the reference category, were 2.5, 7.3, and 17.2, respectively, for whites and 2.7, 5.2, and 15.3 for blacks. Table 3 shows the adjusted odds ratios and 95 percent confidence intervals for the risk of low birth weight, after adjustment for other covariates. Again, the lowest odds ratios were found in group 1, and the highest in group 4. The associations were similar in whites and blacks. The magnitude of both the adjusted and the crude odds ratios was similar. More important, the odds ratio for group 4 could be approximated by multiplying the odds ratio for group 2 by the odds ratio for group 3. This product was much greater than the sum of the individual odds ratios (for whites,  $z=2.43$ ,  $P=0.015$ ; for blacks,  $z=3.42$ ,  $P<0.001$ ), indicating a statistically significant interaction between the mother's birth weight and the index child's birth weight on an additive scale. A stratified analysis was also performed to examine heterogeneity in the associations among the risk strata for the mother and the infant. The interaction between the mother's birth weight and that of the index child persisted across the strata of the mother's cigarette-

Table 3. Adjusted Odds Ratios and 95 Percent Confidence Intervals for the Combined Association of the Birth Weights of the Mother and the Index Child with the Risk of Low Birth Weight among the Child's Siblings, after Stratification According to the Mother's Race and Smoking Status and the Infant's Sex.\*

VARIABLE	GROUP 1	GROUP 2	GROUP 3	GROUP 4
<b>Entire sample</b>				
Odds ratio	1.0	2.6	5.4	14.1
95% CI	—	1.9–3.5	4.3–6.8	10.3–19.3
Siblings with LBW/all siblings	190/3432	77/533	239/902	161/318
<b>Mother's race</b>				
White				
Odds ratio	1.0	2.5	6.8	15.4
95% CI	—	1.4–4.3	4.7–9.8	9.2–25.5
Siblings with LBW/all siblings	68/1902	19/228	89/419	44/113
Black				
Odds ratio	1.0	2.6	4.7	13.9
95% CI	—	1.8–3.8	3.5–6.4	9.2–20.9
Siblings with LBW/all siblings	122/1530	58/305	150/483	117/205
<b>Maternal smoking</b>				
No				
Odds ratio	1.0	2.7	5.3	15.5
95% CI	—	1.9–4.0	4.0–7.1	10.5–23.1
Siblings with LBW/all siblings	139/2752	55/404	138/587	94/191
Yes				
Odds ratio	1.0	2.3	5.6	12.3
95% CI	—	1.3–3.9	3.7–8.5	7.5–20.4
Siblings with LBW/all siblings	51/680	22/129	101/315	67/127
<b>Infant's sex</b>				
Female				
Odds ratio	1.0	3.0	5.3	13.9
95% CI	—	2.0–4.4	3.9–7.3	9.0–21.6
Siblings with LBW/all siblings	101/1684	45/268	130/454	77/151
Male				
Odds ratio	1.0	2.2	5.5	15.8
95% CI	—	1.4–3.5	4.0–7.7	10.4–23.8
Siblings with LBW/all siblings	89/1748	32/265	109/448	84/167

\*Odds ratios and 95 percent confidence intervals were estimated by multiple logistic-regression analysis with the use of generalized-estimation equations, as described in the Methods section. The model for the total sample included the following covariates: the mother's age, parity, race, education, cigarette-smoking status, weight and height before the pregnancy, and place of birth; the year and season of the infant's birth; the interval between the sibling's birth and the birth of the index child; and the infant's sex. In the stratified models the covariates were the same, except that the stratified variable was removed from the model. In group 1, neither the mother nor the index child had low birth weight (weight <2500 g); in group 2, only the mother had low birth weight; in group 3, only the index child had low birth weight; and in group 4, both the mother and the index child had low birth weight. The index child was the youngest child in the family, as in the 1988 survey. CI denotes confidence interval, and LBW low birth weight.

smoking status and the infant's sex (Table 3). Similar results were obtained when the analysis was stratified according to the mother's age, parity, education, weight before the pregnancy, and height (data not shown).

To investigate further whether the correlations in birth weight between the mother and her children and among the siblings were mediated by the intrauterine growth rate or the duration of gestation, we performed additional analyses. We first repeated the above logistic regressions, adding the gestational age of the siblings of the index child to the model. After this adjustment, the odds ratios for low birth weight in groups 2, 3, and 4, with group 1 as the reference category, were 2.5, 3.3, and 10.2, respectively, among whites and 2.7, 3.3, and 10.1 among blacks. Although the odds ratios were smaller, the interactive effect remained among both whites and blacks. We then analyzed two subcategories of low birth weight separately — very low birth weight (<1500 g) and moderately low birth weight (1500 to 2499 g) (Table 4). The mother's birth weight,

considered alone, appeared to have little effect on the risk of very low birth weight in siblings of the index child among blacks, whereas among whites the association could not be evaluated because there was only one white sibling with very low birth weight in group 2. However, the interaction between the mother's birth weight and that of the index child persisted for both very low birth weight and moderately low birth weight. In addition, we assessed the association between the birth weights of the mother and the index child and the risks of preterm birth and intrauterine growth retardation among siblings (Table 4). The results again indicated that these risks were lowest in group 1 and highest in group 4. The combined effect of the mother's birth weight and that of the index child on the risk of preterm birth and intrauterine growth retardation among the siblings of the index child was either additive or interactive.

## DISCUSSION

In findings consistent with those of previous studies,<sup>6,8-12</sup> this study shows that the birth weight of the mother and that of the index child are both significant and independent predictors of low birth weight in the siblings of the index child. More important, the data suggest that this effect is interactive. In contrast to the odds ratios for low birth weight in the siblings of 2.6 in group 2 and 5.4 in group 3, the odds ratio of 14.1 in group 4 was among the highest for the risk factors known to be associated with low birth weight. This interactive effect was observed even after adjustment for the mother's race, age, parity, education, cigarette-smoking status, weight before the pregnancy, and height and for the year and season of the sibling's birth, the interval between the sibling's birth and that of the index child, and the sibling's sex.

Our data support the notion, suggested previously, that when infants are studied individually the birth weight is correlated with both the length of gestation and rates of intrauterine growth,<sup>19</sup> whereas maternal birth weight is more strongly associated with the infant's intrauterine growth than with the duration of gestation.<sup>11</sup> Furthermore, the combined effect of the mother's birth weight and that of the index child on the risk of preterm birth and intrauterine growth retardation in a sibling of the index child is either additive or interactive, which suggests that the combined effect on the risk

Table 4. Adjusted Odds Ratios and 95 Percent Confidence Intervals for the Combined Association of the Birth Weights of the Mother and the Index Child with the Risks of Very Low or Moderately Low Birth Weight, Preterm Birth, and Intrauterine Growth Retardation among the Index Child's Siblings, According to Study Group.\*

VARIABLE	GROUP 1	GROUP 2	GROUP 3	GROUP 4
<b>White siblings</b>				
Very low birth weight (<1500 g)				
Odds ratio	1.0	1.0	15.4	26.0
95% CI	—	0.1–8.2	7.0–34.3	8.7–77.4
No. with LBW/total no.	10/1902	1/228	25/419	9/113
Moderately low birth weight (1500–2499 g)				
Odds ratio	1.0	2.6	5.6	13.5
95% CI	—	1.5–4.7	3.7–8.4	7.9–23.3
No. with LBW/total no.	58/1902	18/228	64/419	35/113
Gestation <37 wk				
Odds ratio	1.0	1.6	5.9	7.6
95% CI	—	0.9–2.7	4.1–8.4	4.5–13.0
No. with LBW/total no.	90/1902	17/228	97/419	33/113
Intrauterine growth retardation†				
Odds ratio	1.0	1.2	2.0	6.0
95% CI	—	0.6–2.2	1.3–3.0	3.6–9.8
No. with LBW/total no.	92/1901	14/227	46/419	33/113
<b>Black siblings</b>				
Very low birth weight (<1500 g)				
Odds ratio	1.0	1.5	6.4	11.0
95% CI	—	0.6–3.8	3.7–11.4	5.0–24.1
No. with LBW/total no.	28/1530	7/305	41/483	17/205
Moderately low birth weight (1500–2499 g)				
Odds ratio	1.0	2.9	4.4	14.6
95% CI	—	2.0–4.4	3.1–6.1	9.7–22.1
No. with LBW/total no.	94/1530	51/305	109/483	100/205
Gestation <37 wk				
Odds ratio	1.0	1.5	4.7	7.7
95% CI	—	0.9–2.5	3.4–6.7	5.0–11.8
No. with LBW/total no.	100/1530	29/305	120/483	73/205
Intrauterine growth retardation†				
Odds ratio	1.0	3.2	3.0	6.3
95% CI	—	2.1–4.9	2.1–4.5	4.0–10.0
No. with LBW/total no.	72/1526	44/303	70/477	58/204

\*Odds ratios and 95 percent confidence intervals were estimated by multiple logistic-regression analysis with the use of generalized-estimation equations and the covariates listed in the note to Table 3. In group 1, neither the mother nor the index child had low birth weight (weight <2500 g); in group 2, only the mother had low birth weight; in group 3, only the index child had low birth weight; and in group 4, both the mother and the index child had low birth weight. The index child was the youngest child in the family, as in the 1988 survey. CI denotes confidence interval, and LBW low birth weight.

†An infant with intrauterine growth retardation was defined as an infant with a birth weight below the 10th percentile for all singleton infants of the same race and gestational age who were included in the study. For this variable, the number of infants studied was slightly smaller than for the other variables, because this analysis was restricted to infants with gestational ages of 20 or more weeks but less than 47 weeks.

of low birth weight is mediated by both attenuated intrauterine growth and shortened gestation.

The strong familial aggregation of low birth weight in this study may result from genetics, environmental factors, or both. Genetic studies of normal birth weight estimate that 10 percent is determined by the fetal genotype and 24 percent by the maternal genotype.<sup>6</sup> Epidemiologic studies to date have identified a number of sociodemographic, environmental, and behavioral risk factors associated with low birth weight.<sup>2,4</sup> Our data confirm previous findings that in mothers, low weight before pregnancy, short stature, and cigarette smoking are significant predictors of low birth weight in their infants.<sup>4</sup> Although these risk factors are more prevalent among both white and black mothers who had low birth weights themselves than among those with higher birth weights, they do not explain the clustering of low

birth weights in their infants. In addition, although black mothers have both more risk factors and higher rates of low birth weight than white mothers, there is no significant difference between the races with regard to the strength of the combined association of the birth weight of the mother and the index child with the risk of low birth weight among the siblings.

Several recent studies have linked low birth weight with the occurrence of impaired glucose tolerance, hypertension, and ischemic heart disease in adulthood.<sup>20</sup> Thus, it is biologically plausible that low birth weight may be associated with subsequent abnormalities of growth and development and of the functional capacity of one or more organ systems, including the reproductive system. This study supports the view that research on low birth weight should go beyond focusing on individual pregnancies and factors pertaining to those specific periods.<sup>2,4,5</sup> Our data underscore the need for a genetic and epidemiologic approach to elucidating the links between biomedical, social, and environmental factors and low birth weight, both within and across generations.

When the results of this study are interpreted, several methodologic limitations should be taken into account. Because the study was limited to singleton live births, the generalizability of its findings to multiple births and stillbirths is unknown. Birth weights were not reported for

14 percent of the white mothers and 30 percent of the black mothers, a circumstance that may have led to a selection bias. Mothers who did not report their birth weights were more likely not to have completed high school, to have been born outside the United States, and to have higher parity. Nevertheless, our analysis indicated no significant association between a mother's knowledge of her own birth weight and the risk that her infant would have low birth weight or be born prematurely.

The accuracy of the birth weights reported by mothers for themselves and their children was unknown in this sample. A study in Washington State found 78 percent agreement between the weights reported in interviews by mothers as compared with the weights shown on their birth certificates (absolute mean deviation, 4.3 oz [120 g]).<sup>21</sup> Previous studies<sup>22–24</sup> have docu-

mented that mothers recall their own children's birth weights accurately. In the Collaborative Perinatal Project,<sup>23</sup> 57 percent of mothers gave the exact weights for their children, and 77 percent gave weights accurate to within 1 oz (28 g). The generalizability of those findings to our sample is uncertain because of the different characteristics of the populations. If the mothers of index children with low birth weight systematically underestimated their own birth weights or those of their older children, the risk estimates would tend to be spuriously inflated, whereas systematic overestimation of birth weights would spuriously reduce the estimates. In this study, the estimates of the effect of maternal birth weight on the birth weights of offspring are consistent with those in previous studies<sup>11,12</sup> in which the maternal birth weights were obtained from birth certificates. This similarity suggests that any recall bias was not sufficient to alter the study conclusions substantially.

The gestational ages of the mothers were not available in this study, so it could not be determined whether the mothers with low birth weights were small at birth because of shortened gestation, intrauterine growth retardation, or both. Data on several characteristics known to affect birth weight, including prenatal care<sup>25</sup> and any use of illicit drugs by the mother during pregnancy,<sup>26</sup> were not available for the siblings. Adjustment for these variables in the analysis that was limited to the index children did not significantly alter the observed associations between a mother's birth weight and that of the child. Finally, from a clinical and a public health perspective, it is important to have information on prior outcomes in order to predict future outcomes. This study was limited by its retrospective nature.

In summary, although selection and recall biases cannot be excluded with certainty, the data suggest strong familial aggregation of low birth weight among both whites and blacks. Health professionals should recognize that the risk of a recurrence of low birth weight in the same generation is related to the birth weights of both the mother and the index child. More important, women who themselves had low birth weight and have ever delivered a baby with low birth weight are at disproportionately high risk for having another low-birth-weight child. This information should allow women and their physicians to decide on a more informed course of prenatal and postnatal assessment and management, one consistent with each woman's reproductive risk. Researchers should be encouraged to elucidate the biomedical, social, and environmental pathways that contribute to the familial aggregation of low birth weight. The identification of these pathways may help us to un-

derstand better the causes of low birth weight and may lead to better strategies for its prevention.

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