

# Maternal Weight Gain and the Outcome of Pregnancy

## United States, 1980

An analysis of maternal weight gain during pregnancy by demographic characteristics of mothers and its association with birth weight and the risk of fetal death.

Data From the National Vital Statistics System  
Series 21, No. 44

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# Contents

Introduction .....	1
Summary of findings .....	2
Weight gain during pregnancy .....	3
Race of mother .....	3
Prepregnancy weight .....	4
Smoking habit .....	5
Socioeconomic status .....	5
Age of mother .....	6
Live-birth order .....	6
Marital status .....	6
Outcome of pregnancy .....	9
Birth weight .....	9
Risk of fetal death .....	14
References .....	20
Appendix. Technical notes .....	21
Sources of data .....	21
Definition of terms .....	21
Sampling error .....	22
Testing differences .....	23
Nonsampling error .....	25

## List of text figures

1. Percent of mothers gaining less than 16 pounds and percent gaining 26 pounds or more during pregnancy by prepregnancy weight: United States, 1980 National Natality Survey .....	5
2. Percent of mothers gaining less than 16 pounds and percent gaining 26 pounds or more during pregnancy by educational attainment of mother: United States, 1980 National Natality Survey .....	8
3. Percent of live-born infants of low birth weight by maternal weight gain during pregnancy, according to mother's prepregnancy weight: United States, 1980 National Natality Survey .....	12
4. Mean birth weight of live births to married mothers by weight gain during pregnancy, weight-for-height index, and smoking habit: United States, 1980 National Natality Survey .....	15
5. Fetal death ratios by weight gain during pregnancy and period of gestation: United States, 1980 National Natality and Fetal Mortality Surveys .....	17

## List of text tables

A. Number of live births and percent distribution by weight gain during pregnancy and mean weight gain, according to race of mother and period of gestation: United States, 1980 National Natality Survey .....	3
B. Number of live births and percent distribution by weight gain during pregnancy and mean weight gain, according to race and prepregnancy weight of mother: United States, 1980 National Natality Survey .....	4
C. Number of live births to married mothers and percent distribution by weight gain during pregnancy and mean weight gain, according to selected maternal characteristics: United States, 1980 National Natality Survey .....	6
D. Number of live births and percent distribution by weight gain during pregnancy and mean weight gain, according to selected maternal characteristics: United States, 1980 National Natality Survey .....	7

E. Number of live births, percent distribution by birth weight, and mean birth weight, according to weight gain during pregnancy and race of mother: United States, 1980 National Natality Survey.....	10
F. Mean birth weight of live births by weight gain during pregnancy, race of mother, and period of gestation: United States, 1980 National Natality Survey .....	11
G. Percent of live births weighing less than 2,500 grams by weight gain during pregnancy, race of mother, and prepregnancy weight of mother: United States, 1980 National Natality Survey.....	11
H. Percent of live births weighing less than 2,500 grams by weight gain during pregnancy and age of mother: United States, 1980 National Natality Survey .....	12
J. Percent of live births weighing less than 2,500 grams by weight gain during pregnancy, age, and educational attainment of mother: United States, 1980 National Natality Survey .....	13
K. Mean birth weight of live births to married mothers by weight gain during pregnancy, period of gestation, and smoking habit of mother: United States, 1980 National Natality Survey .....	13
L. Mean birth weight of live births to married mothers by weight gain during pregnancy, weight-for-height index, and smoking habit of mother: United States, 1980 National Natality Survey.....	14
M. Fetal death ratios by weight gain during pregnancy and period of gestation: United States, 1980 National Natality and Fetal Mortality Surveys .....	16
N. Fetal death ratios by weight gain during pregnancy, prepregnancy weight, and race of mother: United States, 1980 National Natality and Fetal Mortality Surveys.....	18
O. Fetal death ratios by weight gain during pregnancy and age of mother: United States, 1980 National Natality and Fetal Mortality Surveys .....	18
P. Fetal death ratios by weight gain during pregnancy, period of gestation, and educational attainment of mother: United States, 1980 National Natality and Fetal Mortality Surveys.....	19
Q. Fetal death ratios by weight gain during pregnancy, period of gestation, and smoking habit of married mothers: United States, 1980 National Natality and Fetal Mortality Surveys.....	19
R. Fetal death ratios by weight gain during pregnancy, weight-for-height index, and smoking habit of married mothers: United States, 1980 National Natality and Fetal Mortality Surveys .....	19

**List of appendix tables**

I. Standard errors for estimated mean birth weight of live births by weight gain during pregnancy, period of gestation, and race of mother: United States, 1980 National Natality Survey.....	22
II. Standard errors for estimated mean birth weight of live births to married mothers by weight gain during pregnancy, period of gestation, weight-for-height index, and smoking habit: United States, 1980 National Natality Survey.....	23
III. Number of live births by selected characteristics: United States, 1980 National Natality Survey .....	24
IV. Number of live births to married mothers by selected characteristics: United States, 1980 National Natality Survey ...	25
V. Parameters used to compute relative standard errors for live births and fetal deaths by maternal characteristic.....	25

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**Symbols**

- Data not available
  - ... Category not applicable
  - Quantity zero
  - 0.0 Quantity more than zero but less than 0.05
  - Z Quantity more than zero but less than 500 where numbers are rounded to thousands
  - \* Figure does not meet standards of reliability or precision (25 percent or more relative standard error)
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# Maternal Weight Gain and the Outcome of Pregnancy

by Selma M. Taffel, Division of Vital Statistics

## Introduction

For several decades prior to the early 1970's, common medical practice in the United States was to minimize a mother's weight gain during pregnancy in the belief that excessive gain might predispose her to the development of toxemia as well as to other obstetrical problems. A total weight gain of 20 pounds or less was frequently recommended. During this time, however, it became apparent that severe dietary restriction during pregnancy resulted in an elevated risk of low birth weight and neurologic impairment of the infant.<sup>1-5</sup> In 1970, the National Academy of Sciences concluded that "an average weight gain of 24 pounds (range of 20-25 pounds) is commensurate with a better than average course and outcome of pregnancy" and that there was no scientific justification for routinely limiting weight gain to less than this amount.<sup>6</sup>

According to current obstetric guidelines issued in 1983, usual weight gain should be 22-27 pounds. Weight reduction during pregnancy is no longer advised, even for women with a high prepregnancy weight, because of potential adverse effects on fetal growth and development.<sup>7</sup>

Although the relationship between a mother's weight gain during pregnancy and the outcome of pregnancy has been explored in numerous studies, none has been national in scope. The present study investigates this association using information obtained from the 1980 National Natality Survey (NNS) and the 1980 National Fetal Mortality Survey (NFMS) conducted by the National Center for Health Statistics. The NNS is based on a probability sample of all live births occurring in the United States in 1980. The NFMS is based on a probability sample of fetal deaths with a physician's estimate of gestation of 28 weeks or more or delivery weight of 1,000 grams or more if the physician's estimate was not reported.

This study includes only women for whom information on

prenatal care was available. Information about the mother and live birth or fetal death is derived from the live birth certificate or fetal death report and from questionnaires mailed to the mother (if married), to her attendant at delivery, and to the hospital where the delivery occurred. Weight of the mother at the start of pregnancy and at delivery were requested from all sources, but preference has been given in this report to the information reported by hospitals or attendants. Values for missing information have been imputed, and each birth and fetal death has been weighted to derive national estimates. A more detailed description of these surveys is included in the Technical notes.

The first part of this study describes differences in maternal weight gain during pregnancy for live births according to the period of gestation (the time between the first day of the mother's last normal menstrual period and the day of birth) and certain sociodemographic and health characteristics known to be associated with variation in pregnancy outcome. These are race, prepregnancy weight, smoking habit, family income, educational attainment, age, marital status, and live-birth order of the infant. An analysis of weight gain for Hispanic-origin women was not possible because of the small numbers of these women in the NNS and NFMS.

The second part of the study investigates the relationship between weight gain and pregnancy outcome, while controlling for period of gestation and mother's race, prepregnancy weight, age, education, and smoking habit. Pregnancy outcome is assessed in terms of birth-weight distribution; mean birth weight; incidence of low birth weight (less than 2,500 grams or 5 pounds 8 ounces); and the risk of fetal death, as measured by the fetal death ratio (number of fetal deaths of 28 weeks' or more gestation per 1,000 live births).

## Summary of findings

Current obstetrical guidelines state that usual weight gain in a normal pregnancy should be 22–27 pounds. But in 1980, one out of five white mothers and one out of four black mothers whose pregnancy extended to at least 40 weeks gained less than 21 pounds.

Overall, 23 percent of women giving birth in 1980 gained less than 21 pounds during their pregnancy, and 12 percent gained less than 16 pounds. Black mothers were 50 percent more likely than white mothers to gain less than 21 pounds (33 percent compared with 22 percent), and they were twice as likely to gain less than 16 pounds (20 percent compared with 11 percent). The average weight gain of white mothers was 29.1 pounds, 2.3 pounds higher than that of black mothers. Large racial differences in weight gain persist even after taking into consideration the shorter gestational period of black births and variation in prepregnancy weight.

Substantial disparities in weight gain are evident for many groups of mothers: Women who have a high prepregnancy weight, who smoke during pregnancy, who have a low family income, who are 35 years of age or older or in their teens, who have less than 9 years of schooling, who are having a fourth or higher order birth, or who are unmarried are all more likely to gain less than 16 pounds and less likely to gain 26 pounds or more during their pregnancy.

A low weight gain during pregnancy is associated with a lower average birth weight and a higher risk of a low birth weight (less than 2,500 grams) or fetal death outcome. Mean birth weight rises with increased weight gain for all gestational periods. For gestations of 40 weeks or longer, mean birth weight was 290 grams (10 ounces) higher when the mother gained 36 pounds or more than when she gained less than 16 pounds; for gestations of less than 37 weeks, the average birth weight was 380 grams (13 ounces) higher for a comparable increase in weight gain. Mean birth weight also increases with added weight gain for babies of mothers who smoked during pregnancy as well as for nonsmoking mothers. The increase in birth weight is especially marked for babies born prematurely (less than 37 weeks' gestation) to mothers who smoked; for these babies, birth weight was 671 grams (1 pound 8 ounces) higher for weight gains of at least 36 pounds than for weight gains of less than 16 pounds. Birth weight also increases markedly with added weight gain for babies of small women who smoked during their pregnancy.

For comparable maternal weight gain, the average birth weight of black babies is lower than that of white babies, and

black babies are more likely to weigh less than 2,500 grams (5½ pounds), and less likely to weigh at least 3,500 grams (7 pounds 12 ounces).

A low prepregnancy weight combined with a small weight gain is associated with a very high incidence of low birth weight: 29 percent of the babies born to mothers weighing less than 110 pounds at the start of pregnancy who gained less than 16 pounds weighed less than 5½ pounds. The incidence of low birth weight declines sharply as weight gain rises, regardless of prepregnancy weight, and the disadvantage in birth weight for babies of small women is reduced substantially.

Nearly one out of five teenage mothers who gained less than 16 pounds bore a low-birth-weight baby in 1980, but the incidence of low birth weight dropped by three-fourths, to 4.9 percent, when weight gain increased to at least 36 pounds.

Higher educational attainment is associated with a reduced risk of low birth weight. When women gain less than 16 pounds during their pregnancy, however, there is no significant difference in the risk of low birth weight between those with less than a high school education and those who completed college (15.0 percent compared with 12.2 percent). For all levels of educational attainment, the incidence of low birth weight is significantly lower for weight gains of at least 21 pounds than for weight gains of less than 16 pounds.

The risk of a fetal death outcome is also lowered with added weight gain, up to 35 pounds. For the gestational periods 32–40 weeks, the risk of fetal death dropped by about half as weight gain increased from less than 16 to 26–35 pounds.

Although fetal death ratios are higher for mothers with a high prepregnancy weight, the risk of a fetal death outcome declines as weight gain increases for these women as well as for women with lower prepregnancy weight. Large declines in the risk of fetal death with added weight gain are also evident for women of all ages, for all levels of educational attainment, and for women who smoke during pregnancy as well as those who do not, regardless of gestational period or maternal size.

Numerous studies have identified groups of women who are at highest risk of bearing a low-birth-weight infant or of having their pregnancy end in a fetal death. It is apparent from this study that these high-risk groups are also generally the most likely to have a smaller weight gain during their pregnancy. It is also evident that higher weight gain during pregnancy is associated with a significantly lower incidence of an adverse outcome for these high-risk groups.

# Weight gain during pregnancy

The analysis of differences in maternal weight gain in this section is limited to live births because of the dissimilarity in weight gain between live births and fetal deaths. The period of gestation for fetal deaths is shorter on the average than that for live births, resulting in a lower average weight gain. However, because of the far smaller number of fetal deaths than of live births, final conclusions are not altered because of their omission.

## Race of mother

In 1980, about 12 percent of mothers who had a live birth gained less than 16 pounds during their pregnancy, and an additional 11 percent gained 16–20 pounds. Thus, nearly one-quarter of all mothers gained 20 pounds or less. Slightly more

than one-half of all mothers (52 percent) gained 21–35 pounds, and the remaining 25 percent gained 36 pounds or more. This weight gain distribution reflects mainly the experience of white mothers. Black mothers were nearly twice as likely as white mothers to gain less than 16 pounds (20 percent compared with 11 percent) and were also less likely to gain at least 36 pounds (21 percent of black mothers compared with 26 percent of white mothers). One-third of all black mothers gained no more than 20 pounds (table A).

As would be expected, total weight gain during pregnancy is highly related to the length of the gestational period. Weight gain averaged 21 pounds for gestational periods of less than 32 weeks, compared with 31 pounds for gestational periods of 42 weeks or longer (table A).

**Table A. Number of live births and percent distribution by weight gain during pregnancy and mean weight gain, according to race of mother and period of gestation: United States, 1980 National Natality Survey**

Race of mother and period of gestation	Live births	Weight gain during pregnancy						Mean	Standard error of mean
		Total	Less than 16 pounds	16–20 pounds	21–25 pounds	26–35 pounds	36 pounds or more		
	Number in thousands		Percent distribution					Pounds	
All races <sup>1</sup>	3,581	100.0	12.0	11.4	17.1	34.7	24.8	28.7	0.2
Under 32 weeks	64	100.0	37.5	19.4	16.2	16.5	10.3	20.9	1.1
32–35 weeks	164	100.0	22.0	15.3	15.8	32.4	14.6	24.8	0.4
36 weeks	126	100.0	16.6	14.1	19.6	31.5	18.1	26.5	0.9
37–39 weeks	1,238	100.0	12.6	11.9	18.1	36.0	21.4	27.9	0.3
40 weeks	869	100.0	9.4	10.5	17.2	37.2	25.7	29.6	0.3
41 weeks	528	100.0	8.6	10.5	18.3	34.2	28.5	30.1	0.3
42 weeks and over	591	100.0	11.0	9.9	13.9	32.0	33.2	30.5	0.4
White	2,917	100.0	10.5	11.1	17.3	35.4	25.7	29.1	0.2
Under 32 weeks	42	100.0	37.9	19.1	16.9	17.7	*8.4	19.9	1.1
32–35 weeks	113	100.0	20.0	14.4	15.6	34.5	15.5	25.4	0.6
36 weeks	98	100.0	15.6	13.7	19.1	34.0	17.6	27.0	1.1
37–39 weeks	988	100.0	10.3	11.7	18.5	36.9	22.6	28.4	0.3
40 weeks	720	100.0	8.5	10.3	17.4	37.5	26.3	29.9	0.3
41 weeks	455	100.0	8.0	10.8	17.5	35.1	28.5	30.0	0.4
42 weeks and over	501	100.0	10.6	9.3	14.6	31.9	33.7	30.5	0.3
Black	554	100.0	20.0	12.6	16.0	30.0	21.3	26.8	0.5
Under 32 weeks	21	100.0	37.3	*19.0	*15.1	*14.2	*14.4	22.9	1.6
32–35 weeks	47	100.0	27.0	14.6	15.9	29.4	13.1	23.7	0.4
36 weeks	24	100.0	*18.3	*17.0	*23.2	*20.9	*20.6	24.5	-2.0
37–39 weeks	208	100.0	23.6	12.5	16.0	29.4	18.4	25.8	0.8
40 weeks	122	100.0	16.0	11.0	16.4	35.0	21.6	27.4	0.7
41 weeks	58	100.0	*11.4	*9.9	*21.7	28.8	28.1	30.5	1.2
42 weeks and over	74	100.0	*14.1	*13.4	*9.1	32.2	31.2	30.0	1.3

<sup>1</sup>Includes races other than white and black.



White mothers gained, on the average, 2.3 pounds more than black mothers (29.1 pounds compared with 26.8 pounds). This higher weight gain is only partly explained by the one-half week longer median gestational period of white than of black babies (40.3 weeks compared with 39.7 weeks in 1980). For almost all gestational periods there is a consistent pattern of a greater likelihood of a weight gain of less than 16 pounds for black women, although differences are not always statistically significant.

For gestational periods of 37–39 weeks, the period when more than one-third of all births occurred, white mothers gained about 2½ pounds more than black mothers. This greater weight gain reflects the fact that black mothers were more than twice as likely as white mothers to gain less than 16 pounds (24 percent compared with 10 percent), and the greater likelihood that white mothers would gain at least 26 pounds (60 percent compared with 48 percent). Weight gain was also 2½ pounds greater for white than black mothers when gestational age was 40 weeks—again reflecting a much higher proportion of black mothers gaining less than 16 pounds. For gestational periods of 40 weeks or longer, one out of five white mothers and one out of four black mothers gained less than 21 pounds.

### Prepregnancy weight

A mother's weight at the start of pregnancy is known to have a strong bearing on how much a mother gains during pregnancy and on pregnancy outcome.<sup>8</sup> A more meaningful measure of maternal size than prepregnancy weight is the relationship between her weight and height. Maternal height was

requested only on the mother's questionnaire, and, hence, a weight-for-height index could be derived only for married mothers. When analyzing data for all mothers, prepregnancy weight is used as a surrogate for this index.

It is clear from the data in table B and figure 1 that women who weigh at least 150 pounds at the start of pregnancy are far more likely than smaller women to gain less than 16 pounds; 18 percent of women weighing 150–169 pounds and 29 percent of women weighing 170 pounds or more gained this little, compared with only 8 to 10 percent of women weighing less than 150 pounds. In addition, a weight gain of 26 pounds or more is more common among women weighing less than 150 pounds at the start of pregnancy than among those weighing 170 pounds or more. Women with the highest prepregnancy weights, those weighing at least 170 pounds, gained on the average 24.0 pounds, 4 to 6 pounds less than women with lower prepregnancy weights.

Also of note is that black mothers who start pregnancy weighing 110–149 pounds are more likely than white mothers of comparable prepregnancy weight to gain less than 16 pounds and they are also less apt to gain at least 26 pounds. Weight gain averaged 3 pounds less for black than for white mothers weighing 110–149 pounds at the start of pregnancy.

If maternal size is gauged by a woman's weight for her height rather than by her weight alone, it is again apparent that there is a pattern of lower weight gain for larger women; 21 percent of married women who had a high prepregnancy weight for their height gained less than 16 pounds, compared with only 6 percent of the women whose weight for height was low and 8 percent of the women whose weight for height was average.

**Table B. Number of live births and percent distribution by weight gain during pregnancy and mean weight gain, according to race and prepregnancy weight of mother: United States, 1980 National Natality Survey**

Race and prepregnancy weight of mother	Live births	Weight gain during pregnancy						Mean	Standard error of mean
		Total	Less than 16 pounds	16–20 pounds	21–25 pounds	26–35 pounds	36 pounds or more		
	Number in thousands	Percent distribution						Pounds	
All races <sup>1</sup>	3,581	100.0	12.0	11.4	17.1	34.7	24.8	28.7	0.2
Less than 110 pounds	478	100.0	8.0	11.6	20.0	38.7	21.6	28.8	0.3
110–129 pounds	1,315	100.0	7.8	11.4	17.9	39.5	23.4	29.2	0.2
130–149 pounds	968	100.0	10.0	10.6	16.0	34.3	29.0	30.2	0.2
150–169 pounds	441	100.0	18.4	11.3	15.3	27.3	27.6	27.9	0.5
170 pounds or more	379	100.0	28.7	13.1	15.7	22.6	19.8	24.0	0.7
White	2,917	100.0	10.5	11.1	17.3	35.4	25.7	29.1	0.2
Less than 110 pounds	372	100.0	7.7	12.1	19.6	37.7	22.8	29.1	0.4
110–129 pounds	1,094	100.0	6.5	10.8	18.0	40.1	24.4	29.7	0.3
130–149 pounds	791	100.0	7.8	10.1	16.9	35.3	29.8	30.7	0.3
150–169 pounds	370	100.0	16.9	10.7	15.6	29.1	27.6	28.1	0.6
170 pounds or more	290	100.0	27.9	13.7	14.7	23.2	20.5	24.0	0.9
Black	554	100.0	20.0	12.6	16.0	30.0	21.3	26.8	0.5
Less than 110 pounds	73	100.0	8.5	10.1	25.2	37.8	18.4	27.9	1.0
110–129 pounds	178	100.0	16.4	13.8	15.2	36.0	18.6	26.9	0.7
130–149 pounds	154	100.0	21.1	13.0	12.2	29.2	24.5	27.4	0.8
150–169 pounds	63	100.0	24.9	*13.6	*13.4	18.5	29.5	27.8	1.6
170 pounds or more	85	100.0	31.8	*10.9	18.7	20.7	17.8	24.0	0.9

<sup>1</sup>Includes races other than white and black.

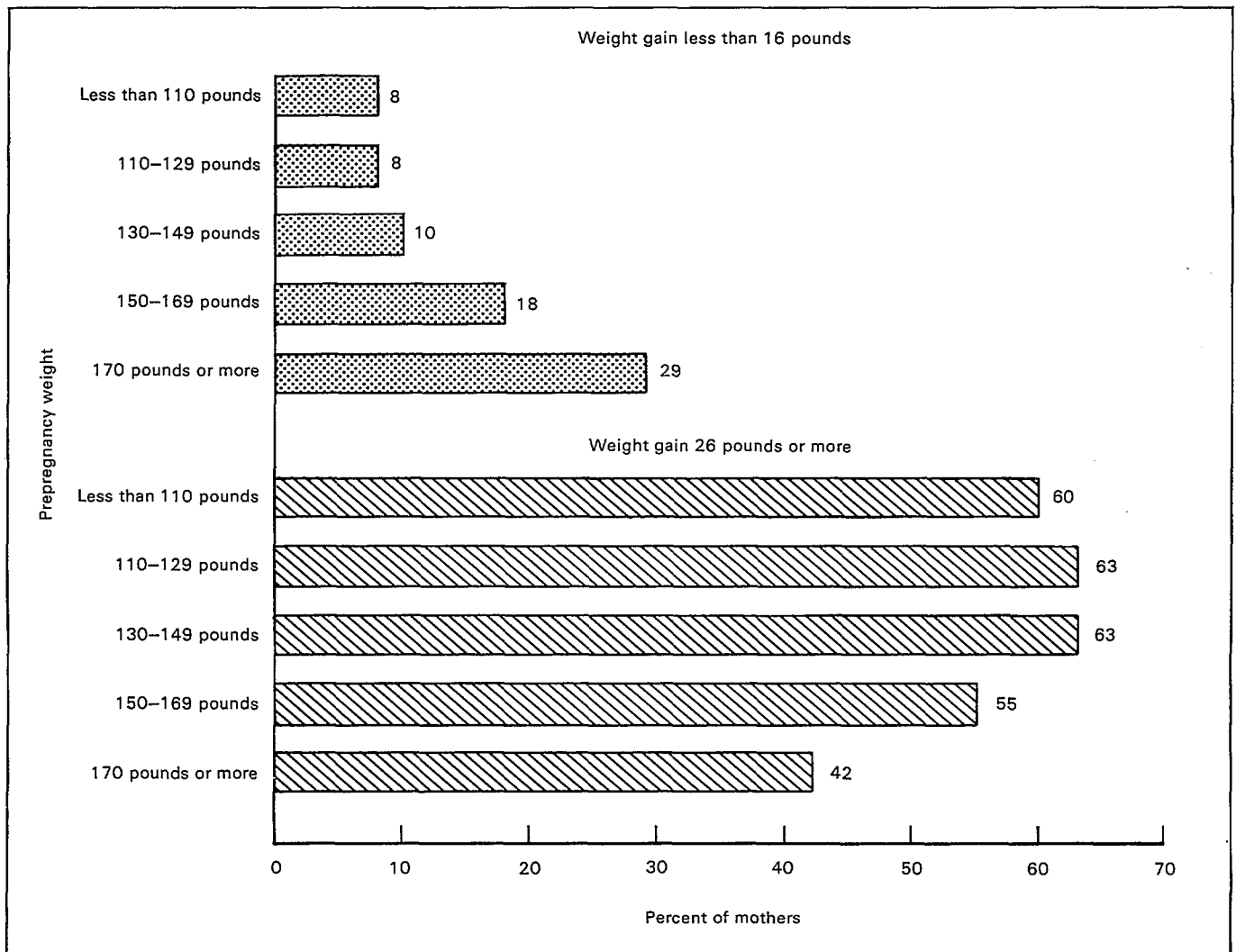


Figure 1. Percent of mothers gaining less than 16 pounds and percent gaining 26 pounds or more during pregnancy by prepregnancy weight: United States, 1980 National Natality Survey

Women whose weight/height index was higher than average gained about 4 pounds less than smaller women (table C).

### Smoking habit

Information on cigarette smoking during pregnancy was available only for married mothers. Mothers who smoked during pregnancy were more likely than nonsmoking mothers to gain less than 16 pounds (14 percent compared with 10 percent). About one in four mothers who smoked during their pregnancy gained less than 21 pounds compared with one in five nonsmoking mothers. This differential cannot be explained by a dissimilarity in gestational period, because the median gestational period for women who smoked was only 0.1 week shorter than that of nonsmoking mothers.

These data are consistent with previous research that found that weight gain during pregnancy is lower for women who smoke than for those who do not.<sup>9</sup> That study also concluded that the difference in mean weight gain between smokers and nonsmokers could not be accounted for by differences in length

of gestation or mother's prepregnancy weight, age, marital status, or educational attainment.

### Socioeconomic status

Family income was requested only on questionnaires sent to mothers, and hence data on income reflect only the economic status of married mothers. The average weight gain of married mothers with a family income of at least \$30,000 was 29.7 pounds, 1.4 pounds higher than when family income was less than \$9,000 (28.3 pounds) (table C).

The proportion of women gaining less than 16 pounds declined by nearly half (from 16 to 9 percent) as family income increased from less than \$9,000 to \$30,000. Also evident is a small increment in the proportion of mothers gaining at least 26 pounds as family income rises, although differences between adjacent income groups are not always significant (table C).

Family income was available only for married mothers from the survey, but information on educational attainment of the mother, a commonly used measure of socioeconomic status,

**Table C. Number of live births to married mothers and percent distribution by weight gain during pregnancy and mean weight gain, according to selected maternal characteristics: United States, 1980 National Natality Survey**

Selected maternal characteristic	Live births	Weight gain during pregnancy						Mean	Standard error of mean
		Total	Less than 16 pounds	16-20 pounds	21-25 pounds	26-35 pounds	36 pounds or more		
	Number in thousands	Percent distribution						Pounds	
All births	2,930	100.0	10.6	11.1	17.1	35.8	25.4	29.1	0.2
Weight-for-height index <sup>1</sup>									
Low	726	100.0	6.3	10.4	19.1	40.1	24.1	29.8	0.2
Average	1,478	100.0	7.6	10.4	16.4	38.0	27.5	30.2	0.2
High	726	100.0	21.0	13.3	16.4	26.9	22.4	26.1	0.4
Smoking habit during pregnancy									
Smoker	767	100.0	13.6	11.8	15.8	33.1	25.8	28.6	0.4
Nonsmoker	2,162	100.0	9.6	10.9	17.6	36.7	25.3	29.2	0.1
Family income									
Under \$9,000	440	100.0	15.9	11.0	15.6	31.6	25.9	28.3	0.4
\$9,000-\$14,999	625	100.0	11.2	11.9	18.1	33.5	25.1	28.9	0.4
\$15,000-\$20,999	708	100.0	10.0	11.8	17.6	35.4	25.2	29.0	0.3
\$21,000-\$29,999	718	100.0	8.4	10.8	17.6	38.0	25.1	29.4	0.4
\$30,000 and over	440	100.0	9.0	9.5	15.3	40.1	26.0	29.7	0.2

<sup>1</sup>Low is less than 25th percentile for study group, average is 25th to 74th percentile, and high is 75th percentile or higher.

was available for both married and unmarried women from the live birth certificate.

The more years of schooling a mother has completed, the higher her weight gain is likely to be (table D). Women who had completed college gained on the average 5 pounds more than women with no more than a grade school education (29.7 pounds compared with 24.9 pounds). The proportion of mothers gaining at least 26 pounds during pregnancy generally increased with added years of education (figure 2), concomitant with a decline in the proportion of mothers gaining less than 16 pounds or 16-20 pounds. A gain of less than 16 pounds was three times as common among mothers with less than 9 years of schooling (20 percent) as among mothers who had completed at least 16 years of schooling (6 percent). Likewise, the proportion of mothers gaining only 16-20 pounds was 75 percent higher for women with only a grade school education (17 percent) than for women who had completed college (10 percent). College graduates were far more likely than mothers who had only a grade school education to gain 26 pounds or more (66 percent compared with 46 percent) (figure 2).

### Age of mother

Mothers 35 years of age or older are more likely than younger women to gain less than 16 pounds during their pregnancy; 24 percent of these older women had this low a weight gain compared with 10-11 percent of mothers aged 20-34 years and 14 percent of teenage mothers. The likelihood of a more adequate weight gain of at least 26 pounds tends to decline for women in the oldest years of childbearing. Only 48 percent of women 35 years or older gained this much compared with 56 percent of teenage mothers and 61 percent of mothers in their twenties. The average weight gain of women 35 years

or older was 3-5 pounds less than that of younger mothers (table D).

One explanation for the lower average weight gain of older women is that they are more likely than younger women are to start pregnancy weighing at least 150 pounds. As noted previously, women with this prepregnancy weight are far more likely than women weighing less to have a low weight gain.

Teenage girls are also more likely than women 20-34 years of age to gain less than 16 pounds. Reports on the nutritive status of pregnant adolescents indicate that suboptimal food intake during pregnancy is common in this age group.<sup>10</sup>

### Live-birth order

Weight gain during pregnancy is likely to decline with each successive birth (table D). Women having their first child gained on the average 5.6 pounds more than women having a fourth or higher order birth (30.5 pounds compared with 24.9 pounds). A woman having a fourth or higher order birth was 2½ times as likely to gain less than 16 pounds (23 percent of these mothers) as a woman having a first child (9 percent); conversely, weight gains of over 25 pounds were about 1½ times as frequent for women having a first birth (65 percent) as for women having a fourth or higher order birth (46 percent). The lower weight gain for women having higher order births is probably related to the fact that these mothers start pregnancy weighing more on the average than other women. As previously noted, weight gain declines with increased prepregnancy weight.

### Marital status

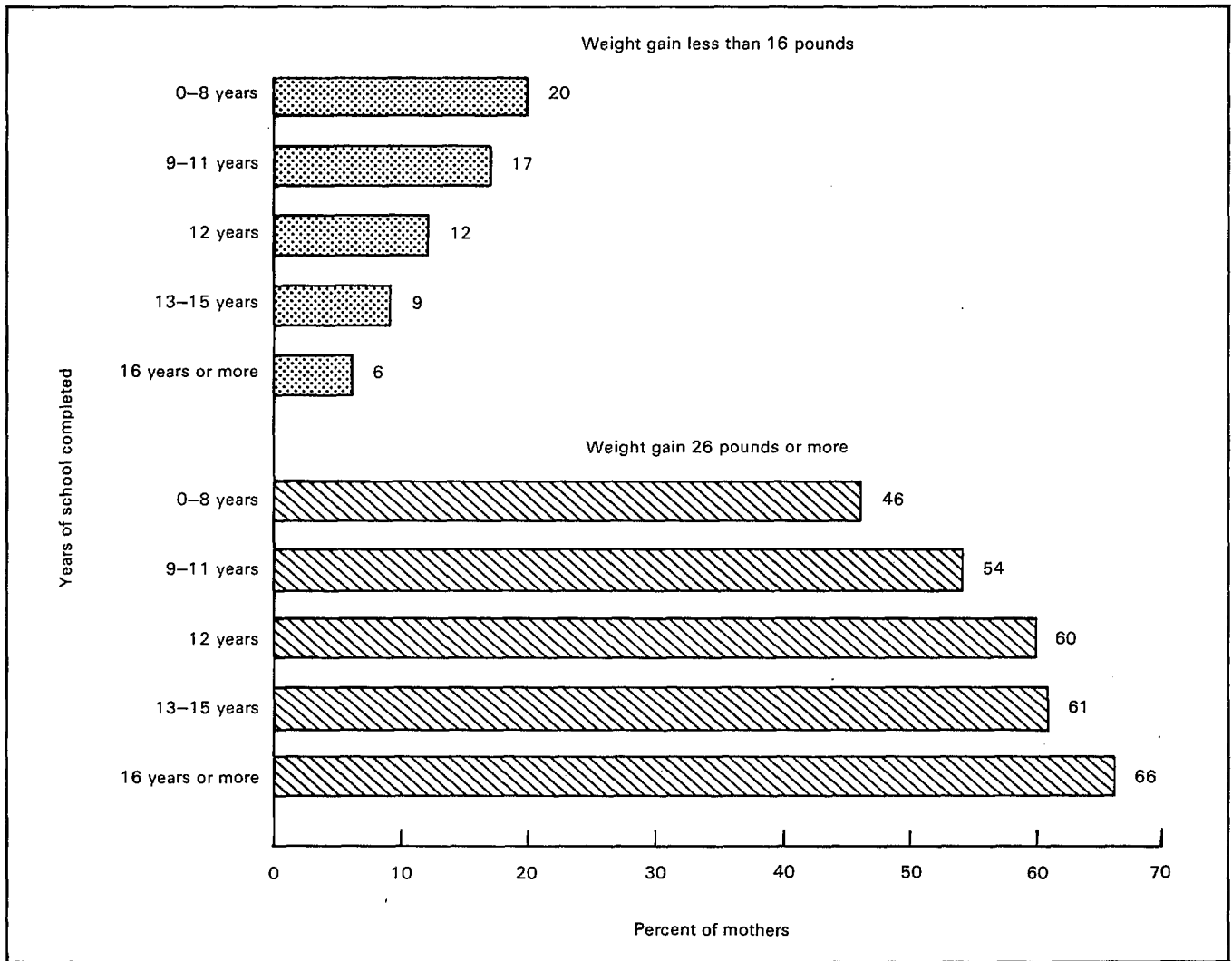
Proportionately fewer married (11 percent) than unmarried women (18 percent) gained less than 16 pounds, and a weight

**Table D. Number of live births and percent distribution by weight gain during pregnancy and mean weight gain, according to selected maternal characteristics: United States, 1980 National Natality Survey**

Selected maternal characteristic	Live births	Weight gain during pregnancy						Mean	Standard error of mean
		Total	Less than 16 pounds	16-20 pounds	21-25 pounds	26-35 pounds	36 pounds or more		
		Number in thousands	Percent distribution				Pounds		
All births .....	3,581	100.0	12.0	11.4	17.1	34.7	24.8	28.7	0.2
Years of school completed									
0-8 years.....	158	100.0	20.4	17.0	16.4	27.7	18.6	24.9	0.5
9-11 years.....	659	100.0	17.3	12.4	16.4	31.0	22.9	27.4	0.4
12 years.....	1,579	100.0	11.8	11.0	16.8	33.7	26.7	29.2	0.3
13-15 years.....	676	100.0	9.4	11.4	18.1	36.2	24.9	29.2	0.4
16 years or more.....	509	100.0	6.4	9.7	18.0	42.6	23.3	29.7	0.3
Age									
Under 20 years.....	553	100.0	14.4	11.7	18.0	31.3	24.7	28.5	0.4
20-24 years.....	1,215	100.0	11.5	10.7	16.3	34.3	27.3	29.6	0.3
25-29 years.....	1,101	100.0	10.4	11.1	17.4	37.0	24.2	28.7	0.3
30-34 years.....	557	100.0	10.6	12.5	18.2	35.9	22.8	28.2	0.3
35 years and over.....	154	100.0	23.6	13.9	15.2	29.5	17.9	24.9	0.7
Live-birth order									
First child.....	1,550	100.0	9.3	9.7	15.7	35.8	29.6	30.5	0.3
Second child.....	1,149	100.0	11.5	12.1	18.4	35.5	22.5	28.3	0.2
Third child.....	541	100.0	13.9	13.6	18.0	34.2	20.3	27.0	0.5
Fourth child or more.....	341	100.0	22.7	13.4	17.9	27.8	18.2	24.9	0.5
Marital status									
Married.....	2,930	100.0	10.6	11.1	17.1	35.8	25.4	29.1	0.2
Unmarried.....	651	100.0	18.0	12.6	17.3	29.8	22.3	27.1	0.4

gain of at least 26 pounds was more common among married women (table D). On the average, married mothers gained 2 pounds more than unmarried mothers (29.1 pounds compared with 27.1 pounds). These differences probably reflect in part the far lower family income of female-headed households than

of husband-wife households,<sup>11</sup> because low family income is associated with lower weight gain. Unmarried mothers are also more likely to be teenagers, another factor related to lower weight gain.



**Figure 2. Percent of mothers gaining less than 16 pounds and percent gaining 26 pounds or more during pregnancy by educational attainment of mother: United States, 1980 National Natality Survey**

# Outcome of pregnancy

The birth weight of live-born infants and the risk of fetal loss, as measured by the fetal death ratio (number of fetal deaths of 28 weeks of gestation or more per 1,000 live births), are both commonly used yardsticks of pregnancy outcome.

The risk of a low-birth-weight outcome (less than 2,500 grams or 5 pounds 8 ounces) for live births has been shown to be related to a number of maternal and infant characteristics, including early or late childbearing, first and high birth orders, low educational attainment, out-of-wedlock childbearing, smoking during pregnancy, and black race.<sup>12,13</sup> Likewise, a higher risk of fetal death is known to be associated with low educational attainment, out-of-wedlock childbearing, and black race.<sup>14,15</sup> As indicated earlier, a low weight gain during pregnancy is also more prevalent for all of these characteristics except first birth order. In this section, the relationship between maternal weight gain and the risk of an unfavorable pregnancy outcome is explored while controlling for period of gestation and mother's race, age, prepregnancy weight, education, and smoking habit.

The percent low birth weight by weight gain for gestational periods of less than 40 weeks and for women who smoked during pregnancy did not meet standards of reliability because of the small number of such births in the sample. Analysis of these variables, therefore, is in terms of mean birth weight. For other characteristics, analysis is in terms of the risk of a low-birth-weight outcome.

## Birth weight

It is widely recognized that an infant's birth weight is a major determinant of its potential for survival and future development. As indicated in table E, there is a dramatic shift in the birth weight distribution of live births as weight gain during pregnancy rises. The proportion of low birth weight babies declined from 13.9 percent, when weight gain was less than 16 pounds, to 6.1 percent for gains of 21–25 pounds, and to 4.0 percent when mothers gained 36 pounds or more. The proportion of babies weighing 2,500–2,999 grams (5 pounds 9 ounces to 6 pounds 9 ounces) also dropped steeply with increases in weight gain, from 24.5 percent for weight gains of less than 16 pounds to 10.2 percent for women gaining at least 36 pounds. Concomitantly, the likelihood of a baby weighing at least 3,500 grams (7 pounds 12 ounces) more than doubled (from 24.8 to 51.7 percent) as weight gain increased from less than 16 to 36 pounds or more. This major shift in the birth weight distribution as weight gain increases is reflected in the mean birth weight, which was 435 grams higher (about 1 pound) for weight gains

of 36 pounds or more than for weight gains of less than 16 pounds (3,515 grams compared with 3,080 grams). Similar changes in birth weight distributions with increased weight gain are evident for both white and black babies. However, for a comparable weight gain, the mean birth weight of black babies is lower than that of white babies, and black babies are more likely to weigh less than 2,500 grams and are less likely to weigh 3,500 grams or more.

## Period of gestation

Because weight gain and fetal size both increase as pregnancy progresses, it is essential to examine the relationship between weight gain and birth weight while controlling for length of the gestational period. The data in table F indicate that for all gestational periods, mean birth weight generally rises with increases in maternal weight gain.

For gestations of less than 37 weeks, mean birth weight was 380 grams (13 ounces) higher for weight gains of 36 pounds or more than for weight gains of less than 16 pounds. The comparable difference in mean birth weight for gestations of 37–39 weeks was 300 grams (11 ounces). For pregnancies extending to 40 weeks and beyond, there is still a noticeable difference in mean birth weight, approximately 290 grams (10 ounces), for the highest compared with the lowest weight gain categories. This same pattern is evident for white births and for black births of at least 37 weeks of gestation.

## Prepregnancy weight

A woman's prepregnancy weight and her weight gain during pregnancy are strongly related to the incidence of low birth weight, and prepregnancy weight interacts with weight gain to increase or lessen this risk. A low prepregnancy weight combined with a small weight gain is associated with the highest incidence of low birth weight (table G).

Regardless of a mother's prepregnancy weight, there is a consistent pattern of declining risk of a low-birth-weight outcome as weight gain increases. This is especially noticeable for women weighing less than 110 pounds at the start of pregnancy, for whom a weight gain of less than 16 pounds was associated with an incidence of low birth weight of 28.8 percent, more than three times the incidence when weight gain was 21–25 pounds (8.7 percent) and five to six times the incidence when weight gain was 26 pounds or more (4.9–5.4 percent). For women weighing 110–129 pounds initially, the difference in incidence of low birth weight with increased weight gain is nearly as dramatic, dropping from 20.1 percent for a gain of

**Table E. Number of live births, percent distribution by birth weight, and mean birth weight, according to weight gain during pregnancy and race of mother: United States, 1980 National Natality Survey**

Race of mother and birth weight	Total	Weight gain during pregnancy				
		Less than 16 pounds	16-20 pounds	21-25 pounds	26-35 pounds	36 pounds or more
<b>All races<sup>1</sup></b>						
Live births	3,581	428	408	613	1,242	889
Number in thousands						
Total	100.0	100.0	100.0	100.0	100.0	100.0
Percent distribution						
Less than 2,500 grams	6.7	13.9	11.4	6.1	5.0	4.0
2,500-2,999 grams	16.1	24.5	19.6	18.1	15.2	10.2
3,000-3,499 grams	37.3	36.8	42.2	38.6	37.5	34.1
3,500 grams or more	39.9	24.8	26.8	37.2	42.3	51.7
Mean in grams						
Birth weight	3,343	3,080	3,175	3,315	3,381	3,515
Standard error	6	20	19	13	10	12
<b>White</b>						
Live births	2,917	306	323	505	1,034	750
Number in thousands						
Total	100.0	100.0	100.0	100.0	100.0	100.0
Percent distribution						
Less than 2,500 grams	5.6	12.5	9.8	5.3	4.2	3.2
2,500-2,999 grams	14.4	21.6	17.9	16.7	13.9	9.0
3,000-3,499 grams	36.8	37.0	43.0	38.1	37.0	33.0
3,500 grams or more	43.2	28.9	29.3	39.8	44.9	54.8
Mean in grams						
Birth weight	3,391	3,149	3,226	3,348	3,418	3,554
Standard error	8	25	22	15	11	13
<b>Black</b>						
Live births	554	111	70	89	166	118
Number in thousands						
Total	100.0	100.0	100.0	100.0	100.0	100.0
Percent distribution						
Less than 2,500 grams	12.5	18.3	19.1	10.0	10.1	8.3
2,500-2,999 grams	24.6	32.4	27.6	26.0	22.1	17.8
3,000-3,499 grams	39.0	36.2	35.7	40.4	41.4	38.9
3,500 grams or more	24.0	13.1	17.6	23.6	26.3	35.1
Mean in grams						
Birth weight	3,099	2,879	2,950	3,137	3,156	3,284
Standard error	12	28	36	36	25	31

<sup>1</sup>Includes races other than white and black.

less than 16 pounds to 7.5 percent for a gain of 21-25 pounds and to 3.6 percent when weight gain exceeded 35 pounds.

This same pattern of a sharply lower incidence of low birth weight as weight gain increases, independent of prepregnancy weight, is evident for both white and black births. However, because of the small numbers of black women in the sample, estimates were generally not reliable or differences statistically significant for many categories.

As shown in figure 3, there is a convergence in the risk of a low-birth-weight outcome from the lowest to the highest prepregnancy weight as weight gain increases. When weight gain was less than 16 pounds, the incidence of low birth weight for babies born to mothers weighing less than 110 pounds was 28.8 percent, four times the incidence for mothers who weighed

150 pounds or more initially (7.2 percent). But when weight gain was at least 26 pounds, there was no significant difference in the incidence of low birth weight between the lowest and highest prepregnancy weights. Apparently, the substantial disadvantage in birth weight for babies of women with a low prepregnancy weight is reduced considerably as weight gain increases.

#### Age of mother

It is well documented that teenage girls are more likely than other age groups to bear a low-birth-weight baby.<sup>12</sup> But increased weight gain during pregnancy lowers this risk substantially. As shown in table H, nearly one out of five teenagers gaining less than 16 pounds (19.2 percent) gave birth to a baby

**Table F. Mean birth weight of live births by weight gain during pregnancy, race of mother, and period of gestation: United States, 1980**  
National Natality Survey

Race of mother and period of gestation	Weight gain during pregnancy					
	Total	Less than 16 pounds	16-20 pounds	21-25 pounds	26-35 pounds	36 pounds or more
	Grams					
All races <sup>1</sup> .....	3,343	3,080	3,175	3,315	3,381	3,515
Under 37 weeks.....	2,624	2,387	2,448	2,704	2,782	2,767
37-39 weeks.....	3,281	3,120	3,187	3,251	3,301	3,420
40 weeks and over.....	3,510	3,340	3,363	3,472	3,521	3,628
White.....	3,391	3,149	3,226	3,348	3,418	3,554
Under 37 weeks.....	2,676	2,445	2,494	2,675	2,833	2,854
37-39 weeks.....	3,321	3,178	3,215	3,286	3,330	3,454
40 weeks and over.....	3,541	3,381	3,396	3,494	3,551	3,655
Black.....	3,099	2,879	2,950	3,137	3,156	3,284
Under 37 weeks.....	2,472	2,223	2,293	2,760	2,613	2,550
37-39 weeks.....	3,095	2,991	3,028	3,085	3,129	3,228
40 weeks and over.....	3,330	3,176	3,218	3,336	3,319	3,475

<sup>1</sup>Includes races other than white and black.

**Table G. Percent of live births weighing less than 2,500 grams by weight gain during pregnancy, race of mother, and prepregnancy weight of mother: United States, 1980 National Natality Survey**

Race and prepregnancy weight of mother	Weight gain during pregnancy					
	Total	Less than 16 pounds	16-20 pounds	21-25 pounds	26-35 pounds	36 pounds or more
All races <sup>1</sup> .....	6.7	13.9	11.4	6.1	5.0	4.0
Less than 110 pounds.....	9.5	28.8	20.5	8.7	4.9	5.4
110-129 pounds.....	7.5	20.1	13.8	7.5	5.5	3.6
130-149 pounds.....	5.7	14.5	7.7	4.7	4.8	3.6
150 pounds or more.....	5.0	7.2	6.4	3.4	3.9	4.3
White.....	5.6	12.5	9.8	5.3	4.2	3.2
Less than 110 pounds.....	8.9	24.9	19.0	8.2	5.2	4.6
110-129 pounds.....	6.3	19.3	11.4	6.2	4.8	3.3
130-149 pounds.....	4.4	13.9	6.5	3.8	3.4	2.7
150 pounds or more.....	4.0	6.0	5.6	3.6	2.8	3.2
Black.....	12.5	18.3	19.1	10.0	10.1	8.3
Less than 110 pounds.....	13.3	56.6	*30.7	*9.0	*4.9	*6.7
110-129 pounds.....	15.0	22.8	27.7	16.4	10.1	*6.9
130-149 pounds.....	13.0	15.9	*12.9	*11.8	14.0	9.9
150 pounds or more.....	8.5	11.5	*9.3	*2.2	*8.9	*8.4

<sup>1</sup>Includes races other than white and black.

weighing less than 2,500 grams, but the incidence of low birth weight dropped to 7.4 percent when teenagers gained 21-25 pounds, to 6.3 percent for gains of 26-35 pounds, and to a low of 4.9 percent for weight gains in excess of 35 pounds.

As weight gain increases, the risk of a low-birth-weight outcome declines for other age groups as well. For women past the teenage years, the incidence of low birth weight was 11-13 percent for weight gains of less than 16 pounds and fell to 4-5 percent when weight gain exceeded 25 pounds (table H).

#### Educational attainment

A mother's educational attainment and her family income are both reliable indicators of her socioeconomic status. Family

income was requested only of married mothers in the NNS, but years of schooling was available for married and unmarried mothers from live birth certificates.

Previous studies of national and State data have found that higher levels of educational attainment are associated with a sharply reduced incidence of low birth weight.<sup>12,16</sup> The proportion of low-birth-weight babies born to mothers in the NNS with 16 years or more of schooling (5.0 percent) was about half that of mothers with less than 12 years of schooling (9.3 percent) (table J). But for women who had completed college, the incidence of low birth weight averaged 12.2 percent when weight gain was less than 16 pounds and 8.5 percent when weight gain was 16-20 pounds. For women gaining less than



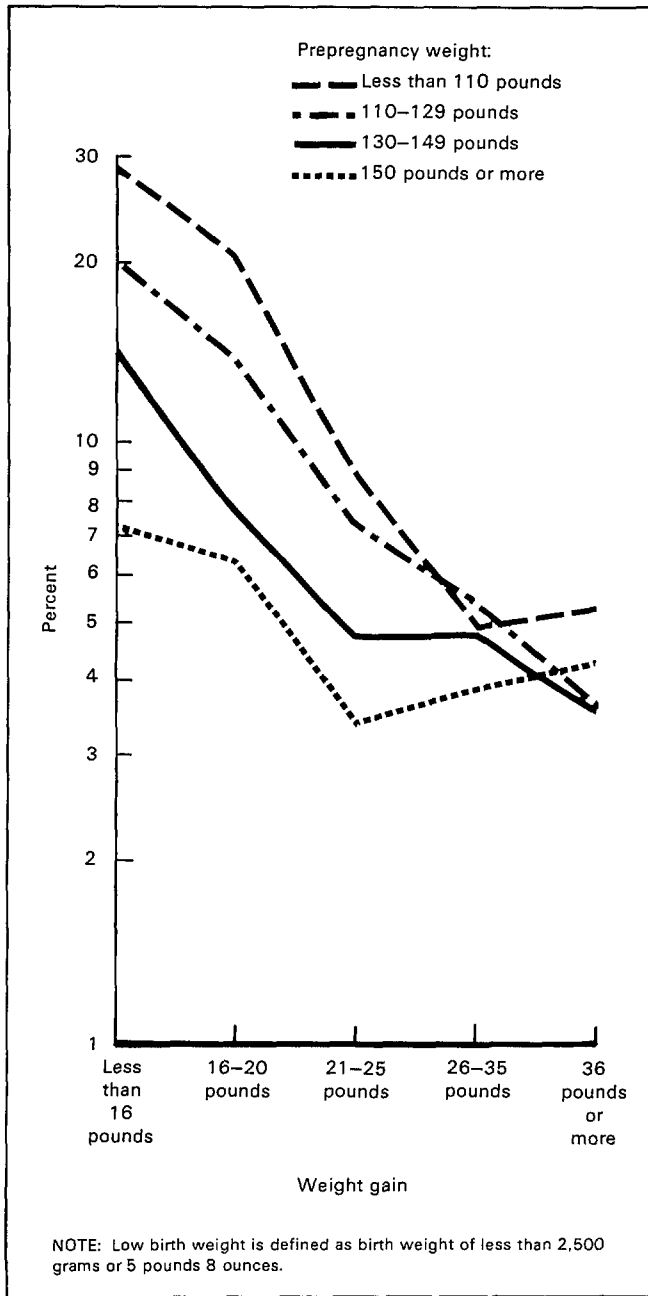


Figure 3. Percent of live-born infants of low birth weight by maternal weight gain during pregnancy, according to mother's prepregnancy weight: United States, 1980 National Natality Survey

16 pounds during pregnancy, the risk of a low-birth-weight outcome is not significantly different for those who had not completed high school than for those who had completed college (15.0 percent compared with 12.2 percent).

For all levels of educational attainment, the incidence of low birth weight is significantly lower for weight gains of at least 21 pounds compared with gains of less than 16 pounds. For women who had not completed high school (who were at highest risk of a low-birth-weight outcome), the incidence of low birth weight dropped from 15.0 percent for a gain of less than 16 pounds to 8.5 percent when weight gain was 21-25 pounds and to 5.7 percent for gains of 36 pounds or more.

Because teenage mothers have not had the opportunity to complete their education, the proportion of low-birth-weight babies by educational attainment is also shown for women 20 years of age and over. The same pattern of a sharply reduced risk of low birth weight with added weight gain is also evident for these women (table J).

Part of the reason for the higher incidence of low birth weight for women with less than a high school education is that they are far more likely to gain less than 16 pounds than those mothers with at least 12 years of schooling (table D).

#### Smoking habit

About one-quarter of the women giving birth in 1980 smoked during their pregnancy. As noted previously, mothers who smoked gained less than nonsmoking mothers. The mean birth weight of babies of mothers who smoked was also lower, by 204 grams (7 ounces), than the mean birth weight of babies of mothers who were nonsmokers (3,236 grams compared with 3,440 grams). But for smoking and nonsmoking mothers alike, mean birth weight rises significantly as weight gain increases from less than 16 to 21 pounds or higher (table K).

The effect of increased weight gain for smoking and nonsmoking mothers was examined according to gestational period because this is so strongly related to birth weight and because a mother who smokes is more likely to have a preterm birth (less than 37 weeks' gestation). For gestational periods of 37-39 weeks and 40 weeks or longer, the babies of mothers who smoked weighed less than those of nonsmoking mothers by approximately 200 grams (7 ounces). For all gestational periods, mean birth weight increases with added weight gain, regardless of smoking habit. For mothers who smoked, the increase in birth weight is especially noticeable for preterm births; mean birth weight rose 671 grams (1 pound 8 ounces), from 2,212 grams

Table H. Percent of live births weighing less than 2,500 grams by weight gain during pregnancy and age of mother: United States, 1980 National Natality Survey

Age of mother	Total	Weight gain during pregnancy				
		Less than 16 pounds	16-20 pounds	21-25 pounds	26-35 pounds	36 pounds or more
All ages	6.7	13.9	11.4	6.1	5.0	4.0
Under 20 years	9.1	19.2	15.2	7.4	6.3	4.9
20-24 years	6.8	13.4	11.6	7.4	4.9	3.9
25-29 years	5.8	11.2	9.4	5.2	4.8	3.8
30 years and over	6.2	13.2	10.9	4.6	4.3	3.6

**Table J. Percent of live births weighing less than 2,500 grams by weight gain during pregnancy, age, and educational attainment of mother: United States, 1980 National Natality Survey**

Age of mother and years of school completed	Weight gain during pregnancy					
	Total	Less than 16 pounds	16-20 pounds	21-25 pounds	26-35 pounds	36 pounds or more
All ages .....	6.7	13.9	11.4	6.1	5.0	4.0
0-11 years .....	9.3	15.0	12.9	8.5	7.4	5.7
12 years .....	6.7	13.7	12.9	6.0	5.0	3.7
13-15 years .....	4.9	12.8	7.6	5.3	3.4	2.5
16 years or more .....	5.0	12.2	8.5	4.0	3.7	4.6
20 years of age or over .....	6.3	12.6	10.6	5.9	4.7	3.8
0-11 years .....	8.8	12.4	12.0	8.1	7.5	5.7
12 years .....	6.6	12.8	12.2	6.1	5.1	3.6
13-15 years .....	4.9	12.7	7.5	5.5	3.4	2.5
16 years or more .....	5.0	12.2	8.6	4.0	3.7	4.6

**Table K. Mean birth weight of live births to married mothers by weight gain during pregnancy, period of gestation, and smoking habit of mother: United States, 1980 National Natality Survey**

Period of gestation and smoking habit of mother	Weight gain during pregnancy					
	Total	Less than 16 pounds	16-20 pounds	21-25 pounds	26-35 pounds	36 pounds or more
				Grams		
All gestational periods .....	3,387	3,138	3,221	3,354	3,418	3,541
Smoker .....	3,236	3,037	3,106	3,173	3,266	3,402
Nonsmoker .....	3,440	3,189	3,266	3,411	3,467	3,592
Under 37 weeks .....	2,664	2,407	2,458	2,695	2,825	2,828
Smoker .....	2,553	2,212	2,343	2,321	2,781	2,883
Nonsmoker .....	2,715	2,505	2,504	2,826	2,846	2,798
37-39 weeks .....	3,314	3,160	3,212	3,289	3,324	3,444
Smoker .....	3,153	3,046	3,059	3,163	3,157	3,269
Nonsmoker .....	3,370	3,216	3,277	3,331	3,375	3,501
40 weeks and over .....	3,541	3,370	3,393	3,499	3,559	3,649
Smoker .....	3,414	3,308	3,320	3,329	3,428	3,518
Nonsmoker .....	3,585	3,401	3,420	3,551	3,600	3,697

to 2,883 grams, as weight gain increased from less than 16 to 36 pounds or more.

Because maternal size is also strongly related to birth weight, the effect of increased weight gain for married mothers who smoked and for those who did not smoke was examined according to their prepregnancy weight for height (table L and figure 4). Regardless of maternal size or smoking habit, increased weight gain is associated with higher birth weight.

The increase in birth weight with added weight gain is especially evident for smoking women whose weight for their height was low or average at the start of pregnancy. The average birth weight of babies born to women with a low weight-for-height index who smoked was 683 grams (1 pound 8 ounces) higher for weight gains of 36 pounds or more than for weight gains of less than 16 pounds (3,314 grams compared with 2,631 grams). For women of average size who smoked, the difference in mean birth weight for weight gains of less than 16 pounds compared with weight gains of 36 pounds or more was 480 grams (1 pound 1 ounce).

While the difference in mean birth weight with increased

weight gain was not as pronounced for the largest women who smoked, mean birth weight was still significantly higher, by 261 grams (9 ounces), for a weight gain of 36 pounds or more compared to weight gains of less than 16 pounds. This same pattern is also apparent for nonsmoking mothers.

In a previous analysis of birth outcome for white mothers in the 1980 National Natality Survey,<sup>17</sup> it was determined that of all factors considered, only period of gestation had a stronger effect than weight gain on the risk of low birth weight. When differences in mother's age and education, and live birth order, sex, and period of gestation of the child were accounted for, women gaining less than 21 pounds were found to be 2.3 times as likely to bear a low-birth-weight infant as women with a higher weight gain. A further analysis limited to married mothers, which included smoking habit as well, did not change this conclusion. It has been postulated that the lower level of birth weight associated with maternal smoking during pregnancy is partly due to the decreased weight gain of mothers who smoke.<sup>9</sup> The data presented in this study support this theory.

**Table L. Mean birth weight of live births to married mothers by weight gain during pregnancy, weight-for-height index, and smoking habit of mother: United States, 1980 National Natality Survey**

Weight-for-height index <sup>1</sup> and smoking habit of mother	Weight gain during pregnancy					
	Total	Less than 16 pounds	16-20 pounds	21-25 pounds	26-35 pounds	36 pounds or more
				Grams		
All mothers .....	3,387	3,138	3,221	3,354	3,418	3,541
Smoker .....	3,236	3,037	3,106	3,173	3,266	3,402
Nonsmoker .....	3,440	3,189	3,266	3,411	3,467	3,592
Low .....	3,263	2,825	3,035	3,217	3,312	3,431
Smoker .....	3,122	2,631	2,811	3,069	3,174	3,314
Nonsmoker .....	3,323	2,927	3,100	3,276	3,374	3,483
Average .....	3,399	3,035	3,181	3,365	3,432	3,555
Smoker .....	3,228	2,918	3,065	3,135	3,292	3,398
Nonsmoker .....	3,453	3,097	3,231	3,428	3,471	3,606
High .....	3,487	3,307	3,432	3,490	3,537	3,626
Smoker .....	3,379	3,258	3,365	3,379	3,384	3,519
Nonsmoker .....	3,526	3,330	3,458	3,526	3,581	3,665

<sup>1</sup>Low is less than 25th percentile for study group, average is 25th-74th percentile, and high is 75th percentile or higher.

### Risk of fetal death

The weight gain of mothers whose pregnancy ended in a fetal death with a physician's estimate of gestation of 28 weeks or more or delivery weight of at least 1,000 grams when the physician's estimate was not reported (late fetal death) is available from the National Fetal Mortality Survey. By combining this information with the weight gain data for live births from the National Natality Survey it is possible to determine the risk of a fetal death outcome for specific weight gains. In this study, the risk of fetal death is measured by the fetal death ratio—the number of late fetal deaths per 1,000 live births.

### Period of gestation

As noted earlier, a woman's weight gain during pregnancy is strongly influenced by the length of the gestational period. More than one-fourth of all late fetal deaths occurred at less than 37 weeks of gestation. Therefore, in this discussion the relationship between weight gain during pregnancy and the risk of a fetal death outcome is examined by gestational period.

As weight gain increases from less than 16 pounds to 26-35 pounds, there is a general pattern of declining risk of fetal death for all gestational periods of 32 weeks or longer (table M and figure 5). For example, for the gestational period 37-39 weeks, the fetal death ratio declined from 5.0 per 1,000 live births for weight gains of less than 16 pounds to 2.8 for weight gains of 26-35 pounds, a drop of 44 percent; for similar weight gains, the drop was 59 percent when period of gestation was 40 weeks. However, weight gains of 36 pounds or more are generally associated with a slight rise in the risk of fetal death compared with weight gains of 26-35 pounds.

### Prepregnancy weight

The risk of a fetal death outcome generally escalates with increases in the mother's prepregnancy weight (table N), in contrast to the decline in incidence in low birth weight with greater prepregnancy weight. The fetal death ratio was nearly twice as high for a woman weighing 170 pounds or more at the start of pregnancy as for a woman weighing less than 110-

pounds initially (8.2 compared with 4.3). But regardless of the mother's prepregnancy weight, the fetal death ratio declines sharply with increased maternal weight gain, up to 26-35 pounds. This is especially evident for women with the lowest prepregnancy weights; among women weighing less than 110 pounds at the start of pregnancy, the fetal death ratio dropped from 11.6 for weight gains of less than 16 pounds to 2.8 for weight gains of 26-35 pounds. The comparable decline in the fetal death ratio was nearly as steep for women with a prepregnancy weight of 110-129 pounds, dropping from 11.2 to 3.3.

Because black women start pregnancy weighing more on the average than white women, fetal death ratios are shown by race. For both white and black mothers, the elevated risk of a fetal death outcome for women with a high prepregnancy weight is evident. For both racial groups, there is a consistent pattern of reduced risk as weight gain increases, although differences for several prepregnancy weight categories for black women are not significant and estimates are not reliable because of the small number of such sample cases.

### Age of mother

For women of all ages, there is a pronounced and consistent decline in the fetal death ratio as weight gain increases from less than 16 pounds to 26-35 pounds. The decline was slightly more than 50 percent for teenagers (from 8.1 to 3.9) and between 64 and 67 percent for other ages (table O).

Regardless of age, when weight gain is more than 35 pounds, there is a slight, but not statistically significant, rise in the fetal death ratio relative to the ratio for gains of 26-35 pounds. However, the fetal death ratios for this highest weight gain category were still at least 40 percent lower than the ratios for weight gains of less than 16 pounds.

### Educational attainment

The risk of a fetal death outcome is 30 percent lower for women who had completed at least 13 years of schooling (4.3) than for women with less than a high school education (6.1) (table P). However, when weight gain is less than 21 pounds,

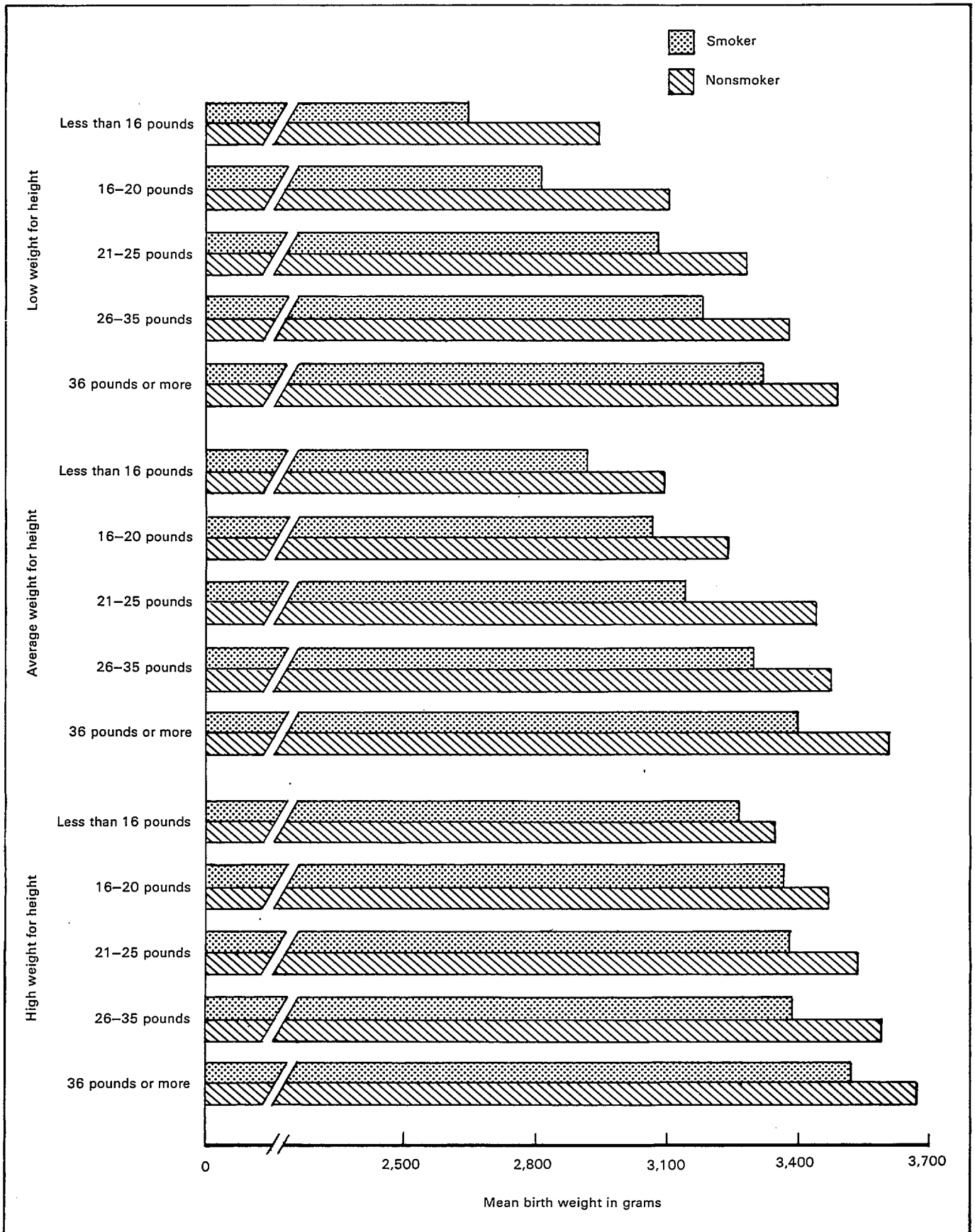


Figure 4. Mean birth weight of live births to married mothers by weight gain during pregnancy, weight-for-height index, and smoking habit: United States, 1980 National Natality Survey

**Table M. Fetal death ratios by weight gain during pregnancy and period of gestation: United States, 1980 National Natality and Fetal Mortality Surveys**

[Ratios are late fetal deaths per 1,000 live births]

Period of gestation	Total	Weight gain during pregnancy				
		Less than 16 pounds	16-20 pounds	21-25 pounds	26-35 pounds	36 pounds or more
All gestational periods	5.2	10.5	6.7	4.8	3.8	4.1
Under 32 weeks	46.8	52.8	48.1	40.9	47.1	*31.7
32-35 weeks	22.4	30.7	25.3	25.3	15.6	18.8
36 weeks	12.7	18.3	15.4	10.8	9.7	12.5
37-39 weeks	3.3	5.0	3.5	3.4	2.8	3.1
40 weeks	3.8	6.9	4.4	3.0	2.8	4.2
41 weeks	1.7	2.3	2.0	1.7	1.4	2.0
42 weeks and over	3.2	4.4	3.3	3.0	3.1	3.1

fetal death ratios are not significantly lower for better educated women.

For all levels of educational attainment, added weight gain is associated with a sharp decline in the risk of fetal death. For women who had not completed high school, the fetal death ratio for women gaining 36 pounds or more (5.1) was about half that of women gaining less than 16 pounds (9.6); for women who had completed at least one year of college, the fetal death ratio was two-thirds lower for women gaining 36 pounds (3.5) than for women gaining less than 16 pounds (10.9).

The pattern of lower risk of fetal death with added weight gain is evident for preterm as well as full-term deliveries (table P).

#### Smoking habit

The risk of a fetal death outcome is higher for women who smoked during pregnancy than for nonsmokers. But for both groups, as weight gain increases (up to 26-35 pounds), the risk declines (table Q). The fetal death ratio for nonsmokers was three times as high when weight gain was less than 16 pounds (10.8) as when weight gain was 26-35 pounds (3.4). For women who smoked during pregnancy, the fetal death ratio was 2½ times as high for gains of less than 16 pounds (10.0) as for gains of 26-35 pounds (4.1).

Because women who smoke are more likely than nonsmokers to deliver prematurely (before 37 weeks of gestation), fetal death ratios according to smoking habit and weight gain are shown by gestational period (less than 37 weeks, 37-39 weeks, and 40 weeks or longer). For all gestational periods, there is a general pattern of lowered risk of fetal death for both

smokers and nonsmokers as weight gain increases to 26-35 pounds. For women who smoked delivering prematurely, the risk was reduced by 62 percent for weight gains of 26-35 pounds compared with weight gains of less than 16 pounds (14.3 compared with 37.3); for gestational periods of 37-39 weeks, the reduction in fetal death risk for a comparable increase in weight gain was 25 percent; and for gestational periods of 40 weeks or longer, the reduction was 43 percent.

As noted earlier, maternal size is strongly related to weight gain. Women in the sample who smoked during pregnancy were more likely to have a low weight-for-height index than nonsmoking mothers. Therefore, fetal death ratios are also shown for mothers who have a low, average, or high prepregnancy weight for their height (table R). For all three groups, there is a general pattern of higher risk of a fetal death outcome for smokers than for nonsmokers, and a substantial reduction in this risk as weight gain increases, up to 26-35 pounds. Among smokers, the sharpest decline in risk with added weight gain was found for women who had a low weight for their height. For these women, the fetal death ratio was 3½ times as high for gains of less than 16 pounds (9.8) than for gains of 26-35 pounds (2.8).

A previous study of white mothers in the NFMS and NNS<sup>17</sup> found that after controlling for differences in the mother's prepregnancy weight and age, in the trimester prenatal care began, in the period of gestation, and in total-birth order, white women who gained less than 21 pounds were 1½ times as likely to have a fetal death outcome as white women who gained more. When the analysis was limited to white married women, this 50-percent higher risk did not change when differences in smoking habit were also taken into account.

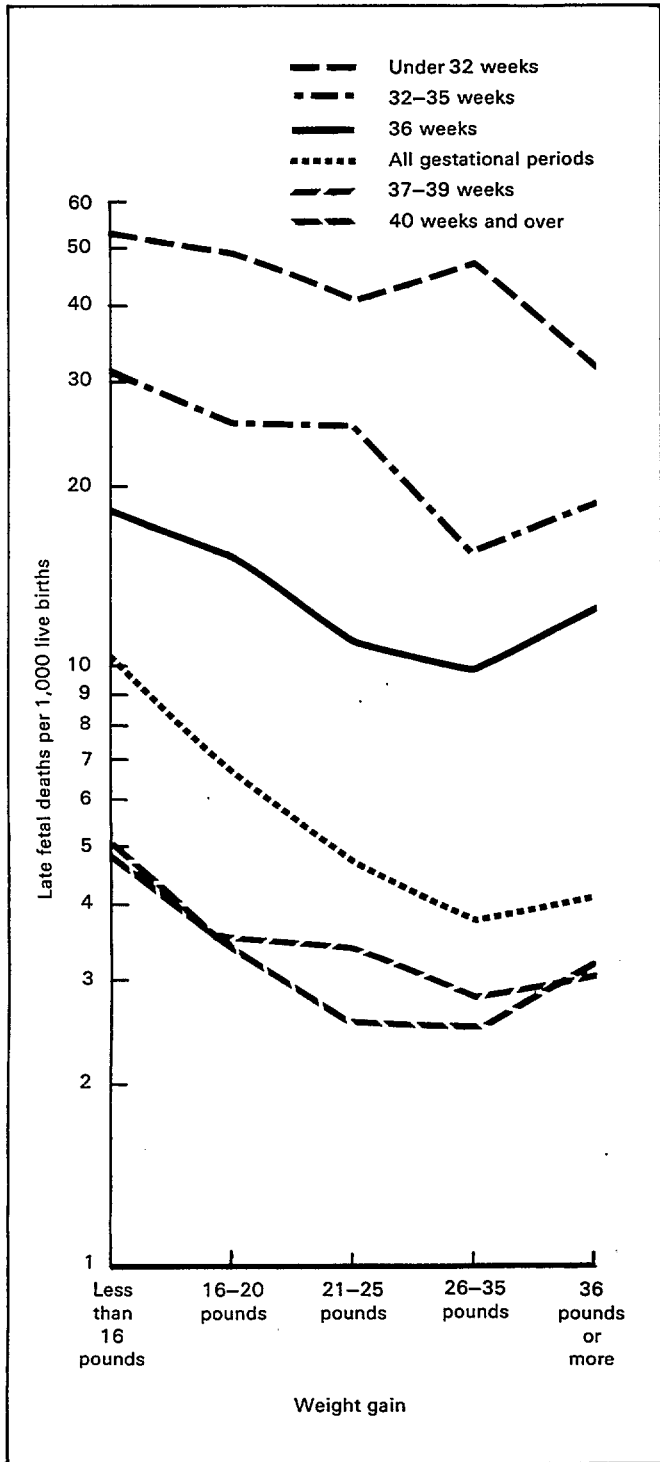


Figure 5. Fetal death ratios by weight gain during pregnancy and period of gestation: United States, 1980 National Natality and Fetal Mortality Surveys

**Table N. Fetal death ratios by weight gain during pregnancy, prepregnancy weight, and race of mother: United States, 1980 National Natality and Fetal Mortality Surveys**

[Ratios are late fetal deaths per 1,000 live births]

<i>Race and prepregnancy weight of mother</i>	<i>Weight gain during pregnancy</i>					
	<i>Total</i>	<i>Less than 16 pounds</i>	<i>16–20 pounds</i>	<i>21–25 pounds</i>	<i>26–35 pounds</i>	<i>36 pounds or more</i>
All races <sup>1</sup> . . . . .	5.2	10.5	6.7	4.8	3.8	4.1
Less than 110 pounds . . . . .	4.3	11.6	6.5	3.8	2.8	3.6
110–129 pounds . . . . .	4.5	11.2	6.4	4.6	3.3	3.4
130–149 pounds . . . . .	5.1	10.2	7.2	5.2	3.9	4.1
150–169 pounds . . . . .	5.5	7.1	6.0	5.2	5.6	4.2
170 pounds or more . . . . .	8.2	12.2	7.2	6.0	6.1	7.0
White . . . . .	4.8	10.1	6.4	4.5	3.6	3.8
Less than 110 pounds . . . . .	4.2	9.6	6.3	3.6	3.2	3.4
110–129 pounds . . . . .	4.3	11.0	6.4	4.4	3.3	3.3
130–149 pounds . . . . .	4.9	11.4	7.3	4.7	3.7	3.8
150–169 pounds . . . . .	4.8	6.4	5.7	4.3	4.6	3.9
170 pounds or more . . . . .	7.4	11.3	5.5	6.4	5.2	6.6
Black . . . . .	7.2	11.8	8.3	6.8	4.9	5.8
Less than 110 pounds . . . . .	5.5	*24.8	*8.4	*4.4	*1.7	*4.4
110–129 pounds . . . . .	5.9	10.9	7.3	6.7	3.3	5.1
130–149 pounds . . . . .	6.6	8.3	*6.9	8.9	4.8	6.1
150–169 pounds . . . . .	9.5	10.2	*7.8	*11.4	*14.9	5.7
170 pounds or more . . . . .	10.7	15.0	*14.7	*4.8	*9.5	8.1

<sup>1</sup>Includes races other than white and black.

**Table O. Fetal death ratios by weight gain during pregnancy and age of mother: United States, 1980 National Natality and Fetal Mortality Surveys**

[Ratios are late fetal deaths per 1,000 live births]

<i>Age of mother</i>	<i>Weight gain during pregnancy</i>					
	<i>Total</i>	<i>Less than 16 pounds</i>	<i>16–20 pounds</i>	<i>21–25 pounds</i>	<i>26–35 pounds</i>	<i>36 pounds or more</i>
All ages . . . . .	5.2	10.5	6.7	4.8	3.8	4.1
Under 20 years . . . . .	5.1	8.1	7.4	4.0	3.9	4.7
20–24 years . . . . .	4.8	10.4	5.7	4.8	3.5	3.7
25–29 years . . . . .	4.6	9.4	6.1	4.7	3.4	3.7
30 years and over . . . . .	6.8	13.8	8.2	5.9	5.0	5.1

**Table P. Fetal death ratios by weight gain during pregnancy, period of gestation, and educational attainment of mother: United States, 1980**  
National Natality and Fetal Mortality Surveys

[Ratios are late fetal deaths per 1,000 live births]

<i>Period of gestation and years of school completed by mother</i>	<i>Weight gain during pregnancy</i>					
	<i>Total</i>	<i>Less than 16 pounds</i>	<i>16-20 pounds</i>	<i>21-25 pounds</i>	<i>26-35 pounds</i>	<i>36 pounds or more</i>
All gestational periods	5.2	10.5	6.7	4.8	3.8	4.1
0-11 years	6.1	9.6	7.0	5.7	4.5	5.1
12 years	5.4	10.9	6.9	5.3	4.0	4.0
13 years and over	4.3	10.9	6.1	3.8	3.2	3.5
Under 37 weeks	23.3	34.0	27.2	22.0	16.5	17.7
0-11 years	21.5	26.3	28.9	18.0	15.7	20.0
12 years	23.9	36.0	26.7	25.1	16.9	16.6
13 years and over	24.5	46.4	26.5	22.1	16.8	17.6
37 weeks and over	3.2	5.0	3.4	2.9	2.6	3.2
0-11 years	3.8	5.0	3.8	3.7	3.0	4.0
12 years	3.3	5.2	3.4	3.2	2.8	3.2
13 years and over	2.7	4.6	3.2	2.2	2.3	2.8

**Table Q. Fetal death ratios by weight gain during pregnancy, period of gestation, and smoking habit of married mothers: United States, 1980**  
National Natality and Fetal Mortality Surveys

[Ratios are late fetal deaths per 1,000 live births]

<i>Period of gestation and smoking habit of mother</i>	<i>Weight gain during pregnancy</i>					
	<i>Total</i>	<i>Less than 16 pounds</i>	<i>16-20 pounds</i>	<i>21-25 pounds</i>	<i>26-35 pounds</i>	<i>36 pounds or more</i>
All gestational periods	4.9	10.5	6.7	4.7	3.6	3.9
Smoker	5.6	10.0	7.2	5.2	4.1	4.7
Nonsmoker	4.7	10.8	6.4	4.5	3.4	3.6
Under 37 weeks	24.7	38.3	31.6	24.2	16.0	18.5
Smoker	24.8	37.3	33.0	26.9	14.3	21.4
Nonsmoker	24.6	38.9	31.0	23.3	16.8	17.0
37-39 weeks	3.2	5.4	3.5	3.4	2.7	2.7
Smoker	3.3	4.4	3.3	3.1	3.3	2.7
Nonsmoker	3.2	5.9	3.5	3.5	2.6	2.7
40 weeks and over	3.0	4.8	3.5	2.5	2.5	3.2
Smoker	3.5	4.7	4.3	3.0	2.7	3.8
Nonsmoker	2.9	4.9	3.2	2.3	2.4	3.0

**Table R. Fetal death ratios by weight gain during pregnancy, weight-for-height index, and smoking habit of married mothers: United States, 1980**  
National Natality and Fetal Mortality Surveys

[Ratios are late fetal deaths per 1,000 live births]

<i>Weight-for-height index<sup>1</sup> and smoking habit</i>	<i>Weight gain during pregnancy</i>					
	<i>Total</i>	<i>Less than 16 pounds</i>	<i>16-20 pounds</i>	<i>21-25 pounds</i>	<i>26-35 pounds</i>	<i>36 pounds or more</i>
All births	4.9	10.5	6.7	4.7	3.6	3.9
Smoker	5.6	10.0	7.2	5.2	4.1	4.7
Nonsmoker	4.7	10.8	6.4	4.5	3.4	3.6
Low weight for height	4.1	11.3	6.8	3.8	2.8	3.5
Smoker	4.5	9.8	9.8	4.2	2.8	*4.4
Nonsmoker	3.9	12.0	5.9	3.6	2.8	3.2
Average weight for height	4.5	9.6	6.8	4.8	3.5	3.5
Smoker	5.5	9.2	6.9	6.0	4.5	4.4
Nonsmoker	4.2	9.8	6.8	4.5	3.2	3.2
High weight for height	6.6	11.0	6.3	5.5	5.1	5.2
Smoker	7.0	10.6	6.1	5.2	5.5	5.9
Nonsmoker	6.4	11.1	6.4	5.6	4.9	5.0

<sup>1</sup>Low is less than 25th percentile in study group, average is 25th-74th percentile, and high is 75th percentile or higher.



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# Appendix

## Technical notes

### Sources of data

The data presented in this report are based on the 1980 National Natality Survey (NNS) and the 1980 National Fetal Mortality Survey (NFMS) conducted by the National Center for Health Statistics. A detailed description of the methods and procedures employed in these surveys can be found in "Methods and response characteristics: 1980 National Natality and Fetal Mortality Surveys."<sup>18</sup> These notes briefly describe survey procedures relevant to this report.

The NNS is based on a probability sample of registered live births in the United States for the year 1980. Approximately 1 in 95 infants weighing less than 2,500 grams and 1 in 400 infants of higher birth weights were selected for the sample. The oversampling of low-birth-weight infants was to aid in the analysis of this high-risk group. Overall, the NNS sample consists of 9,941 live births, or approximately 1 in every 363 live births. The NFMS is based on a probability sample of registered fetal deaths occurring in 1980 with a physician's estimate of gestation of 28 weeks or more or, when this information on gestation was lacking, with delivery weight of 1,000 grams or more. The sample consists of 6,386 fetal deaths, representing approximately 1 in 3 late fetal deaths in 1980.

Information beyond that available from the certificates of live birth and reports of fetal death was sought from sources named on these vital records. Questionnaires were mailed to married mothers requesting information on their prenatal health practices, prenatal care, previous pregnancies, and on social and demographic characteristics. To ensure their privacy, mothers who were not married were not contacted.

Regardless of the mother's marital status, questionnaires were mailed to the hospital and to the attendant at delivery named on the vital record. A questionnaire was sent to the hospital for all deliveries that occurred in a hospital or en route to a hospital. A questionnaire was also mailed to the attendant at delivery (physician, nurse-midwife, etc.) for those deliveries where the attendant's address was not the same as the address of the hospital. If the hospital or the attendant had little or no information concerning prenatal care, the name and address of another facility or individual that could provide this information were requested and questionnaires were sent accordingly.

Because the provider of prenatal care is considered the most reliable source of information on weight gain during pregnancy, this report is based only on mothers for whom informa-

tion on prenatal care was available (9,811 for the NNS sample and 6,150 for the NFMS sample). Information on the mother's smoking habit, income, and height is available only from the mother's questionnaire, so some of the analyses are limited to married mothers who received prenatal care (7,774 for the NNS and 4,699 for the NFMS). Hospitals and/or attendants at delivery supplied information on the mother's prepregnancy weight and her weight at delivery, which were used to derive the weight gain during pregnancy. Married women were also asked to provide their weight before pregnancy and before delivery. If the medical sources failed to provide the mother's weights, values were derived from the mother's data, when available. Otherwise, the data were imputed on the basis of the mother's age and race and the period of gestation.

The NNS and NFMS data have been weighted to provide estimates for the appropriate populations of live births and fetal deaths in the United States in 1980. The estimates in this report represent all mothers for whom prenatal care information was available (3,580,596 for the NNS and 18,508 for the NFMS) or married mothers for whom information was available (2,929,713 for the NNS and 14,439 for the NFMS). About 1 percent of the live births and 4 percent of the late fetal deaths were excluded from this study because information on prenatal care was lacking.

### Definition of terms

*Low birth weight*—Low birth weight is defined as less than 2,500 grams or 5 pounds 8 ounces.

*Fetal death ratio*—The fetal death ratio is defined as the number of fetal deaths with a physician's estimate of gestation of 28 weeks or more or delivery weight of 1,000 grams or more when physician's estimate is not reported (late fetal deaths) per 1,000 live births. These ratios differ from those published annually in *Vital Statistics of the United States*, Volume II, Mortality, which are fetal deaths of 20 weeks or more gestation per 1,000 live births.

*Weight-for-height index*—This is a measure of maternal size computed from the formula

$$\frac{W}{H^2}$$

where  $W$  = mother's prepregnant weight in pounds

$H$  = mother's height in inches

NOTE: A list of references follows the text.

Low represents the first quartile of the study population; average, the second and third quartiles; and high, the fourth quartile.

**Race**—In all tables, race refers to the race of the mother. The category “white” comprises mothers whose race was reported as white, Mexican, Puerto Rican, Cuban, or other Hispanic origin.

### Sampling error

Because NNS and NFMS estimates are based on a sample, they may differ from the figures that would have been obtained had all live births and fetal deaths been surveyed. The use of probability sampling techniques makes it possible to approximate sampling errors for these estimates.

The standard error is a measure of the variability that occurs by chance because a sample rather than the entire population is surveyed. While the standard errors calculated for this report reflect some of the random variation inherent in the measurement process, they do not measure any systematic error, or bias, that may be present in the data.

The chances are about 68 out of 100 that an estimate from the sample differs by less than one standard error from the figure that would be obtained from a complete census of all births or fetal deaths; the chances are about 95 out of 100 that the estimate differs by less than two standard errors. The relative standard error of an estimate is obtained by dividing the standard error of an estimate by the estimate itself, and can be expressed as a percent. In this report an estimate is considered unreliable if it is based on less than 30 sample cases, or if its relative standard error is 25 percent or greater. For purposes of this report, standard errors were estimated using a balanced repeated replication technique. This technique produces highly reliable, unbiased estimates of sampling errors. Its application to the NNS and NFMS is described elsewhere.<sup>18</sup>

Standard errors for estimated mean weight gains and mean birth weights are included in tables A–E. The standard errors

NOTE: A list of references follows the text.

for mean birth weights in table F are shown in table I, and for mean birth weights in tables K and L, in table II. Sampling errors for other aggregates, percents, and fetal death ratios in this report can be calculated according to the procedures described in the sections that follow. Weighted numbers of women needed to compute standard errors for the percent low birth weight in tables G–J and for the fetal death ratios in tables M–P are shown in table III, and for fetal death ratios in tables Q and R, in table IV.

### Aggregates

To approximate the relative standard error ( $RSE_x$ ) and the standard error ( $SE_x$ ) of an estimated number of live births or fetal deaths, the appropriate values of  $A$  and  $B$  from table V are to be used in the following equations:

$$RSE_x = \sqrt{A + \frac{B}{x}}$$

and

$$SE_x = x \cdot RSE_x$$

where  $x$  = the estimated number of live births or fetal deaths. This formula should not be used to compute sampling errors for estimates of less than 10,890 live births or 90 fetal deaths, approximately 30 sample cases.

### Percents

To approximate the relative standard error ( $RSE_p$ ) and the standard error ( $SE_p$ ) of a percent  $p$ , the appropriate values of  $B$  from table V are to be used in the following equations:

$$RSE_p = \sqrt{\frac{B}{p} \frac{100 - p}{y}}$$

$$SE_p = p \cdot RSE_p$$

Table I. Standard errors for estimated mean birth weight of live births by weight gain during pregnancy, period of gestation, and race of mother: United States, 1980 National Natality Survey

Race of mother and period of gestation	Weight gain during pregnancy					
	Total	Less than 16 pounds	16–20 pounds	21–25 pounds	26–35 pounds	36 pounds or more
		Grams				
All races <sup>1</sup> . . . . .	6	20	19	13	10	12
Under 37 weeks . . . . .	24	63	56	24	40	82
37–39 weeks . . . . .	9	26	24	23	16	23
40 weeks and over . . . . .	9	17	21	19	18	13
White . . . . .	8	25	22	15	11	13
Under 37 weeks . . . . .	29	69	79	45	44	81
37–39 weeks . . . . .	12	41	31	26	16	26
40 weeks and over . . . . .	10	21	23	22	20	15
Black . . . . .	12	28	36	36	25	31
Under 37 weeks . . . . .	38	119	100	62	79	158
37–39 weeks . . . . .	21	49	94	47	46	39
40 weeks and over . . . . .	20	37	58	77	47	56

<sup>1</sup>Includes races other than white and black.



Table III. Number of live births by selected characteristics: United States, 1980 National Natality Survey

Selected characteristic	Weight gain during pregnancy					
	Total	Less than 16 pounds	16-20 pounds	21-25 pounds	26-35 pounds	36 pounds or more
<b>RACE</b>						
Number in thousands						
All races <sup>1</sup> .....	3,581	428	408	613	1,242	889
White .....	2,917	306	323	505	1,034	750
Black .....	554	111	70	89	166	118
<b>PREPREGNANCY WEIGHT</b>						
All races <sup>1</sup>						
Less than 110 pounds .....	478	38	56	96	185	103
110-129 pounds .....	1,315	103	150	235	519	308
130-149 pounds .....	968	97	103	155	332	281
150-169 pounds .....	441	81	50	67	120	122
170 pounds or more .....	379	109	50	60	86	75
White						
Less than 110 pounds .....	372	29	45	73	140	85
110-129 pounds .....	1,094	71	119	197	439	267
130-149 pounds .....	791	62	80	134	279	236
150-169 pounds .....	370	63	40	58	108	102
170 pounds or more .....	290	81	40	43	67	59
Black						
Less than 110 pounds .....	73	6	7	18	28	13
110-129 pounds .....	178	29	25	27	64	33
130-149 pounds .....	154	32	20	19	45	38
150-169 pounds .....	63	16	9	9	12	19
170 pounds or more .....	85	27	9	16	18	15
<b>YEARS OF SCHOOLING OF MOTHER</b>						
Under 37 weeks of gestation .....	354	81	55	61	104	53
0-11 years .....	107	32	14	19	29	13
12 years .....	159	35	26	25	47	27
13 years or more .....	89	14	16	17	28	13
37 weeks of gestation and over .....	3,226	347	353	552	1,138	836
0-11 years .....	710	114	94	115	219	167
12 years .....	1,421	151	148	240	486	395
13 years or more .....	1,096	82	111	197	433	273
<b>PERIOD OF GESTATION</b>						
Under 32 weeks .....	64	24	12	10	11	7
32-35 weeks .....	164	36	25	26	53	24
36 weeks .....	126	21	18	25	40	23
37-39 weeks .....	1,238	156	147	224	446	266
40 weeks .....	869	82	92	149	323	223
41 weeks .....	528	45	55	97	181	151
42 weeks and over .....	591	65	59	82	189	196
<b>AGE OF MOTHER</b>						
Under 20 years .....	553	79	65	99	173	136
20-24 years .....	1,215	139	130	198	416	331
25-29 years .....	1,101	114	122	192	407	266
30 years and over .....	712	96	91	125	245	155
<b>YEARS OF SCHOOLING OF MOTHER</b>						
All ages						
Less than 12 years .....	817	146	108	134	248	180
12 years .....	1,579	186	173	265	533	422
13-15 years .....	676	63	77	123	244	168
16 years or more .....	509	33	49	91	217	119
Mothers 20 years of age and over .....	3,028	349	343	514	1,069	753
Less than 12 years .....	480	92	68	76	143	102
12 years .....	1,380	163	154	229	469	367
13-15 years .....	659	61	73	118	240	166
16 years or more .....	508	33	49	91	217	118

<sup>1</sup>Includes races other than white and black.

Table IV. Number of live births to married mothers by selected characteristics: United States, 1980 National Natality Survey

Selected maternal characteristic	Total	Weight gain during pregnancy				
		Less than 16 pounds	16-20 pounds	21-25 pounds	26-35 pounds	36 pounds or more
SMOKING HABIT						
Number in thousands						
All births	2,930	311	326	501	1,048	744
Smokers	767	104	91	121	254	198
Nonsmokers	2,162	207	235	380	794	546
PERIOD OF GESTATION						
All births						
Under 37 weeks	249	51	37	43	78	41
37-39 weeks	1,023	111	119	182	383	228
40 weeks and over	1,657	149	170	275	587	475
Smoker						
Under 37 weeks	79	17	10	11	26	14
37-39 weeks	263	36	35	45	90	56
40 weeks and over	426	51	45	64	138	128
Nonsmoker						
Under 37 weeks	171	34	27	32	52	26
37-39 weeks	760	74	83	137	293	173
40 weeks and over	1,231	99	125	211	449	348
WEIGHT-FOR-HEIGHT INDEX <sup>1</sup>						
All mothers						
Low	726	46	76	138	291	175
Average	1,478	113	154	243	562	407
High	726	153	96	119	195	162
Smoker						
Low	216	16	17	39	90	54
Average	357	39	47	52	120	100
High	194	50	27	30	44	44
Nonsmoker						
Low	510	30	59	99	201	121
Average	1,121	74	107	191	442	307
High	532	103	70	89	151	119

<sup>1</sup>Low is less than 25th percentile for study group, average is 25th-74th percentile, and high is 75th percentile or higher.

cant difference in weight gain by race, compute

$$t = \frac{20.0 - 10.5}{\sqrt{(0.38)^2 + (1.34)^2}} = 6.82$$

Because the two-tailed 0.05 critical value for a *t*-statistic with 20 degrees of freedom is 2.09, the difference in weight gain by race is statistically significant at the 0.05 level.

### Nonsampling error

Estimates based on the NNS and NFMS are also subject to nonsampling errors. The sources of nonsampling error include incomplete coverage; misinterpretation of questions; incomplete or inaccurate responses; and errors in coding, editing,

Table V. Parameters used to compute relative standard errors for live births and fetal deaths by maternal characteristic

Maternal characteristic	Parameter	
	A	B
Live births to unmarried mothers and to mothers of races other than white	-0.00054674	390.07705
Live births to married mothers, to white mothers, and to all mothers	-0.00010438	377.81921
Fetal deaths	-0.00019317	3.71310

keying, and imputing for nonresponse. Although the extent of these nonsampling errors cannot be measured, the procedures employed in the NNS and NFMS were designed to minimize them.



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