

Contribution of Excess Weight Gain During Pregnancy and Macrosomia to the Cesarean Delivery Rate, 1990–2000

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ABSTRACT. *Objective.* After declining for many years, cesarean delivery rates recently increased. To explore whether this increase is associated with excess weight gain during pregnancy, resulting in macrosomic infants who require cesarean delivery, we examined trends in excess weight gain, macrosomia, and cesarean delivery.

Methods. Analysis of 1990–2000 US Natality Files of birth certificate data were restricted to first birth, singleton infants of 37 to 42 weeks' gestation to avoid confounding by repeat cesarean delivery, complications of multigestational pregnancy, and preterm and postterm birth. Excess weight gain was defined according to current guidelines (41+ lb) and macrosomia as birth weight >4000 g.

Results. From 1990–2000, excess weight gain rose steadily from 18.6% to 24.2%. There was a 19.3% decline in macrosomic infants among women who gained excess weight compared with an 11.9% decline among women who gained 15–40 lb, although the absolute risk remained substantially greater among women who gained excess weight (eg, 14.2% vs 7.2%, in 2000). From 1990–1997, cesarean delivery declined by 20.2% among women who gained excess weight compared with 15.7% among women who gained 15 to 40 lb. After 1997, cesarean delivery increased in all weight gain categories, and absolute risks in 2000 were 25.8% for women who gained excess weight compared with 21.6% for women who gained 15–40 lb. Overall, women who gained excess weight accounted for 24.1% of cesarean deliveries in 1990 and 28.1% in 2000.

Conclusions. Excess weight gain and macrosomia do not seem to be the primary factors that contribute to the recent increase in cesarean delivery because cesarean delivery rates have increased in all weight gain categories and macrosomia rates have decreased steadily from 1990–2000. Nonetheless, women who gain excess weight account for a growing proportion of cesarean deliveries because their relative numbers have grown. *Pediatrics* 2003;111:1181–1185; *pregnancy, prenatal nutrition, weight gain, cesarean section, birth weight.*

ABBREVIATIONS. IOM, Institute of Medicine; BMI, body mass index.

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During the past century, weight gain recommendations for pregnant women have reflected changing beliefs about the risks of various pregnancy outcomes. Before the 1970s, pregnant women were advised to limit their weight gain to 20 lb or less, primarily to reduce the risk of toxemia but also to reduce the risks associated with delivering a large (macrosomic) fetus. At that time, cesarean deliveries performed to manage obstructed delivery of macrosomic infants were associated with significant morbidity and mortality for infants and mothers.¹ During the 1960s and 1970s, the associations between severely restricted weight gain, low infant birth weight, and infant mortality were recognized. By this time, cesarean delivery had become much safer. In an effort to reduce rates of low birth weight and infant mortality, maternal weight gain recommendations were relaxed, and by 1970 women were counseled to eat unrestricted diets and gain up to 25 lb.² After an intensive review of the available data, the Institute of Medicine (IOM) issued weight gain guidelines in 1990 designed to lower the risk of fetal death, preterm birth, and low birth weight. The new guidelines recommend that normal-weight women gain 25 to 35 lb.¹ It is interesting that these higher weight gain guidelines have brought the debate full circle and researchers are again discussing whether excess weight gain during pregnancy leads to macrosomia and cesarean delivery.^{3–6}

The question of whether excess weight gain during pregnancy leads to macrosomia and cesarean delivery is especially relevant to current public health practice considering that, after declining from 1990 through 1996, the cesarean delivery rate has risen for the past 5 years, and preliminary data suggest that it rose again in 2001.⁷

To shed new light on this issue, we examined trends in pregnancy weight gain, macrosomia, and cesarean delivery; the relationships between these 3 factors; and how these relationships have changed over the past decade. We then assessed whether increases in excess weight gain could account for the recent increases in cesarean delivery.

METHODS

The data source for these analyses was the 1990–2000 US Natality Files, which are compiled annually from all US birth certificates by the Centers for Disease Control and Prevention's National Center for Health Statistics.⁷ The analyses were restricted to first birth, singleton infants delivered at 37 to 42 weeks' gestation, which account for 33.8% of all registered births from 1990–2000. Multiparous women were excluded partially because of inaccuracies in the repeat cesarean delivery data⁸ but more importantly

because the decision of whether to deliver via cesarean delivery is heavily influenced by previous delivery experiences.⁹ Similarly, the analyses were restricted to singletons delivered between 37 and 42 weeks' gestation because fetal distress and other indications, rather than management of an obstructed delivery, are likely to be the major determinants of cesarean delivery among preterm infants, postterm infants, and multigestational infants.

In response to the 1989 revision of the US Standard Certificate of Live Birth, all states except California modified their birth certificates to include maternal weight gain during pregnancy.¹⁰ Because California does not report weight gain, births that occurred in California were excluded (13.3% of all primiparous, term, singleton births in the United States from 1990–2000). An additional 9.6% of records were excluded because of missing data on either weight gain (8.9%) or method of delivery (0.7%). From 1990–2000, data completeness improved substantially. In 1990, 13.9% of birth certificates were excluded because of missing data. During the next few years, the missing data gradually declined; from 1997–2000, the proportion of records that were excluded because of missing data fluctuated between 7.8% and 7.3%. Annual cesarean delivery rates differed by $\leq 2\%$ between women with and without pregnancy weight gain data.

After restricting the analyses to primiparous, full-term singletons and excluding records with missing data, the final data set consisted of 11 617 919 births, with the number for each year varying from 1 025 189 in 1992 to 1 100 247 in 2000. Confidence intervals and statistical testing are not presented; because of the large number of observations, confidence intervals were too narrow to be meaningful and statistical testing was uniformly significant.

In contrast to previous guidelines, the 1990 IOM pregnancy weight gain guidelines are based on prepregnancy body mass index (BMI): the recommended weight gain for women with a low BMI (<19.8) is 28 to 40 lb, for women with a normal BMI (19.8–26.0) is 25–35 lb, and for women with a high BMI (> 26.0) is 15–25 lb.¹ Weight gain during pregnancy is collected on birth certificates, but prepregnancy weight and height, which are needed to calculate prepregnancy BMI, are not collected. Consequently, it is not possible to determine from birth certificates whether a woman's weight gain was in accordance with the IOM guidelines. Nonetheless, weight gains <15 lb and >40 lb are clearly outside the range of recommended guidelines; thus, these analyses were conducted using the pregnancy weight gain categories of <15 lb (less than recommended), 15 to 40 lb (within the recommended range), and 41+ lb (excess weight gain). Macrosomia was defined as birth weight >4000 g (8 lb, 8 oz).^{11–13}

For examining trends, macrosomia rates, cesarean delivery rates, and rates of weight gain within each category were calcu-

lated for each year. Proportional changes from 1990–2000 were calculated using predicted values from linear regression models of the annual rates of each factor: weight gain, macrosomia, and cesarean delivery. Because cesarean delivery declined and then rose during this period, linear spline regression models with a single knot at 1997 were used to calculate proportional changes in cesarean delivery from 1990–1997 and from 1997–2000.¹⁴ For examining the relationships between these factors, annual rates of macrosomia and cesarean delivery were examined within each weight gain category.

To examine the contribution of excess weight gain to the recent increase in cesarean delivery, we first looked at whether the increasing cesarean delivery rates were specific to any particular weight gain category. We then calculated the proportions of cesarean deliveries that were performed on women who gained <15 lb, 15 to 40 lb, and 41+ lb for each year, 1990–2000. These proportions were then adjusted for age and race using direct standardization to the 1990 age and race distributions of the study population.

RESULTS

From 1990–2000, the proportion of women who gained weight outside the IOM-recommended range of 15 to 40 lb increased by 28.5%: from 24.1% in 1990 to 30.5% in 2000. This increase is largely driven by a 23.9% rise in the number of women who gained more than the maximum recommended weight of 40 lb: from 19.8% in 1990 to 24.7% in 2000 (Fig 1). Among women who gained 41+ lb, the median weight gain rose from 48 to 50 lb, and the proportion who gained >45 lb rose from 61.8% in 1990 to 65.9% in 2000.

Macrosomia was strongly associated with excess weight gain during pregnancy; macrosomia rates among women who gained >40 lb were substantially higher than rates among women who gained 15 to 40 lb (see Fig 2). From 1990–2000, the overall frequency of macrosomic infants fell steadily from 9.9% to 8.8%. This decline was more substantial among women who gained excess weight (19.3%) compared with women who gained within the recommended range of 15 to 40 lb (11.9%).

Cesarean delivery rates were lowest for women

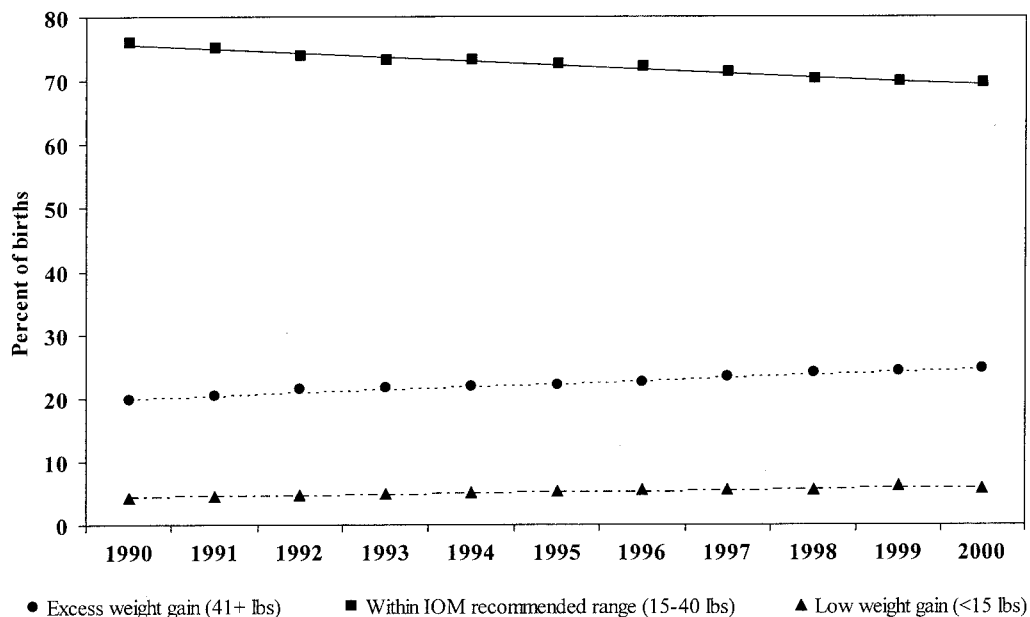


Fig 1. Trends in weight gain during pregnancy, 1990–2000. Symbols represent observed values. Trend lines were estimated by linear regression models.

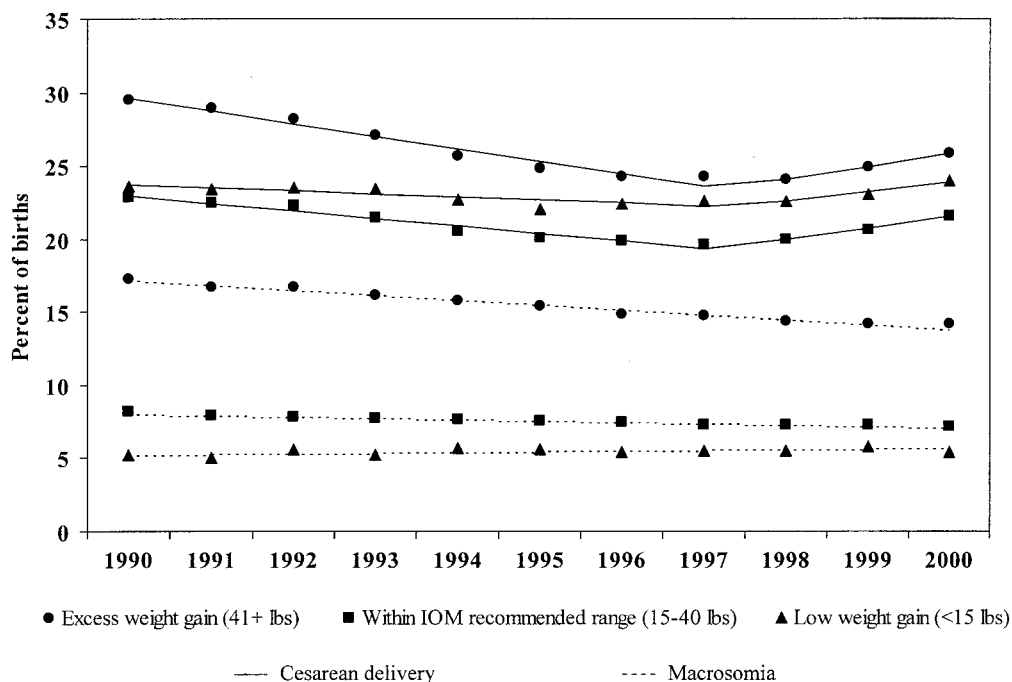


Fig 2. Trends in macrosomia and cesarean delivery by pregnancy weight gain categories, 1990–2000. Symbols represent observed values. Trend lines for macrosomia were estimated by linear regression models. Trend lines for cesarean delivery were estimated by linear spline regression models with a single knot at 1997.

who gained within the recommended range of 15 to 40 lb and elevated for both women who gained <15 lb and for women who gained 41+ lb (Fig 2). From 1990–2000, the cesarean delivery rate first declined and then rose. In 1990, the cesarean delivery rate was 24.2%. It fell slightly each year, until 1997 (20.9%), and then rose to 22.8% in 2000. From 1990–1997, cesarean delivery fell in all weight gain categories; however, the decrease was more pronounced among women who gained excess weight: –20.2% among women who gained >40 lb versus –15.7% among women who gained 15 to 40 lb. The recent upturn in cesarean delivery rates has occurred within all 3 weight gain categories: 9.5% among women who gained >40 lb, 11.2% among women who gained 15 to 40 lb, and 7.4% among women who gained < 15 lb.

As expected, infant birth weight was strongly associated with cesarean delivery such that cesarean delivery rates are lowest for normal infant birth weights and increased for both low and high infant birth weights: overall data for 1990–2000 indicate that 18.3% of infants who weighed between 2500 and 3499 g were delivered by cesarean delivery compared with 25.7% of infants <2500 g, 24.5% of infants 3500 to 3999 g, and 38.6% of infants who weighed 4000 g or more. Between 1990 and 1997, the cesarean delivery rate decreased within all birth weight categories: 11.6% for birth weights <2500 g, 15.7% for 2500 to 3499 g, 15.1% for 3500 to 3999 g, and 12.1% for 4000 g or more. From 1997–2000, cesarean delivery increased in all birth weight categories: 10.9%, 12.2%, 10.4%, and 8.0% for birth weights <2500 g, 2500 to 3499 g, 3500 to 3999 g, 4000 g or more, respectively.

The percentage of cesarean deliveries contributed

by women who gained excess weight increased from 24.1% in 1990 to 28.1% in 2000 (Fig 3). In contrast, the percentage of cesarean deliveries contributed by women who gained excess weight and also delivered macrosomic infants changed little (–1.3%; Fig 3). Direct adjustment to 1990 age and race distributions increased each point estimate slightly (data not shown), indicating that changes in age and race distributions between 1990 and 2000 do not explain the increasing contribution of excess weight gain to the cesarean delivery rate. The percentage of cesarean deliveries contributed by women who gained weight below the recommended range also rose from 4.2% in 1990 to 6.1% in 2000, whereas the percentage contributed by women who gained weight within the recommended range of 15 to 40 lb decreased from 71.6% in 1990 to 65.9% in 2000.

DISCUSSION

This is the first analysis of national data to examine changes in pregnancy weight gain, macrosomia, and cesarean delivery and their relationships to one another. The results indicate that an increasing number of pregnant women are gaining weight in excess of the range recommended by the IOM. The results also indicate that despite dramatic declines in both macrosomia and cesarean delivery among women who gained excess weight, their rates remain high relative to those among women who gained weight within the recommended range of 15 to 40 lb. Overall, women who gain excess weight contribute an increasing proportion to the cesarean delivery rate because their relative numbers have grown and their cesarean delivery rate remains high. This increasing contribution by women who gain excess weight gain does not seem to be operating through macrosomia

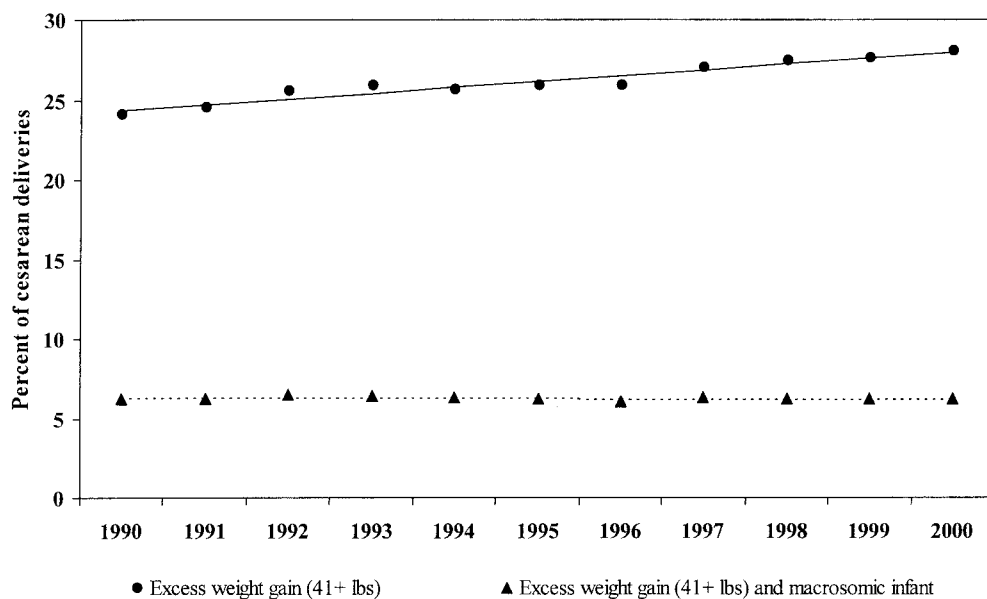


Fig 3. Excess weight gain during pregnancy among women with cesarean delivery, 1990–2000. Symbols represent observed values. Trend lines were estimated by linear regression models.

because 1) macrosomia declined among women who gained excess weight (Fig 2), and 2) the contribution of women who gained excess weight and also delivered macrosomic infants did not increase (Fig 3). In sum, increases in excess weight gain during pregnancy account for some of the recent increase in cesarean delivery; however, that cesarean delivery has increased in all weight gain categories indicates that other factors also contribute.

The US Natality Files contain the only ongoing national data collected on pregnancy weight gain. However, estimates from other large, well-conducted studies support our observations that a large proportion of pregnant women gain excess weight during pregnancy^{12,15–21} and that rates of excess weight gain during pregnancy are increasing.^{21,22} Previous research also supports our observation that excess weight gain, independent of prepregnancy weight, is associated with macrosomia and cesarean delivery.^{12,15,20,23,24} Furthermore, our finding that macrosomia does not explain the increasing contribution of excess weight gain to the cesarean delivery rate is consistent with previous attempts to disentangle these associations through multivariate analyses, which indicate that the relationship between excess weight gain and cesarean delivery is not entirely explained by macrosomia.^{4,15,24} Finally, we observed that between 1990 and 2000, women who gained excess weight accounted for an increasing proportion of cesarean deliveries. Age standardization indicated that the contribution of excess weight gain would have been even higher had maternal age not increased during this period,⁷ which is consistent with previous observations in that excess weight gain is less common in older mothers.^{21,25}

The most important limitation of these analyses is that because the US Natality Files lack prepregnancy BMI data, we cannot classify women into the IOM weight gain categories. It is likely that many women who gained between 15 and 40 lb gained excess

weight based on their prepregnancy BMI. Thus, the proportion of women who gained 41+ lb, can be interpreted as a conservative estimate of the proportion of women who gained excess weight, and the proportion of cesarean deliveries that occurred to women who gained 41+ lb can be interpreted as a conservative estimate of the contribution of excess weight gain to the cesarean delivery rate.

Other limitations also result from data that either are not collected or are not accurately reported in the US Natality Files. For instance, to avoid potential problems with the reporting of methods of delivery with a historical component (eg, repeat cesarean delivery), we limited our analyses to first births.⁸ Another limitation is that detailed clinical data describing maternal diet and the pattern and components (eg, fat, fluid, fetus) of weight gain during pregnancy are not collected on birth certificates. Without these data, which have been shown to effect outcomes,^{24,26,27} we cannot examine the mechanisms that link excess weight gain to cesarean delivery and determine to what extent this association is modifiable through changes in maternal diet. Finally, numerous pregnancy complications, such as gestational diabetes and preeclampsia, are likely to influence to the relationship between excess weight gain and cesarean delivery. Although the US Natality Files include numerous pregnancy complications, underreporting of these data has been well-documented.^{28–30} Expanding these analyses to include pregnancy complications as reported in the US Natality Files would not allow for adequate examination of their effects and may introduce substantial bias.

These analyses identify several areas for future research—for one, identification of the causes of the disproportionate declines in macrosomia and cesarean delivery among women who gained excess weight and whether these declines could be a result of improved diabetes screening and management. In addition, research is needed to investigate whether

reductions in excess weight gain during pregnancy could result in reduced cesarean delivery rates and prevent postpartum maternal overweight and obesity as previous studies have suggested.^{31–35}

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