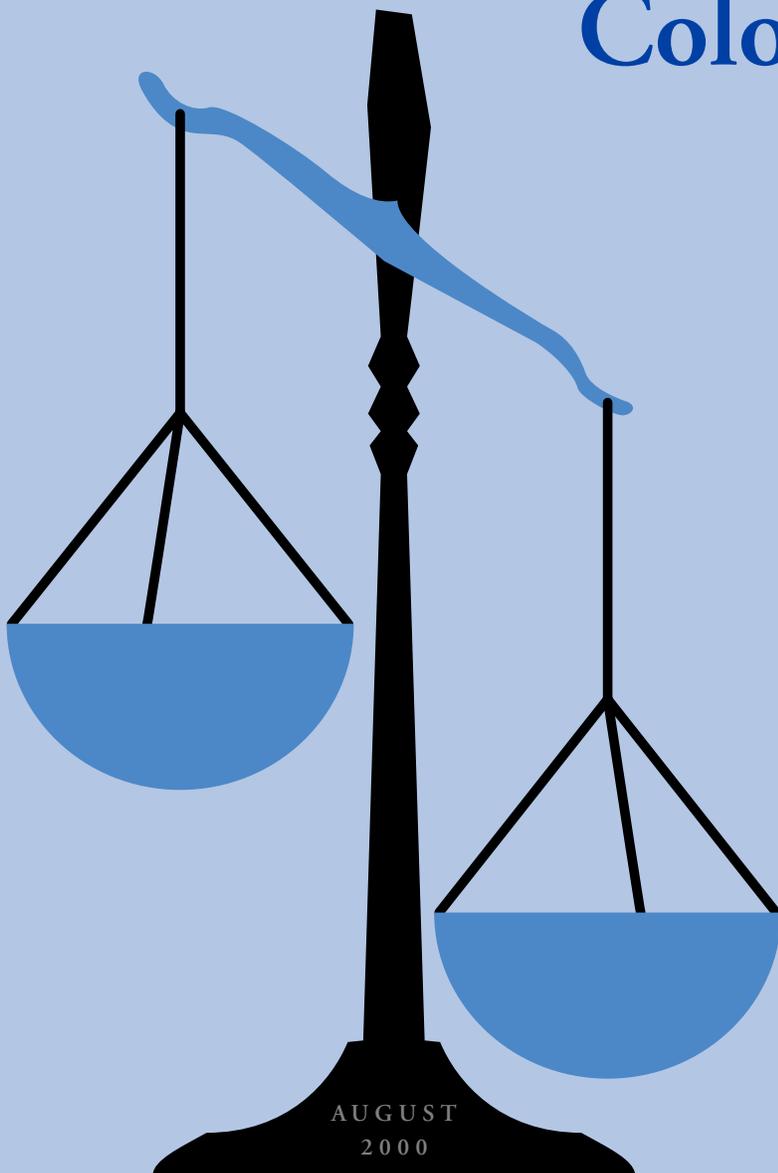


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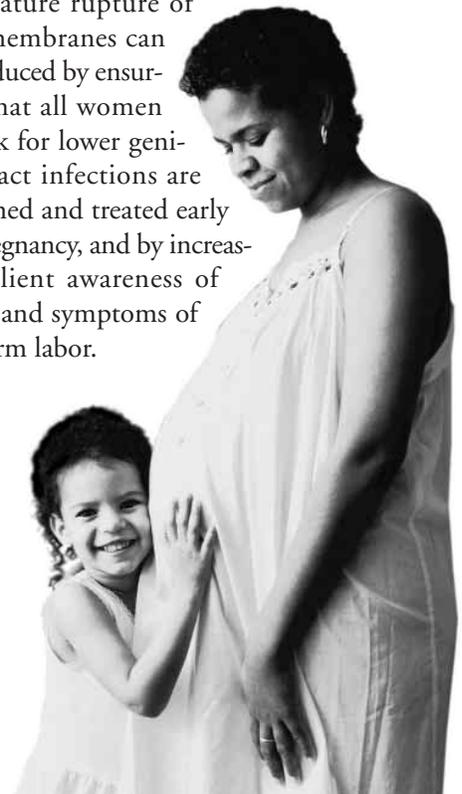
Weighing in on Solutions to the Low Birth Weight Problem in Colorado



Colorado Department of Public Health & Environment • 4300 Cherry Creek Drive South, Denver, Colorado 80246
This report is available in PDF format at <http://www.cdphe.state.co.us/fc/lbwreport.pdf>

Highlights

- ▼ **Colorado has one of the highest low birth weight rates in the nation.** In 1997, the state's low birth weight rate was 8.9 percent, with over 5,000 babies born low birth weight. The Healthy People goal for the nation for the year 2000/2010 is 5.0 percent.
- ▼ **The major contributing factors to low birth weight in Colorado (based on 1995–1997 birth certificate data) are multiple births, inadequate maternal weight gain, smoking, and premature rupture of the membranes.**
- ▼ **Multiple births are a large contributor to Colorado's low birth weight problem: one out of every five low weight births is a multiple.** If the state's multiple rates could be reduced to a naturally occurring level (eliminating multiple gestations resulting from assisted reproduction), there would be a decline of about half a percentage point in the state's overall low birth weight rate (based on 1995–1997 data).
- ▼ **Inadequate maternal weight gain during pregnancy is the largest contributor to the number of *singleton* low weight births.** If this problem were completely eliminated, the low birth weight rate for singleton births would be reduced by 12.8 percent, from 7.1 percent to 6.2 percent, a decline of nearly one percentage point.
- ▼ **Smoking among pregnant women is a significant contributor to Colorado's low birth weight problem.** If all pregnant women were nonsmokers or quit smoking during pregnancy, Colorado's singleton low birth weight rate would be reduced by 11.9 percent, resulting in a drop from 7.1 percent to 6.3 percent.
- ▼ **Premature rupture of the membranes is another significant contributor to Colorado's low birth weight problem.** If this problem could be eliminated, the low birth weight rate for singleton births would be reduced by 9.1 percent, from 7.1 percent to 6.5 percent.
- ▼ **Colorado's singleton low birth weight rate could be reduced by one-third, and the overall state low birth weight rate by one-quarter, if all pregnant women gained weight adequately and no pregnant women smoked.** If these conditions had been met for the 1995–1997 period, the state low birth weight rate would have been reduced from 8.7 percent to 6.4 percent.
- ▼ **The prevalence of each of the four most important risk factors can be reduced.**
 - Multiple gestation can be decreased by reducing the number of multiple gestations resulting from assisted reproduction;
 - Inadequate weight gain can be reduced by assuring that all women have appropriate nutrition counseling and gain an adequate amount of weight;
 - Smoking among pregnant women can be reduced by assisting all women to be smoke-free prior to conception or to quit smoking early in pregnancy; and
 - Premature rupture of the membranes can be reduced by ensuring that all women at risk for lower genital tract infections are screened and treated early in pregnancy, and by increasing client awareness of signs and symptoms of preterm labor.



Executive Summary

Colorado has one of the highest low birth weight rates in the nation. Low birth weight is a significant health problem that contributes to infant mortality and to developmental and neurological disability. In 1997, the state's low birth weight rate was 8.9 percent, with over 5,000 babies born low birth weight (5 pounds, 8 ounces or less, or less than 2,500 grams). The Healthy People goal for the nation for the year 2000/2010 is 5.0 percent.

In 1998, the Colorado Department of Public Health and Environment conducted a multiple regression analysis of low weight births in an attempt to further quantify the problem of low birth weight. Eighteen factors captured on the birth certificate were determined to be closely associated with low birth weight. The most important factors included premature rupture of the membranes, poor maternal weight gain, pregnancy-associated hypertension and/or eclampsia, maternal smoking, abruptio placenta, previous preterm or small for gestational age birth, hydramnios/oligohydramnios, and black race. In 1999 the Department conducted a follow-up study to determine which of these factors were associated with the greatest number of low weight births. Population attributable risks were calculated to address this question.

Population attributable risk is a statistical measure that combines the prevalence of a condition in a population (e.g., what percent of women smoke) with the severity of that condition (smoking doubles the risk of low birth weight) to yield a percentage of the total (low birth weight) rate which is "attributable" to the condition in that population. Four factors were found to have high population attributable risks: multiple births, inadequate maternal weight gain during pregnancy, smoking during pregnancy, and premature rupture of the membranes.

Multiple births are a large contributor to Colorado's low birth weight problem, accounting for one out of every five low weight births. If the causes of low birth weight among multiple gestations could be elimi-

nated, and multiple births were no more likely than singleton births to be low weight, the state's low birth weight rate would be reduced by 19.9 percent, from 8.7 percent in 1995–1997, to 7.1 percent. However, if the state's multiple rate could be reduced to a naturally occurring level, eliminating just the multiple gestations resulting from assisted reproduction, without a change in the low birth weight rate among twins and higher order multiples, there would be a decline of about half a percentage point in the state's overall low birth weight rate.

Among singleton births, inadequate weight gain during pregnancy is the largest contributor to low birth weight in Colorado. If all pregnant women gained weight adequately, the low birth weight rate for singleton births would be reduced by 12.8 percent, from 7.1 percent to 6.2 percent, a decline of nearly one percentage point.

Smoking among pregnant women is another significant contributor to Colorado's low birth weight problem. If all pregnant women did not smoke or quit smoking early in pregnancy, Colorado's singleton low birth weight rate would be reduced by 11.9 percent, resulting in a decline from 7.1 percent to 6.3 percent.

Inadequate weight gain during pregnancy and smoking are together the two most important factors in low birth weight among singleton births. Since the two factors have an effect on each other, the population attributable risk for inadequate weight gain and smoking is greater than the effect of each considered separately. Colorado's low birth weight rate among singleton births could be reduced by one-third, from 7.1 percent to 4.7 percent, if pregnant women who smoked were able to stop smoking and if women who gained too little were able to gain weight adequately. The *overall* state low birth weight rate (including multiple gestations) could be reduced by one-quarter, from 8.7 percent to 6.4 percent, if all pregnant women gained weight adequately and did not smoke.

By reducing the occurrence of other treatable factors, the state's low birth weight rate could be

decreased even more. Nearly one-half (47 percent) of the rate could be eliminated by ensuring adequate weight gain, eliminating smoking, beginning prenatal care in the first trimester, and lengthening the interpregnancy interval among parous women. If this could be accomplished, over 2,000 low weight singleton births could be averted, decreasing the singleton low birth weight rate from 7.1 percent to 3.8 percent. In addition, if multiple births were reduced to a naturally occurring level (eliminating those resulting from assisted reproduction), the overall state rate could be reduced to 5.1 percent. Such declines would enable Colorado to come close to meeting the Healthy People 2000/2010 goal for low birth weight of 5.0 percent. If the occurrence of premature rupture of the membranes (PROM) could be decreased or eliminated, the state rate could drop even further.

The analysis of low birth weight in this report focuses on those factors with high population attributable risks that are also seen as amenable to modification or treatment. Some of these factors are more behavioral in nature and therefore, less likely to be altered by traditional medical interventions. Thus, addressing these factors requires a significant change in approach. Health care providers, policymakers, pregnant women and payors all have a role to play in reducing Colorado's low birth weight rate. Solutions recommended in this report include:

- ▼ Decreasing the incidence of multiple gestation by reducing the likelihood that assisted reproductive techniques will result in multiple births;
- ▼ Assuring that all women have appropriate nutrition information and monitoring to gain an adequate amount of weight;
- ▼ Assisting all women to stop smoking prior to conception and during pregnancy;
- ▼ Decreasing the incidence of premature rupture of the membranes by assuring that all women at risk for lower genital tract infections are screened and treated during pregnancy, and by increasing client awareness of signs and symptoms of premature labor.

From the standpoint of prevention, efforts during the preconception period should focus on promoting access to and consistent use of contraception, screening and counseling women to assist in reducing modifiable risk factors for low birth weight, and educating consumers in general about the risks for and consequences of low weight births. Behavioral and lifestyle counseling should also be incorporated into the content of prenatal care.

Statewide commitment to these strategies, supported by all stakeholders, can result in a decrease in the low birth weight rate in Colorado to a level close to the Healthy People goal of 5.0 percent.

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Principal authors

Sue Ricketts, Ph.D., Demographer, Family and Community Health Services Division
Karen Trierweiler, MS, CNM, Nurse Consultant, Women's Health Section, Family and Community Health Services Division

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Steve Burnite, B.A., Health Statistics Section
Darci Cherry, M.P.H., Health Statistics Section
Carol Garrett, Ph.D., Director, Health Statistics and Vital Records
Teresa Hamby, MPH, Women's Health Section
Helene Kent, MPH, Director, Women's Health Section
Marilyn Leff, MSW, MSPH, Director, Health Statistics Section
Bill Letson, M.D., Family and Community Health Services Division
Erin Murray, RD, CNSD, Women's Health Section
Huiyun Xiang, M.D., Ph.D., Health Statistics Section

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Tipping the Scales:

Weighing in on Solutions to the Low Birth Weight Problem in Colorado

The Problem

Introduction

Low birth weight is a significant health problem, contributing both to infant mortality and to long-term developmental and neurological disability.^{1,2} Low birth weight infants are defined as those weighing 5 pounds, 8 ounces or less (under 2,500 grams). This classification includes those low weight infants who are small for gestational age as well as those who may be born prematurely (less than 37 weeks gestation). The United States low birth weight rate of 7.5 percent in 1997 falls well short of the Healthy People 2000 goal, a major U.S. public health initiative, which was set at a rate of 5.0 percent to be achieved by the year 2000. (The Healthy People 2010 goal remains the same.) The United States low birth weight rate is currently at a level that is 50 percent higher than the goal.

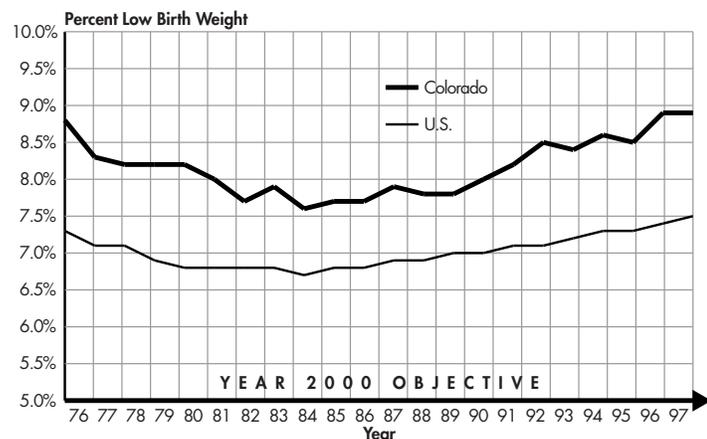
Within the United States, Colorado reports one of the highest low birth weight rates in the nation (see Appendix A). Colorado's low birth weight rate in 1997 was 8.9 percent.^a Only five states and the District of Columbia had higher rates (Louisiana, Mississippi, Alabama, South Carolina, and Wyoming). Moreover, Colorado had the second highest rate among white mothers of any state, with 8.5 percent giving birth to low birth weight infants.³

Low birth weight infants have a higher mortality rate than normal weight infants. In Colorado, the 1997 infant mortality rate for all births was 7 deaths per 1,000 births. For low birth weight infants, the rate was 48.1, a level seven

times higher. However, serious and costly morbidity is a far more common outcome than mortality for low birth weight infants. Beginning with neonatal intensive care, assisted ventilation, multiple invasive medical procedures and therapies, and continuing through developmental delays, repeated hospitalizations, and increased susceptibility to illness, the health of low weight infants is often compromised for many years; for some throughout life. The most severe problems are found in very low birth weight infants weighing 3 pounds, 4 ounces or less (less than 1,500 grams) at birth, many of whom are born prematurely. Colorado's very low birth weight rate of 1.3 percent equals the U.S. rate, while the state's prematurity rate of 8.6 percent was below the national average of 11.4 percent in 1997.

For at least the past 50 years, Colorado's low birth weight rate has consistently been higher than the U.S. rate. Figure 1 displays the trends since 1976, and reveals that Colorado's rate exceeds the U.S. rate by about one percentage point or more; in 1997 it exceeded it by 1.4 percentage points. A total of 5,014 low birth weight infants were born out of 56,505 births to Colorado residents in that year.

Figure 1—Low Birth Weight Rates, 1976–1997, Colorado and the United States



^a The 1998 low birth weight rate was 8.7 percent for Colorado.

Background

The Colorado Department of Public Health and Environment has been monitoring Colorado's high low birth weight rate for many years, and has provided information about county low birth weight rates and age- and race-specific low birth weight rates in the annual *Colorado Vital Statistics* reports.^b In an attempt to further quantify this problem in 1998, the Department conducted a multiple regression analysis of low weight births. Eighteen factors captured on the birth certificate were determined to be closely associated with low birth weight.⁴ The most important factors included premature rupture of the membranes, poor maternal weight gain, pregnancy-associated hypertension (PIH) and/or eclampsia, maternal smoking, abruptio placenta, previous preterm or small for gestational age birth, hydramnios/oligohydramnios, and black race.^c The identified factors are similar to those noted in the extensive literature on low birth weight.^{5,6,7} The study identified factors that are serious, but did not analyze how prevalent these conditions were in the population.

Although the factors most commonly associated with low weight births were identified, their precise contribution to the numbers of low weight births in Colorado had not been determined. Thus, in 1999, the Department conducted an investigation to determine which of these factors were associated with the most low weight births.⁸ This new analysis provided estimates of the number of low weight births that can be attributed to a variety of risk factors. It is important to note that the factors identified were confined to those collected on the state birth certificate. Although the results are not reported, the data were stratified to control for confounding factors. There were no significant differences among groups when stratifying.

^b The most recent published report is Colorado Vital Statistics 1998, Health Statistics and Vital Records, Colorado Department of Public Health and Environment, May 2000.

^c Race categories on the birth certificate are "American Indian, Black, White," etc. This report uses the birth certificate designation of black in place of other terms such as African-American.

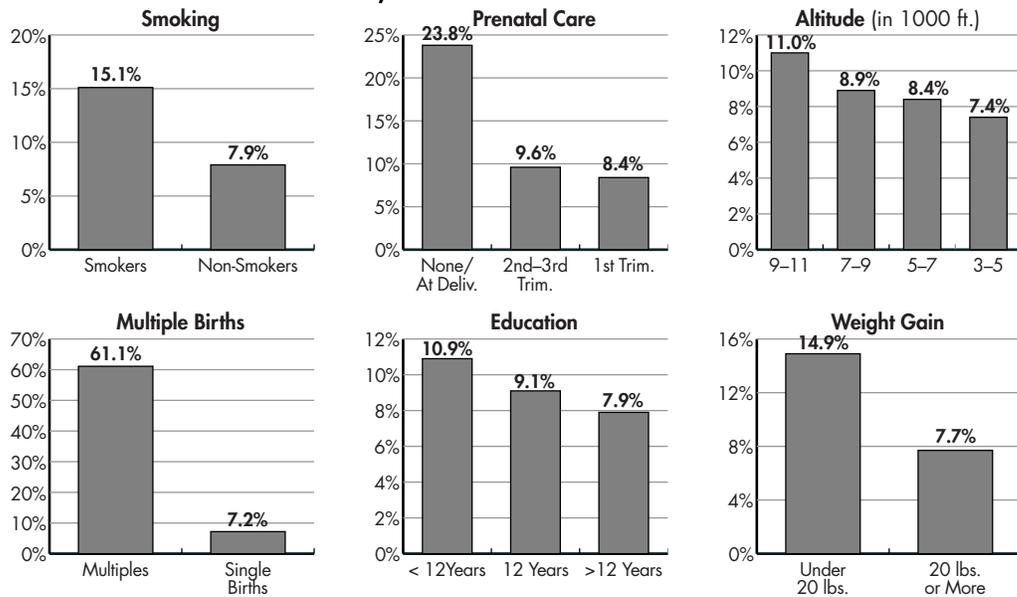
Risk Factors for Low Birth Weight

The perennial explanation for Colorado's relatively high low birth weight rates compared to other states has been high altitude. Colorado's residents live at altitudes between 3,000 and 11,000 feet above sea level. It has been demonstrated that high altitude contributes to an excess of low birth weight, and that this excess increases as altitude increases, reaching a 50 percent excess at the highest (9,000–11,000 feet) compared to the lowest (3,000–5,000 feet) elevations. Altitude has an effect independent of other factors, such that with each incremental increase of 1,000 meters (3,300 feet) between 3,000 and 11,000 feet of elevation, there is a decrease of 102 grams (3.5 ounces) in birth weight (about one ounce per 1,000 feet). In addition, the occurrence of pregnancy-induced hypertension, another risk factor for low birth weight, is increased at high altitude. Pregnancy-induced hypertension is two and a half times more common at the highest compared to the lowest altitude in Colorado.⁹

This current report does not specifically address the contribution of high altitude to Colorado's low birth weight problem compared to other states. The advent of geographic information software systems (GIS) has added to our understanding of the impact of elevation, confirming that a portion of the state's low birth weight rate can be attributed to births occurring at elevations above 3,000 feet (a level above which all births in the state take place). However, both GIS data and the 1998 regression analysis suggest that elevation plays a secondary role in Colorado's low birth weight problem, and that other factors are far more important. The Department anticipates further study of the role of high altitude, but recognizes that since altitude is not a factor that can be eliminated or reduced, solutions must be found in areas that are amenable to intervention. Indeed, Colorado's high altitude makes it imperative that effective solutions be identified.

Figure 2 on the following page illustrates the impact of a variety of risk factors and characteristics, including altitude, on low birth weight. For example, information in Figure 2 suggests that a real reduction in the proportion of pregnant women who smoke

Figure 2—Low Birth Weight (LBW) Rates by Risk Factors/Characteristics, Colorado 1996, Overall LBW Rate = 8.9%



Source: Colorado Birth Certificate Data, 1996. Altitude data calculated from the mother's place of residence.
 Note: Left (vertical) axis is percent low birth weight.

would be associated with a reduction in the state's overall low birth weight rate. Theoretically, if pregnant women did not smoke, the state's low birth weight rate would drop from 8.9 percent overall to 7.9 percent, the level for all non-smokers (1996 data). Similarly, better access to early prenatal care, improvements in weight gain, and so on, would also lead to a reduction in the overall level of low birth weight as well. While some factors can be altered more readily than others, a factor such as altitude is fixed.

Since many factors have an impact on Colorado's low birth weight rate, it is challenging to determine which factors exert the largest effects. Some medical factors are closely associated with low birth weight. For example, low birth weight is closely associated with abruptio placenta; about half of all births complicated by abruptio placenta are low weight. However, not many women (fewer than 350 per year) experience this condition, and therefore, abruptio placenta accounts for a very small proportion of low weight births in the state. Many of the medical factors are manifested in only a small number of women. Even though the low birth

weight rates in these groups are high, their contribution to overall low birth weight is small.

Therefore, the question that the 1999 study was designed to answer was, "Which factors in Colorado are associated with the most low weight births?" Population attributable risks were calculated to answer the question.

Population Attributable Risk: Which Factors are Associated with the Most Low Weight Births

Population attributable risk (PAR) is a statistical measure that combines the prevalence of a condition in a population (e.g., what percent of pregnant women smoke) with the severity or importance of that condition (smoking doubles the risk of low birth weight) to yield a percentage of the total (low birth weight) rate that is "attributable" to the condition in that population. The population attributable risk due to smoking will be *high* in a population where many women smoke and it will be *low* in a population where few women smoke, even though women who smoke are at increased risk for low birth weight.

For purposes of this analysis, the Colorado Department of Public Health and Environment was interested in conditions which were prevalent or common *and at the same time* conditions that were serious (highly related to low weight births). The combination of prevalence and severity yields high population attributable risks. Identifying these risks, and then determining those which can be altered or reduced would assist the Department in targeting those factors that should be addressed in Colorado.

Calculating population attributable risk is useful because its value represents the reduction in low birth weight that can theoretically be achieved by eliminating the risk factor. Therefore, if the population attributable risk of factor A is 10 percent, the low birth weight rate of the population can be reduced by 10 percent if factor A can be eliminated. To achieve such reductions, however, several conditions must be met:

- ▼ the risk factor must be causally related to low birth weight for its elimination or treatment to reduce the risk of low birth weight;
- ▼ a treatment must be available and effective in removing the risk factor;
- ▼ removal or treatment of the risk factor must eliminate its effects on low birth weight (treatment must stop the pathophysiologic processes through which the risk factor causes low birth weight); and
- ▼ the risk factor being treated must be independent from other risk factors that influence low birth weight.^d

^d For example, the educational level of the mother is inversely related to low birth weight, and appears to be very important, since the low birth weight rate for mothers with less than a high school education is 10.9 percent, while it is 7.9 percent for those with more than a high school education (See Figure 2). The educational level of a mother, however, is unrelated to the physiological processes that take place during pregnancy. The educational level is a confounding variable; that is, a marker, for example, for smoking status (only 2 percent of women with a college education are smokers vs. 18 percent among women with less than a high school education). Smoking may be the underlying variable which must be eliminated in order for the low birth weight rate to improve.



It is possible to add population attributable risks together if the factors are not related. Therefore, if Factor A with a PAR of 10 percent is completely unrelated to Factor B which has a PAR of 5 percent, then the population attributable risks may be added together for a combined PAR of 15 percent. If both Factor A and Factor B could be fully addressed and eliminated, the low birth weight rate would decline by 15 percent. However, to the extent that Factor A and Factor B are interrelated, the PARs cannot be summed because the result will either overstate or understate the impact of the combined factors.

Population Attributable Risk Results Among All Births

Multiple Gestation

Population attributable risks were calculated using all birth certificate data from the 166,591 births occurring to residents of Colorado in the three-year period 1995–1997. The largest population attributable risk was determined to be 19.9 percent for multiple gestation. This PAR means that the state's overall low birth weight rate of 8.7 percent could theoretically be reduced by 19.9 percent, to 7.1 percent, if multiple births were no more likely to be low weight than singletons.

Multiple gestation is associated with a large population attributable risk not because of its prevalence (just 3.1 percent of all births), but because of its severity. Nearly six out of every ten twins (58.1 percent) are low birth weight, as are 94.7 percent of triplets, and all quadruplets. Rates of low birth weight, very low birth weight and infant mortality are 4 to 33 times higher for twin, triplet and higher order births versus singletons.¹⁰ Given these data, even small increases in the rate of multiple births lead directly to increases in the overall low birth weight rate.

In the U.S., the number and rate of twin, triplet and other higher order multiple births have increased dramatically over the past decade. The number of twin births overall rose 52 percent between 1980 and 1997 and the number of triplet and higher orders births rose 404 percent. Between 1980–1982 and 1995–1997, the twin rate rose 63 percent for women age 40 to 44 and increased almost 1,000 percent for women age 45 to 49 (the group with the highest twin and triplet birth rates in the nation). Non-Hispanic white women were more than twice as likely as non-Hispanic black or Hispanic women to have a triplet or higher order birth.¹⁰

In Colorado, these data are much the same. Colorado ranks as one of the ten states in the country with the highest twin and triplet birth rates.^e The percentage of multiple births in Colorado has increased by 60 percent from 1.9 percent in 1975 to 3.1 percent in 1997. While a percentage of multiple gestation occurs naturally in a population, especially to those women who delay childbearing until older ages,¹⁰ this rapid increase is mainly attributable to the use of assisted reproductive technologies which greatly increase the likelihood of multiple gestation.^{11,12} Assisted reproduction, then, while enabling infertile couples to bear children, has at the same time contributed disproportionately to the growing number of low birth weight and very low birth weight infants in Colorado. Additional information on multiple births in Colorado is provided in Appendix B.

^e The states with the highest rates for twins are Connecticut and Massachusetts (3.3%); New Jersey (3.1%); Nebraska (3.0%); Delaware, Maryland, and New York (2.9%); and Colorado, the District of Columbia, and North Dakota (2.8%), using 1995–1997 data. For triplets, the states are the same with the exceptions of North Dakota and the District of Columbia, which drop out, and Minnesota and Illinois, which are added. Source: National Vital Statistics Reports, “Trends in Twin and Triplet Births: 1980–1997,” Vol. 47, No. 24, September 14, 1999.

Colorado has one county (Douglas) where over 4 percent of all births are multiples, meaning that more than one out of every 25 infants born in that county is a twin or triplet, and that fully one out of every three of the county’s low birth weight infants is a multiple.

Multiple Birth Reduction

Low birth weight related to multiple birth could be reduced by effecting some change in assisted reproductive technology (ART) to decrease the incidence of twin and higher order births. If the proportion of multiple gestations could be reduced to naturally occurring levels, a prospect more likely than reducing the low birth weight rate occurring with multiple gestations, the state’s overall low birth weight rate could be reduced by an estimated half of a percentage point, from 8.7 percent in 1995–1997, to 8.3 percent. A 19.9 percent decline in the state low birth weight rate (based on the population attributable risk for multiples noted earlier) is not likely, because such a decline is dependent on eliminating the excess low birth weight that is commonly associated with multiple compared to singleton gestations.

Since other medical risk factors are often associated with multiple gestations, the remainder of this analysis is limited to singleton births. This approach removes multiple gestation as a potential confounding factor, focusing on major contributors to low birth weight in singleton births, which made up 96.9 percent (161,491) of all births in the state during the three-year study period, 1995–1997.

Population Attributable Risk Results Among Singleton Births

Three factors, with PARs close to 10 percent or greater, were determined to play a significant role in Colorado’s singleton low birth weight rate:

- ▼ Inadequate maternal weight gain during pregnancy
- ▼ Maternal smoking
- ▼ Premature rupture of the membranes (PROM)

Table 1 lists a number of factors along with their population attributable risks. The three factors with the highest population attributable risks appear to be remediable, i.e., the contribution of each to low birth weight can be reduced through intervention. Other factors have population attributable risks that are lower and therefore contribute less significantly to the problem of low birth weight.

Table 1—Population Attributable Risks for Low Birth Weight Among Singleton Births, Colorado, 1995–1997
State Singleton LBW Rate = 7.1%

Factor	Population Attributable Risk (PAR)	Prevalence Among Mothers	LBW Rate For Factor	Hypothetical State Singleton LBW Rate if Factor Eliminated
Top Three PARs:				
Inadequate Weight Gain	12.8%	25.7%	9.4%	6.2%
Smoking	11.9%	11.6%	13.4%	6.3%
Prem. Rupture of Membranes	9.1%	2.6%	31.0%	6.5%
Other PARs:				
PIH or Eclampsia	6.8%	3.5%	20.3%	6.6%
Maternal Black Race	6.3%	4.6%	13.4%	6.7%
Hispanic Ethnicity	4.6%	22.0%	7.7%	6.8%
Age < 18	3.9%	4.8%	11.0%	6.8%
Hydramnios	3.2%	1.5%	22.0%	6.9%
Abruptio Placenta	3.1%	0.6%	45.6%	6.9%
Prior Preterm Birth	2.9%	1.2%	24.2%	6.9%
Short Interpregnancy Interval*	2.4%	15.9%	7.1%	6.9%
No Prenatal Care**	2.3%	0.9%	21.4%	6.9%
Other Bleeding	1.3%	0.6%	23.9%	7.0%
Placenta Previa	1.0%	0.3%	29.0%	7.0%
Alcohol Use	1.0%	1.3%	12.5%	7.0%
Altitude > 10,000 feet	0.8%	3.6%	9.1%	7.1%
Incompetent Cervix	0.8%	0.2%	32.8%	7.0%

* Less than 12 months between previous delivery and subsequent conception.

** No prenatal care or care only at delivery.

Most of the factors in Table 1 are self-explanatory, (inadequate weight gain, smoking, pregnancy-induced hypertension), and clearly identify problems to be addressed. Some of the others are less clear. For instance, the PAR for women under the age of 18 may be a marker for the different biological, sociological, and environmental factors that impact young women. In addition, race and ethnicity are used in this context to reflect social, cultural, and environmental influences, such as stress, racism, and/or poverty, rather than biological or genetic factors. Black race and Hispanic ethnicity are best thought of as indicators of other risks and not as causal factors on their own.

Inadequate Weight Gain

Inadequate weight gain is a significant factor in low birth weight, with a population attributable risk of 12.8 percent. If the problem of inadequate weight gain could be eliminated among pregnant women, resulting in all pregnant women gaining an adequate amount of weight, the state's singleton low birth weight rate of 7.1 percent could be reduced to 6.2 percent (a 12.8% reduction), lowering Colorado's singleton low birth weight rate by nearly one full percentage point.

Data concerning the effects of weight gain on fetal growth are virtually unanimous in reporting a pos-

itive relationship between prenatal weight gain and birth weight. The risk of delivering a low weight infant therefore decreases as more weight is gained during pregnancy. Among women who gain weight adequately, the rate of low birth weight is well below the rate found among women who do not gain an adequate amount of weight. Furthermore, the pattern of gestational weight gain, especially during late pregnancy, is also important, with a positive relationship existing between incremental second and third trimester weight gains and birth weight.

Inadequate weight gain is defined as total weight gain during pregnancy below the amount recommended in the Institute of Medicine (IOM) guidelines,^{13,14} based on pre-pregnancy body mass index (BMI) (Appendix C).^f For example, a woman whose BMI is normal (19.8–26) should gain between 25 and 35 pounds at term (38–42 weeks gestation). A woman whose BMI is low (<19.8) should gain 28 to 40 pounds, while a woman with a high BMI should gain between 15 and 25 pounds.

Inadequate weight gain has a large population attributable risk because of its prevalence in the population of pregnant women. In Colorado, for 1995 to 1997, one out of every four (25.7 percent) pregnant women gained less than the recommended amount of weight during pregnancy.^g While the impact of inadequate weight gain on fetal outcome is not comparable in severity to some other med-

One out of every four pregnant women in Colorado gains less than the recommended amount of weight during pregnancy.

ical conditions, the fact that it is so common makes it a major contributor to the number of low weight births. The low birth weight rate among women who gain an adequate amount of weight is 6.0 percent, compared to 9.4 percent among women with an inadequate gain (1995–1997 data).⁸

While inadequate weight gain is a risk for all pregnant women, the risk is higher among the one in five Colorado mothers who are underweight at conception, according to the Colorado Pregnancy Risk Assessment Monitoring System (PRAMS)^{h,15}. Over one-third (35 percent) of these underweight women do not gain enough weight during pregnancy, compared to one-quarter (24 percent) of normal weight women, and 15 percent of women who are overweight at conception. However, over half (54 percent) of those who do not gain enough weight during pregnancy begin the pregnancy at normal weight.

Appropriate nutritional counseling is increasingly recognized as critical to ensure adequate weight gain during pregnancy. According to PRAMS data, more than two out of every three



^f In this analysis, weight gain was determined for term infants to be adequate or inadequate according to IOM guidelines for normal weight women (adequate requires a 25 pound gain). For infants born prior to 37 weeks gestation, an adjustment for adequate weight gain was made, based on gestational age. Therefore, the mother of an infant born prematurely was classified as having an adequate weight gain if she had gained enough weight for that gestational age, as defined by the Women, Infant and Children (WIC) program prenatal weight gain grid.

^g In this analysis, using birth certificate data, information was available on weight gain during pregnancy, but not on each mother's BMI. Colorado Pregnancy Risk Assessment Monitoring System (PRAMS) data, which do provide BMI information, were used in conjunction with the birth certificate data to estimate the proportion of women in the state who did not gain weight adequately.

^h PRAMS is an on-going population-based surveillance system designed to supplement vital records data and to generate state-specific data for planning and assessing perinatal health programs. Each month, a random sample of postpartum women is surveyed about a variety of perinatal health issues.

(65 percent) women who currently begin pregnancy underweight are able to gain an adequate amount of weight.¹⁵ Intensive effort is needed to improve medical advice regarding prenatal weight gain and to increase access to nutritional counseling and follow-up when weight gain is inadequate.

Smoking

The population attributable risk of smoking is 11.9 percent, nearly the same as the population attributable risk for inadequate weight gain. If pregnant women did not smoke in Colorado, the singleton low birth weight rate would fall from 7.1 percent to 6.3 percent, again nearly a full percentage point. Smoking is a major contributor to the state's low birth weight rate because of its prevalence and its severity. It is a relatively common risk factor, which could theoretically be eliminated.

Maternal cigarette smoking is associated with an increased risk for perinatal and infant death as well as other complications of pregnancy including spontaneous abortion, placenta previa and abruptio placenta, fetal growth restriction resulting in low birth weight infants, and preterm birth.^{16,17} There is also some evidence that Attention Deficit Hyperactivity Disorder and other behavioral or learning problems may be linked to smoking during pregnancy.¹⁸ Exposure to environmental tobacco smoke has been linked to sudden infant death syndrome and respiratory illnesses, middle ear infections, and decreased lung function in children.^{19,20,21} In addition, smoking during pregnancy places a considerable financial burden on the health care system, as the costs of pregnancy-related complications due to smoking are estimated at about two billion dollars annually in the U.S.²²

Adolescence is the critical period during which most women begin to smoke. Ninety-one percent of adult smokers initiate smoking before age 20; 77 percent of this group become daily smokers. Few women begin smoking after age 20, as in general, smoking decreases as age and education increase.²³ In 1997 in Colorado, similar to the nation, almost 16 percent of mothers age 15 to 19 and 14 percent of mothers age 20 to 24 smoked during pregnancy. Of

mothers reporting less than 12 years of education, 18 percent reported smoking as opposed to 2 percent of those with 16 or more years of education. Women on Medicaid are also more likely to smoke during pregnancy. Data from Colorado PRAMS (1997) reveal that nearly 25 percent of pregnant women on Medicaid reported smoking in the last three months of pregnancy versus 10 percent of non-Medicaid women.¹⁵

White women in Colorado are more likely to smoke than women of color. Having a partner who smokes is also a risk factor for smoking. The challenge, then, is to eliminate smoking in women of reproductive age and to assist pregnant women to achieve smoking cessation early in pregnancy. Colorado data demonstrate that even light smokers (fewer than 10 cigarettes per day) exhibit markedly higher rates of low birth weight than non-smokers, whose low birth weight rate was 8.1 percent (1997). For light smokers, the low birth weight rate is 13.9 percent, compared to 16.7 percent for heavier smokers (10 or more cigarettes per day).ⁱ While light smokers do exhibit a slightly lower low birth weight rate than heavier smokers, significant reduction in low birth weight is only seen in those who do not smoke. Based on these data, cutting back on smoking is not an effective option during pregnancy.

It is important to stress that among women who smoke during pregnancy, fully three-quarters (76 percent) state that they smoke fewer than 10 cigarettes per day, while 22 percent claim 20 or fewer cigarettes per day, and only 2 percent state that they smoke more than a pack a day.^j The population attributable risk for light smoking is 8.8 percent, while the population attributable risk for moderate to heavy smoking is 4.4 percent. The low birth weight rate among singleton births has the potential to be reduced by almost 9 percent, from 7.1 percent to 6.5 percent, by eliminating smoking among light

ⁱ Colorado Vital Statistics 1997, Health Statistics and Vital Records, Colorado Department of Public Health and Environment, March 1999, Table B-23, p. 69.

^j Birth certificate data relative to smoking during pregnancy are based on self-reports. Smoking rates are probably under-reported.

smokers only. Intervention and elimination of smoking in this group could reduce low birth weight in Colorado to a greater extent than intervention among women who admit smoking more, simply because the great majority of pregnant smokers categorize themselves as light smokers.

Interestingly, reported smoking has declined among Colorado birth mothers during the last decade. In 1990, 18 percent of mothers reported smoking during pregnancy. In 1997, just 10.6 percent of mothers smoked, a decline of 40 percent. The reduction that has already occurred suggests that further declines are possible.

Premature Rupture of the Membranes

Premature rupture of the membranes (PROM) is defined as rupture of the chorioamniotic membranes prior to the onset of labor (for more than twelve hours^k), regardless of the gestational age of the fetus.²⁴ About 8 to 10 percent of women experience PROM at term.²⁴ More important to the discussion of low birth weight is the fact that preterm PROM (PROM occurring at less than 37 weeks gestation) accounts for 25 percent of all cases of PROM and 30 percent of all premature deliveries in the U.S.²⁵ Premature delivery and the resulting complications of preterm birth (including infection) are the most common causes of perinatal morbidity and mortality associated with preterm PROM.²⁴

PROM, in general, affects few women (2.9 percent) but plays a significant role in Colorado's low birth weight problem. The population attributable risk for PROM is 9.1 percent, meaning that the state's singleton low birth weight rate of 7.1 percent could be reduced to 6.5 percent (a reduction of 9.1 percent), if this risk could be eliminated. Premature rupture of the membranes has a significant population attributable risk not because of its prevalence, which is small, but because of its severity: 31 percent of all births resulting from PROM in Colorado are low weight.

Because the membranes serve as a barrier between the sterile intrauterine cavity and the bacteria-rich environment of the vagina, ascending bacterial infec-

tion from the vagina is thought to be a likely cause of preterm PROM.²⁶ Studies consistently show that women with group B streptococci, gonococci, and bacterial vaginosis (BV) have an increased risk for preterm PROM.^{27,28,29,30} A prospective, controlled trial confirmed that the presence of BV was associated with an increased risk of pregnancy loss at gestational ages under 22 weeks, preterm PROM, and premature birth.³¹ There has been considerable work demonstrating that treatment of BV in pregnancy reduces infection and decreases the rate of preterm birth with the greatest effect being achieved in populations at highest risk for BV.^{31,32,33,34,35}

While the literature consistently notes that both BV and intrauterine infection are associated with preterm birth, a recent large randomized trial of antibiotics for preterm birth prevention in women with asymptomatic BV did not note a decrease in the incidence of premature delivery.³⁶ However, there are several methodologic issues which must be considered in interpreting the results of this study.¹ An editorial response to the study suggests that there is "enough evidence of the benefit of prophylactic antibiotics that women at high risk for adverse sequelae of infection should still be screened and treated" for BV.^{37,38} In addition, treatment for BV should be initiated pre-conceptually or during the first or early second trimester to prevent "colonization of the upper genital tract from the vagina and the subsequent inflammatory process that results in preterm labor."³⁷

^k PROM is defined as "greater than 12 hours" on the birth certificate. The addition of this time period changes the classic medical definition of this condition in this analysis.

¹ While this investigation did not find any differences between women treated before or after 20 weeks gestation, no one in the sample was treated before 16 weeks gestation. The earlier in pregnancy that labor occurs, the more likely it is that a "pathologic initiating factor, such as infection" is involved (37). When lower genital infections are detected early in pregnancy, the likelihood of an adverse outcome is greater. Thus, late identification of BV is of concern in interpreting the study results. In addition, the treatment regimen used was not one recommended by the Centers for Disease Control (CDC) and the rate of elimination of BV in women receiving the placebo was so high that the results of the study could have been affected.

Other factors are also associated with PROM. Smoking has been suggested as a factor in some studies while multiple gestation, abruptio placenta, previous preterm PROM, and previous cervical surgery or lacerations are also correlated with an increased risk of PROM.²⁴

Other Population Attributable Risk Factors

The population attributable risks of the other factors shown in Table 1 are substantially lower. These factors include pregnancy-induced hypertension (PIH) or eclampsia, maternal black race, Hispanic ethnicity, age under 18, hydramnios, abruptio placenta, prior preterm birth, short inter-pregnancy interval, no prenatal care, other bleeding, placenta previa, alcohol use, very high altitude, and incompetent cervix. Most of these factors are medical conditions that occur so infrequently that their contribution to the number of low weight births is small, even though the low birth weight rates associated with the conditions are high.

Some of these factors are difficult to impact or eliminate. It is known that there are more low weight births at higher altitudes, but altitude is also a risk that is not amenable to intervention (other than moving to a lower elevation). The PAR analysis demonstrates that the relative risk of low birth weight *within Colorado* is not significantly affected until elevation is greater than 10,000 feet (Table 1) and that, as noted above, other risk factors have much greater population attributable risks.

Some of the factors represent population rather than specific etiologic factors. For instance, if it were possible to identify reasons for the excess risk of low birth weight among black women, Hispanic women, or those under age 18, the low birth weight rate for Colorado could be further reduced. At this time, the PARs within these groups must be seen as markers for a myriad of other unknown causal factors. More research is needed to determine why these women are at higher risk for low weight birth.

In addition, a number of factors closely associated with low birth weight do not turn out, on their own, to have a large impact on the total number of low



weight births in the state. These include a variety of severe complications, (e.g., abruptio placenta, placenta previa) and mothers receiving no prenatal care (of which there are very few). Indeed, the complete lack of prenatal care does not appear by itself to seriously affect the state's overall low birth weight rate, since only 2.3 percent of all pregnant women receive, according to the birth certificate, "no care/care only at delivery." If provision of care to these women were the sole focus of intervention, the state's singleton low birth weight rate would only be reduced by 2.3 percent from 7.1 percent to 6.9 percent.

Combinations of Factors

The population attributable risks discussed so far have been presented as independent factors in low birth weight. Low birth weight, however, is a complex issue. Some risk factors are interrelated, such that calculation of the population attributable risk of two (or more) risks considered together is recommended. With this in mind, the Colorado Department of Public Health and Environment analyzed the top two remediable conditions, inadequate weight gain and smoking, together. These two factors were subsequently combined with two other remediable factors, delayed prenatal care and short interpregnancy interval. Addressing these factors in combination provides a measure of the potential overall power of intensive intervention in Colorado's low birth weight problem.

Inadequate Weight Gain and Smoking

Smoking in combination with inadequate weight gain has a particularly powerful impact on low birth weight, so that for all women who smoke and who also gain weight inadequately the risk of low birth weight is far greater than the risk associated with each factor alone. In Colorado, 8.3 percent of women smoked during pregnancy, 22.3 percent did not gain weight adequately, and 3.4 percent both smoked and did not demonstrate adequate weight gain. Those 3.4 percent of women were over three times more likely to have a low weight baby than those who did not smoke and who gained weight adequately, illustrating that these two factors in combination result in a much higher risk of low birth weight than when each factor exists alone. Because of this synergistic effect, the PAR for both of these factors is greater than the sum of the two individual factors.

The population attributable risk of inadequate weight gain and/or smoking is 34.4 percent, a PAR which is much greater than the sum (24.7 percent) of the two individual PARs for inadequate weight gain (12.8 percent) or smoking alone (11.9 percent). The population attributable risk of these two factors taken together means that Colorado's singleton low birth weight rate *could be reduced by over one-third* if all women gained weight adequately and did not smoke. Such a reduction in risk would lower the singleton low birth weight rate in Colorado from 7.1 percent to 4.7 percent (Table 2). In fact, the overall state low birth weight rate could be reduced by one-quarter, from 8.7 percent to 6.4 percent, if this occurred.

The combined PAR for inadequate weight gain and smoking is high because one in every three pregnant women in the state exhibits these factors alone or in combination. While the overall low birth weight rate is not especially high for those who gain weight inadequately and/or who smoke (9.8 per-

cent), the fact that so many women demonstrate these risk factors means that their low birth weight experience exerts a large impact (Table 2).

Inadequate Weight Gain, Smoking, Delayed Prenatal Care, and Short Interpregnancy Interval

Considering other modifiable risk factors along with inadequate weight gain and smoking results in further potential declines in low weight births. A total of 11.6 percent of all pregnant women smoke, 25.7 percent gain weight inadequately, 18.6 percent do not begin prenatal care in the first trimester, and 15.9 percent experience an interpregnancy interval of less than 12 months.^m Women experiencing one or more of these risks total about half of all pregnant women.

The population attributable risk associated with inadequate weight gain, smoking, delayed prenatal care (after the first trimester), and conception within one year of the last birth, in combination, is 47 percent. If all women gained weight adequately, did not smoke, accessed prenatal care in the first trimester, and did not conceive in less than 12 months from the last birth, the singleton low birth weight rate could be reduced by nearly half, declining from 7.1 percent to 3.8 percent, a very low rate.

The Colorado low birth weight rate can be reduced by 25 percent if all pregnant women gain weight adequately and no pregnant women smoke.

^m One in six women (15.9 percent) who have had a baby experience a rapid repeat pregnancy, with conception occurring less than 12 months after the previous birth (8). (Colorado PRAMS data show that 48 percent of all pregnancies are unintended, i.e., pregnancy was not intended at the time of conception.) While medical experts differ on the minimum ideal interpregnancy interval, research shows that the best outcomes occur with at least 18 months between delivery and subsequent conception (39).

Table 2—Combinations of Population Attributable Risks for Low Birth Weight Among Singleton Births, Colorado, 1995–1997, State Singleton LBW Rate = 7.1%

Factors	Population Attributable Risk (PAR)	Prevalence Among Mothers	LBW Rate For Combined Factors	Hypothetical State Singleton LBW Rate if Factors Eliminated
Inadequate Weight Gain and/or Smoking	34.4%	34.0%	9.8%	4.7%
Inadequate Weight Gain, and/or Smoking, and/or Delayed Prenatal Care, and/or Short IPI*	47.0%	50.5%	8.7%	3.8%

* Interpregnancy interval of less than 12 months between previous delivery and subsequent conception.

Summary of the Problem

Colorado has one of the highest low birth weight rates in the nation, with 8.7 percent of all infants born in 1995–1997 weighing 5 pounds 8 ounces or less. One out of every five of these low weight births was a multiple birth.

Reduction of the impact of multiple gestation on Colorado’s low birth weight rate appears to be dependent on changes in assisted reproduction. If multiple births were limited to those that occur naturally, the state’s low birth weight rate would decline by half of a percentage point. The largest contributors to Colorado’s singleton low birth weight problem are inadequate weight gain, smoking, and premature rupture of the membranes. Addressing any one of these three fully, so that all women gain weight adequately, *or* do not smoke, *or* do not experience premature rupture of the membranes, would reduce the state’s singleton low birth weight rate from 7.1 percent to 6.5 percent or less (Table 1).

Addressing combinations of factors found to be important determinants of low birth weight among singleton births, such as inadequate weight gain and smoking together, would have an even greater impact on low birth weight. If all women gained weight adequately and did not smoke, the state’s singleton low birth weight rate would fall from 7.1 per cent to 4.7 percent (Table 2). Finally, if all women gained

weight adequately, did not smoke, began care in the first trimester, and experienced an interpregnancy interval greater than 12 months, Colorado’s low birth weight rate among singletons would drop from 7.1 percent to 3.8 percent, a decline of nearly 50 percent. The combination of a reduction in the prevalence of multiples and a reduction in the low birth weight rate among singletons would result in a low birth weight rate for Colorado of 5.1 percent among all births, essentially meeting the Healthy People 2000/2010 goal of 5.0 percent.

Table 3 contains estimates for possible (theoretical) reductions in low birth weight in Colorado for the year 2001 (based on an expected total number of births of 65,000). At the current low birth weight rate, 5,680 low weight births are expected. However, if inadequate weight gain were fully eliminated, there would be 5,110 low weight births instead of the 5,680 expected, a drop of 570. If smoking were eliminated along with inadequate weight gain, there would be 4,170 low weight births instead of 5,680, a total drop of 1,510. In addition, ensuring early prenatal care and eliminating short interpregnancy intervals has the potential to drop the number of low weight births by 2,080. And if no more multiple births related to ART occurred, there would be only 3,320 low weight births instead of the 5,680 expected, a total decline of 2,360. If premature rupture of the membranes could be eliminated, the state rate and the absolute numbers of low weight births could decline even further.

**Table 3—Estimates and Possible Reductions in Low Weight Births:
Colorado 2001***

Possibilities for the Year 2001	Estimated Low Weight Births	Estimated Low Birth Weight Rate	Difference from Expected Number of Low Weight Births
Expected Number of Low Weight Births (based on actual 1995–1997 low birth weight rate)	5,680	8.7%	0
Inadequate Weight Gain Eliminated	5,110	7.9%	570
Inadequate Weight Gain and Smoking Eliminated	4,170	6.4%	1,510
Inadequate Weight Gain, Smoking, Delayed Prenatal Care, and Short Interpregnancy Interval Eliminated	3,600	5.5%	2,080
Inadequate Weight Gain, Smoking, Delayed Prenatal Care, Short Interpregnancy Interval, and ART-related Multiple Births Eliminated	3,320	5.1%	2,360

*Based on an expected total number of births in 2001 of 65,000.

It is clear that Colorado’s low birth weight rate could be dramatically reduced if these particular risks were reduced or eliminated. Proposed solutions to the problem of low birth weight are discussed in detail in the following section.



comparable live birth rates along with a decreased risk of multiples when only two embryos were transferred; women age 35–39 did so when three were transferred). Furthermore, the use of higher-quality embryos appeared to result in increased live birth rates when fewer embryos were transferred.⁴⁸ Similarly, a study using population-based data from the United Kingdom noted that transfer of two embryos reduced the risk of multiple birth without affecting live birth rates in women regardless of their age.¹¹ Emerging technology, resulting in improved embryo culturing techniques, may also decrease the need to transfer a large number of embryos.⁴⁹

Ideally then, judicious use of ovulation-inducing drugs and implantation of a limited number of high-quality embryos (based on maternal age) should result in acceptable live birth rates while decreasing the incidence of multiple gestation.^{12,43} Convening a group of reproductive endocrinologists involved in ART to discuss voluntary limits on embryo transfer and the use of newer technologies is one strategy to effect statewide change in ART practice. While preterm birth prevention is paramount, the likelihood of early delivery with higher order multiples is so great that reducing the number of pregnancies with twin or higher order multiples would result in the greatest reduction in low birth weight. Therefore, the solution lies in reducing the incidence of multiple gestations, because the low birth weight rate of multiples will probably remain high.

Inadequate Weight Gain

Inadequate weight gain plays a significant role in low birth weight, with a population attributable risk of 12.8 percent. If inadequate weight gain could be eliminated among pregnant women, the state's singleton low birth weight rate could be reduced by 12.8 percent, from 7.1 percent to 6.2 percent, dropping nearly one full percentage point. When maternal weight gain is within the recommended range, the incidence of low weight births is significantly decreased.^{13,14}

Inadequate weight gain during pregnancy is a readily modifiable risk.



The Institute of Medicine (IOM) recommendations for weight gain during pregnancy are shown in Appendix C. These recommendations are based on studies of antepartal weight gain in large groups of women in order to achieve optimal birth outcomes (prevention of low weight births), while minimizing postpartum weight retention.^{14,50,51,52} Inadequate weight gain is defined as total weight gain during a term pregnancy (as reported on the birth certificate) that is below the amount recommended in the IOM guidelines,^{13,14} based on pre-pregnancy body mass index (BMI). For example, a woman whose BMI is in the normal range (19.8–26) should gain between 25 and 35 pounds at term. A woman whose BMI is low (below 19.8) should gain 28 to 40 pounds at term and a woman with a high BMI (26–29) should gain 15 to 25 pounds.

To reduce the incidence of low weight births due to inadequate weight gain, both the rate of weight gain and the total amount gained are used as important determinants of adequacy.¹⁹ Giving appropriate advice about nutrition and weight can influence weight gain during pregnancy and improve birth

begin in childhood, with cessation efforts ideally commencing in the preconception period. Twenty-five percent of women quit smoking as they prepare for pregnancy or once their pregnancy is confirmed.⁵⁵ Colorado PRAMS data for 1997 reveal that nearly half of all women who smoked prior to conception stated that they had quit smoking by the last trimester of their pregnancies.¹⁵ Those who quit spontaneously appear to be more concerned about the effects of smoking on the fetus and have more years of schooling. As a group, they are probably less addicted.⁵⁶ Thus, those providing health care services to adolescents and childbearing-age women should address both the perinatal (including the effects of environmental tobacco smoke on the infant) and general health risks of smoking, initiating smoking cessation efforts prior to pregnancy. Pharmacologic methods to enhance cessation should be employed in the preconception period, based on the client's readiness to quit. These efforts to facilitate cessation are especially important as Colorado PRAMS data demonstrate that half (52 percent) of all women who quit smoking during pregnancy resume after delivery.¹⁵

In spite of these problems, pregnancy does provide a unique opportunity for smoking cessation because women are motivated to stop smoking to protect the health of their infants. This motivation functions as the cornerstone of provider counseling efforts. Complete cessation of smoking should be the message, as cutting back on smoking is not an effective option for low birth weight reduction. *Women should stop smoking prior to pregnancy and pregnant smokers should quit.*

Research has established a set of "Best Practice"ⁿ interventions to promote smoking cessation during pregnancy. Brief (5–15 minute) counseling from a trained health care provider, incorporated into routine prenatal care, along with culturally relevant,

ⁿ Evidence-based strategies/approaches that have been shown by research and evaluation to be effective are called "Best Practices."

pregnancy-specific, self-help materials can increase cessation rates during pregnancy from 5 to 10 percent to 15 to 20 percent.⁵⁶ In addition, Phase I of the Robert Wood Johnson Foundation Smoke-Free Families Initiative identified that combining these interventions with economic incentives and biochemical feedback (maternal/infant cotinine levels, carbon monoxide levels or ambient home cotinine levels) seemed to be an effective strategy to increase the rate of cessation.⁵⁵ The provider's personal commitment to helping women stop smoking was also viewed as an important component of successful interventions.⁵⁷ Colorado PRAMS data for 1997 note that 14 percent of pregnant women who reported smoking in the three months before pregnancy did not receive any information about smoking cessation from their prenatal providers.¹⁵ Thus, health care providers must consistently address this issue with clients.

However, due to the addictive nature of tobacco, many women continue to smoke during pregnancy, despite knowledge of the risks for maternal and infant health. The Smoke-Free Families Initiative notes that "growing awareness of the adverse effects of smoking on pregnancy has led an increasing number of pregnant smokers to conceal or underreport their smoking behavior."⁵⁵ When compared with hospital medical reports, birth certificates underreport smoking by 15 to 28 percent.^{58,59}

The heaviest smokers are usually not able to achieve cessation with behavioral interventions alone. The use of pharmacologic therapies with this population is currently being explored.^{60,61} Since the majority of pregnant smokers in Colorado classify themselves as light smokers (less than 10 cigarettes per day), even taking into account client underreporting of smoking behavior, implementing the Best Practice recommendations should be an effective way of promoting smoking cessation. Utilizing these recommendations along with a multidisciplinary approach, the Colorado Prenatal Plus Program has demonstrated self-reported prenatal smoking cessation rates of 52 percent.⁵³

Prenatal smoking cessation is cost-effective. A recent California study estimated that the average excess direct medical cost per live birth for each pregnant smoker (in 1995 dollars) was \$511.⁶³ Similarly, other studies have demonstrated that smoking cessation for pregnant women results in savings of \$2 to \$3 for every dollar spent.⁶⁴ The savings from preventing hospitalizations for illnesses and conditions related to low birth weight are more than \$6 for every \$1 spent on smoking cessation.⁶⁵ It is estimated that an annual decrease of only 1 percent in smoking prevalence in the United States would result in 1,300 fewer low weight births nationally and would save \$21 million in direct medical costs in the first year of a smoking cessation program.⁶³ Lack of consistent reimbursement for smoking cessation does impose a significant financial barrier to widespread implementation of a smoking cessation effort. Long-term strategies include advocacy with insurance companies, including Medicaid, to encourage and adequately reimburse providers and programs for these services.

Inadequate Weight Gain and Smoking

Interventions for women who experience inadequate weight gain and who also smoke should be focused on resolving both of these behaviors. In 1998, in the Colorado Prenatal Plus Program, 40 percent of those women who were at nutritional risk and who also smoked were able to both gain adequate weight and quit smoking after receiving nutritional counseling from registered dietitians and consistent provider messages about smoking cessation.⁵³ Counseling and follow-up around weight gain and smoking cessation is paramount.

Premature Rupture of the Membranes (PROM)

PROM affects few women (2.9 percent) but demonstrates a PAR of 9.1 percent. Colorado's singleton low birth weight rate of 7.1 percent could be reduced by 9.1 percent to 6.5 percent, if this risk could be eliminated. As noted earlier, preterm PROM (PROM occurring at less than 37 weeks gestation) is associated with 30 percent of all premature deliveries in the U.S.²⁵ Premature delivery and the result-

ing complications of preterm birth (including infection) are the most common causes of perinatal morbidity and mortality associated with this condition.²⁴

As noted earlier, ascending bacterial infection from the vagina is thought to be a likely cause of preterm PROM.²⁶ Studies consistently show that women with group B streptococci, gonococci, and bacterial vaginosis (BV) have an increased risk for preterm PROM.^{27,28,29,30} From the standpoint of prevention, better identification of those at risk for preterm PROM, including prompt diagnosis and treatment of lower genital infections (e.g., gonococci, chlamydia, trichomonas, and bacterial vaginosis) may decrease the incidence of this condition. McGregor and French recommend that pregnant women be screened and treated (if positive) for BV, chlamydia, gonorrhea, trichomonas, and bacteriuria as early in pregnancy as possible.^{31,33} Screening and treatment can be repeated at 20 and 28 weeks gestation for those at risk for repeated infection. Partners should be treated for STDs. "Tests of cure" are recommended for both STDs and BV after completion of therapy. Treatment of both asymptomatic and symptomatic infections is recommended.^{31,33} Despite the results of a recent study by Carey, there is still enough evidence of the benefit of antibiotic therapy that women at high risk for lower genital tract infections should be screened and treated in early pregnancy.³⁸

In addition, efforts such as the Colorado Premature Birth Prevention Project aim to educate both clients and health care providers about preterm birth prevention. This project encourages providers to screen for historical and medical risk factors for preterm birth; to educate the client about the signs and symptoms of premature labor; to screen and treat for lower genital tract infections; and to evaluate clients for a "shortened cervix" at 22 to 24 weeks gestation. A media campaign along with a comprehensive client education booklet conveys prevention information to clients and consumers to increase awareness about this issue.



Inadequate Weight Gain, Smoking, Delayed Prenatal Care, and Short Interpregnancy Interval

Since fifty percent of women in Colorado experience one or more of these risks, addressing weight gain and smoking issues during pregnancy is only part of the solution. Prenatal care must begin in the first trimester and access to care must be assured. Consistent use of family planning can increase the interval between births which leads to subsequently improved pregnancy outcomes.⁶⁶ Thus, effective contraceptive methods, including emergency contraception, must be available, accessible, and consistently utilized during both the preconception and postpartum periods. Assuring adequate weight gain and smoking cessation along with accessing early prenatal care after an appropriate interpregnancy interval (at least 18 months) would result in significantly reduced rates of low birth weight in Colorado.

Recommendations for Providers, Policymakers, Childbearing-age Women, and Payors

The above discussion has included a number of strategies for impacting Colorado's low birth weight rate. A summary of solutions is outlined next, followed by a list of tasks that can be accomplished by particular constituent groups, such as health care providers, policymakers, childbearing-age women, and payors for health care services. All stakeholders must understand that low birth weight is a critical problem in Colorado that can be reduced through intervention/risk reduction.

Summary of Solutions

▲ Focus preconception planning, screening, and counseling on low birth weight risk reduction

The prevalence of each of the major population attributable risks (multiple births, inadequate weight gain, smoking, and premature rupture of the membranes) could be reduced during the preconception period. Information about the risks and benefits of assisted reproductive technology, including the risks and possible long-term problems associated with multiple birth, could reduce the incidence of higher order multiple births. Early identification of childbearing-aged women who are underweight, and increasing awareness of healthy eating habits prior to pregnancy are steps that can improve pre-pregnancy nutrition status. Preconception smoking cessation not only reduces potential fetal exposure to tobacco, but also allows utilization of pharmacologic approaches to assist women in achieving cessation. Pre-pregnancy identification of lower genital tract infections may reduce colonization of the upper genital tract and subsequent inflammation that could later result in preterm labor. Finally, promoting access to and consistent use of contraception can assist women in planning pregnancy and increasing the interpregnancy interval.

▲ Train providers in the Best Practices interventions to impact modifiable risk factors for low birth weight

Prenatal health care providers should be trained to provide culturally competent client education and counseling around weight gain, smoking cessation, and prevention of preterm birth and premature rupture of the membranes. Best Practices information should be easily accessible (practice guides/monographs, educational modules, Web-based materials, continuing education presentations) to assist providers in incorporating proven techniques.

What HEALTH CARE PROVIDERS can do about Low Birth Weight...

Emphasize that low birth weight is a critical problem that can be decreased through risk reduction.

Multiple Gestation

- ▼ Counsel couples about the risks, benefits, and treatment options for infertility
- ▼ Counsel women accessing assisted reproductive technology (ART) about the possible outcomes of ART, including the likelihood, risks, and potential long-term consequences of multiple birth

Inadequate Weight Gain

- ▼ Counsel about nutrition and weight issues prior to pregnancy
- ▼ Use the Institute of Medicine's Guidelines for Weight Gain during Pregnancy
- ▼ Calculate a pregnant woman's BMI and discuss target weight gain range during pregnancy, with special attention to teens and women who are underweight at the initial visit
- ▼ Counsel all pregnant women, utilizing culturally appropriate messages, about nutrition and weight gain during pregnancy
- ▼ Follow the woman's rate of weight gain and total amount of weight gained during pregnancy
- ▼ Refer women who are underweight before pregnancy to a registered dietitian at the first visit
- ▼ Refer women with inadequate weight gain to an registered dietitian by the second prenatal visit

Smoking

- ▼ Develop a personal commitment to helping child-bearing-age and pregnant women stop smoking
- ▼ Counsel all women about the health risks of smoking, including environmental tobacco smoke
- ▼ Assess readiness for quitting and encourage smoking cessation prior to pregnancy
- ▼ Ask every pregnant woman about her smoking status initially and at every prenatal encounter

- ▼ Implement a tobacco-user identification system in the prenatal record
- ▼ Inform women that cessation, not reduction, is associated with the best reduction in low weight births
- ▼ Provide, along with all other personnel who come into contact with pregnant women, a brief counseling session to promote smoking cessation at every prenatal and postpartum contact
- ▼ Use pregnancy-related motivational messages to enhance cessation
- ▼ Provide follow-up and pharmacologic therapy (as needed) to maintain postpartum smoking cessation
- ▼ Refer clients to case management/home visitation programs proven to assist in smoking cessation

Premature Rupture of the Membranes (PROM)

- ▼ Identify women at risk for preterm PROM
- ▼ Educate all pregnant women about the signs and symptoms of preterm labor
- ▼ Screen and treat pregnant women at risk for lower genital tract infections early in pregnancy
- ▼ Follow steps for preventing preterm birth from the Colorado Premature Birth Prevention Project

Entry into Prenatal Care

- ▼ Emphasize the importance of early prenatal care
- ▼ Schedule women for prenatal care in the first trimester of pregnancy

Interpregnancy Interval

- ▼ Promote access to and consistent use of contraception, including emergency contraception
- ▼ Emphasize the health benefits of increasing the interpregnancy interval to at least 18 months

What POLICYMAKERS can do about Low Birth Weight...

Communicate to the public that low birth weight is a critical problem in Colorado that can be decreased through risk reduction.

Multiple Gestation

- ▼ Convene a task force to study the implications of assisted reproductive technology (ART)
- ▼ Explore the feasibility of insurance coverage for ART

Inadequate Weight Gain

- ▼ Promote positive messages about weight and body image among adolescents
- ▼ Promote the use of the Institute of Medicine guidelines as the standard for nutrition counseling during pregnancy
- ▼ Support/direct the development of community education/social marketing campaigns to inform consumers about the importance of weight gain during pregnancy
- ▼ Advocate/support multidisciplinary approaches to prenatal care

Smoking

- ▼ Support/direct the development of community education/social marketing campaigns to inform consumers about the risks of smoking during pregnancy and environmental tobacco exposure
- ▼ Support/direct the development of a smoking cessation hotline to provide 24-hour, 7-day-per-week assistance and support for smokers trying to quit
- ▼ Support/promote the use of Best Practice recommendations for smoking cessation during pregnancy
- ▼ Support/advocate for multidisciplinary approaches to smoking cessation during pregnancy

Premature Rupture of the Membranes (PROM)

- ▼ Join in the efforts of the Colorado Premature Birth Prevention project to educate consumers about the risks and signs/symptoms of preterm labor
- ▼ Promote current Best Practice recommendations for preventing premature rupture of the membranes (PROM)

Entry into Prenatal Care

- ▼ Promote/support access to prenatal care for all women
- ▼ Support/direct efforts to raise the Medicaid eligibility rate for pregnant women

Interpregnancy Interval

- ▼ Support/direct the development of community education campaigns about the benefits of pregnancy spacing
- ▼ Support widespread access to contraception, including emergency contraception

What CHILDBEARING-AGE WOMEN can do about Low Birth Weight...

Realize that low birth weight is an important risk that can be reduced by adopting or maintaining a healthy lifestyle.

Multiple Gestation

- ▼ Seek comprehensive information about infertility treatment
- ▼ Become knowledgeable about the risks as well as the benefits of assisted reproductive technology and multiple birth

Inadequate Weight Gain

- ▼ Work to develop a healthy body image
- ▼ Be knowledgeable about body mass index (BMI) measurements and the amount of weight that should be gained during pregnancy
- ▼ Understand that weight must be gained during pregnancy in order to have a healthy baby
- ▼ Make a commitment to eat a healthy diet during pregnancy

Smoking

- ▼ Quit smoking prior to pregnancy
- ▼ Make a commitment to being smoke-free during and after pregnancy
- ▼ Be honest with providers about tobacco use prior to and during pregnancy
- ▼ Get partners and family members involved and committed to smoking cessation
- ▼ Seek assistance from providers and support systems for smoking cessation
- ▼ Avoid environmental tobacco smoke

Premature Rupture of the Membranes

- ▼ Request screening for lower genital tract infections early in pregnancy
- ▼ Be aware of the signs and symptoms of preterm labor

Entry into Prenatal Care

- ▼ Access prenatal care early in pregnancy

Interpregnancy Interval

- ▼ Make a commitment to consistently use contraception
- ▼ Plan pregnancy and wait at least 18 months between delivery and subsequent conception

What PAYORS can do about Low Birth Weight...

Support strategies that reduce the critical problem of low birth weight through risk reduction.

Multiple Gestation

- ▼ Reimburse infertility treatment, including assisted reproductive technology
- ▼ Work with providers to establish guidelines for assisted reproductive technology, including embryo transfer

Inadequate Weight Gain

- ▼ Encourage/reimburse multidisciplinary approaches to prenatal care

Smoking

- ▼ Inform enrollees about the risks of smoking and encourage cessation for all childbearing-age women
- ▼ Provide reimbursement to providers for smoking cessation counseling and follow-up
- ▼ Provide reimbursement for over-the counter pharmacologic therapy for smoking cessation

Premature Rupture of the Membranes

- ▼ Discuss guidelines for screening pregnant women for lower genital tract infections with providers
- ▼ Join the Colorado Premature Birth Prevention project to educate consumers about the risks and signs/symptoms of preterm labor
- ▼ Promote current Best Practice recommendations for preventing premature labor and birth

Interpregnancy Interval

- ▼ Provide reimbursement for all contraceptive methods
- ▼ Emphasize the importance of pregnancy planning and spacing

Conclusions

The problem of low birth weight in Colorado is significant. The state's low birth weight rate is one of the highest in the nation, and the rate has remained above the U.S. rate for the last fifty years. This report reveals that the major factors contributing to Colorado's high low birth weight rate are multiple births, inadequate weight gain, smoking, and premature rupture of the membranes; factors which can be altered. Solutions lie in promoting proven strategies to impact each one of these potentially treatable risk factors.

Solutions include decreasing the incidence of multiple gestation by reducing the likelihood that assisted reproductive techniques will result in multiple births; assuring that all pregnant women have appropriate nutrition information and monitoring to gain an adequate amount of weight; assisting all women to stop smoking prior to conception or during pregnancy; ensuring that all pregnant women at risk for lower genital tract infections are screened and treated early in pregnancy; and increasing client awareness of the signs and symptoms of preterm labor.

Statewide commitment to proven strategies can result in a significant decrease in the low birth weight rate in Colorado.

Health care providers, policymakers, childbearing-age women, and payors all have a role to play in reducing Colorado's low birth weight rate. All must realize that low birth weight is a critical problem that can be decreased through risk reduction. Solutions are at hand, which require putting into practice on a broad scale the recommendations discussed in this report. Statewide commitment to these strategies, supported by all stakeholders, can result in a decrease in the low birth weight rate in Colorado to a level close to the Healthy People 2000/2010 goal of 5.0 percent.

Low birth weight is a critical problem in Colorado that can be reduced through intervention and risk reduction.

Appendix B

Year	Total Births	Total Multiple Births	Percent Multiple Births	Total LBW Births	LBW Multiple Births	Percent LBW Multiple Births
1975	40,148	763	1.9%	3,622	476	13.2%
1980	49,716	945	1.9%	4,090	534	13.1%
1985	55,115	1,166	2.1%	4,257	654	15.4%
1990	53,491	1,246	2.3%	4,286	731	17.1%
1995	54,310	1,641	3.0%	4,613	973	21.1%
1996	55,779	1,730	3.1%	4,941	1,072	21.7%
1997	56,505	1,729	3.1%	5,014	1,056	21.1%

In 1975, there were a total of 763 multiple births to Colorado residents. In 1997, the number had grown to 1,729, an increase of 127 percent. During that time period, the number of births in the state increased from 40,148 to 56,505, an increase of 41 percent.

Multiple births comprised 1.9 percent of all births in 1975 and 1980. During the following decade, the proportion grew to 2.3 percent. After 1990, the proportion grew rapidly to 3.0 percent in 1995 and 3.1 percent in 1996 and 1997.

The number of low weight births in the state in 1975 was 3,622, of which 476, or 13.2 percent, were multiple births. By 1997, the number of low weight births had increased by 38 percent to 5,014, and the number of LBW multiple births had grown to 1,056, an increase of 122 percent.

In 1975 in Colorado, only one of every eight low weight births was a multiple birth, i.e., a twin (or triplet or quadruplet). In 1997 and 1998, more than one out of every five low weight births was a multiple birth.

Appendix C

Institute of Medicine Recommendations for Total Weight Gain During Pregnancy

To determine the recommended weight gain for pregnant women, the Institute of Medicine's National Academy of Sciences Subcommittee on Nutritional Status and Weight Gain During Pregnancy uses body mass index (BMI) as the standard for weight-for-height categories.

All women, regardless of race or age, should follow the weight gain recommendations listed below:

Pre-pregnancy BMI	Recommended Total Weight Gain
Low < 19.8	28–40 pounds
Normal = 19.8–26.0	25–35 pounds
High = 26.1–29.0	15–25 pounds
Obese > 29.0	15 pounds

Recommendations for Rate of Weight Gain During Pregnancy

Use an appropriate weight gain chart to show the range and rate of weight gain recommended.

Prepregnancy BMI	Recommended Rate of Weight Gain
Low < 19.8	Slightly more than 1 pound/week
Normal = 19.8–26.0	Approximately 1 pound/week
High = 26.1–29.0	$\frac{2}{3}$ pound/week

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There would be at least 2,000 fewer low weight births in Colorado each year if all pregnant women gained weight adequately, no pregnant women smoked, all pregnant women began care early, and no women experienced short interpregnancy intervals.



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