Infant Mortality in Colorado

Trends, 1990-2002
Perinatal Periods of Risk Analysis, 1997-2002
Infant Mortality Rate 2010 Goals
County Starting Point Worksheets by Perinatal Periods of Risk Category

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Introduction

In the last decade, the rate of Colorado infants dying in the first year of life declined dramatically. The rate decreased from 8.8 deaths per 1,000 births in 1990 to 6.0 deaths per 1,000 births in 2002, resulting in approximately 400 deaths among some 68,000 births each year. But many of these deaths are preventable, and it is fully possible for infant mortality to be further reduced. *Healthy People 2010*, published by the US Department of Health and Human Services, established a set of national objectives for health in many areas, including infant mortality. Nationally, every effort is being made to reduce infant mortality in the United States to 4.5 deaths per 1,000 births by the year 2010. With a rate in Colorado of 6.0 in 2002, an additional reduction of 1.5 deaths per 1000 births seems small. However, the desired decline would decrease the number of infant deaths by 100 annually (25 percent). Such a change presents an immense challenge.

The Colorado Department of Public Health and Environment is committed to achieving a rate of 4.5 statewide by the year 2010. This report is part of a major effort by the Maternal and Child Health Program, Prevention Services Division, to describe the pattern of infant mortality, to delineate contributing factors, and to outline strategies for reducing the rate. In 2003, the department analyzed infant mortality data from 1990 through 2002. This analysis was made possible through the services of an intern supported by the Maternal and Child Health Bureau under the Graduate Student Intern Program.

This report contains information about infant, neonatal and postneonatal mortality in Colorado, presented for the state as a whole, for major racial and ethnic subgroups of the population, and for the state's largest counties. Additional analysis was performed using the Perinatal Periods of Risk (PPOR) model, which further breaks down the components contributing to infant mortality, including fetal deaths, and suggests modes of intervention. This model allows for an in-depth analysis of infant and fetal deaths from 1997 through 2002 across the state. Finally, additional survey and vital statistics data are presented for each of the large counties, further highlighting risk behaviors and potential interventions.

Recommendations are presented according to the categories outlined in the PPOR model: Maternal Health/Prematurity, Maternal Care, Newborn Care, and Infant Health. These recommendations vary by county. The numbers of mothers and infants affected are included so that local county health departments can begin to establish interventions to reduce risks. For example, agencies may attempt to reduce the number of unintended pregnancies, or to provide smoking cessation programs to pregnant women.

A reduction in the infant mortality rate of 25 percent, from 6.0 to 4.5, is anticipated between 2002 and 2010 as a result of focused interventions implemented to address areas prioritized in the PPOR analysis. Although these efforts will require intensive work at the local level, such a reduction can be attained.

Methods

The data used in this report are principally derived from birth and infant death certificates for the period 1990 through 2002. Other information, such as the survey data from the Pregnancy Risk Monitoring System (PRAMS), was compiled using the Colorado Health Information Dataset (CoHID) available at www.cdphe.state.co.us/cohid/. In addition, some of the analysis required access to the linked birth and death certificates files from the Colorado Department of Public Health and Environment Vital Statistics Section, and use of the statistical analysis software package SAS.

The descriptive data analysis primarily focuses on how infant mortality rates changed between 1990 and 2002. Initial investigation of births and deaths reveals the rates of infant mortality, which were then classified into neonatal and postneonatal deaths. Because Sudden Infant Death Syndrome (SIDS) previously exerted such immense impact on postneonatal mortality rates, further analysis was performed to distinguish the frequency of deaths related to SIDS. A series of factors, including race/ethnicity of the mother, country of birth of Hispanic women, and residence based on a particular region in the state were then utilized to calculate rates of infant mortality for these subgroups.

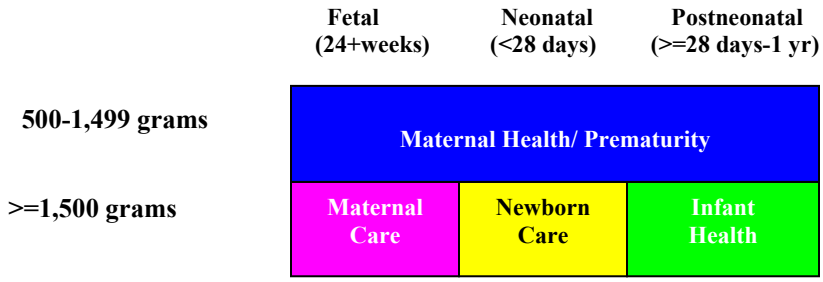
The state of Colorado was divided into 14 population-based regions--nine counties and five regions--in order to calculate county or regional rates. Counties with the largest populations, Denver, Jefferson, Boulder, Adams, Arapahoe, El Paso, Larimer, Pueblo, and Weld, were considered separately and individually, while the rest of the counties are divided as follows:

- Northwest Region: Garfield, Mesa, Moffat, and Rio Blanco
- Western Region: Delta, Eagle, Grand, Gunnison, Hinsdale, Jackson, Montrose, Ouray, Pitkin, Routt, San Miguel, and Summit.
- Eastern Region: Baca, Bent, Cheyenne, Crowley, Elbert, Kiowa, Kit Carson, Lincoln, Logan, Morgan, Otero, Phillips, Prowers, Sedgwick, Washington and Yuma
- Central Region: Chafee, Clear Creek, Custer, Douglas, Fremont, Gilpin, Lake, Park, and Teller
- Southern Region: Alamosa, Archuleta, Conejos, Costilla, Dolores, Huerfano, La Plata, Las Animas, Mineral, Montezuma, Rio Grande, Saguache, and San Juan.

Once an initial analysis of infant, neonatal, and postneonatal mortality was completed by county or region in Colorado, a further review was undertaken, using the Perinatal Periods of Risk (PPOR) approach as defined by the Centers for Disease Control, CityMatCH, March of Dimes, and the Maternal and Child Health Bureau. The PPOR approach requires the analysis of fetal mortality in addition to infant mortality, and classifies deaths by weight (below or at or above 1,500 grams) and by when they occurred (during pregnancy, the neonatal or postneonatal period). This approach provides a more detailed analysis of mortality utilizing a variety of risk factors including maternal behavior. Ultimately, the methodology can assist communities in the development and implementation of locally derived prevention strategies that will result in an overall reduction in fetal-infant mortality rates at the community level.

The steps involved in determining values in each of the PPOR categories (Maternal Health, Maternal Care, Newborn Care, and Infant Health) include "mapping" the deaths to the four different cells based on the age at the time of death and the birth weight as shown in Figure 1 below.

Fig. 1 Perinatal Periods of Risk Map of Fetal and Infant Deaths



The study population was identified by thoroughly analyzing linked birth and infant death certificate data for the period between 1997 and 2002. The data included live births and infant deaths with a birth weight of 500 grams or greater and fetal deaths of at least 24 weeks gestation with a birth weight of 500 grams or more. While it is recommended that the most recent data be analyzed in time intervals of three years, we used six years of data, from 1997 to 2002, so that more counties and regions in Colorado could meet the inclusion criteria of at least 60 fetal and/or infant deaths with a frequency of at least 10 in each of the categories listed above. The rates were then compared to a predetermined Colorado reference group (see below) to calculate the excess mortality for each county or region.

The counties in Colorado that had enough births and fetal deaths based on the inclusion criteria were Adams, Arapahoe, Boulder, Denver, El Paso, Jefferson, Larimer, Mesa, Pueblo, and Weld. The counties of Eagle, Garfield, Lake, Pitkin, and Summit, considered together, had the requisite number and were grouped to make up the Mountain West region. Similarly, Logan, Morgan, Phillips, Sedgwick, Washington, and Yuma counties (the Northeast Region) qualified together.

The population with the most optimal birth outcomes, defined as Colorado White non-Hispanic women, 20 years or older, with at least 13 years of education, served as the reference group for the period 1997-2002. Comparison with the reference group demonstrates the magnitude of the infant mortality problem and potential etiologies to be considered when developing prevention strategies. Each county is compared to the reference group to show both the overall feto-infant excess mortality as well as the category/cell-specific excess mortality. The comparisons reflect which cells contribute most to the feto-infant mortality rate. Furthermore, these rates can be compared over time for the same populations to detect trends.

The results of the PPOR approach offer insight into the factors contributing to infant mortality in Colorado, in addition to providing suggestions for interventions to assist with reduction. Tables A, B, C, and D in this report include additional information from

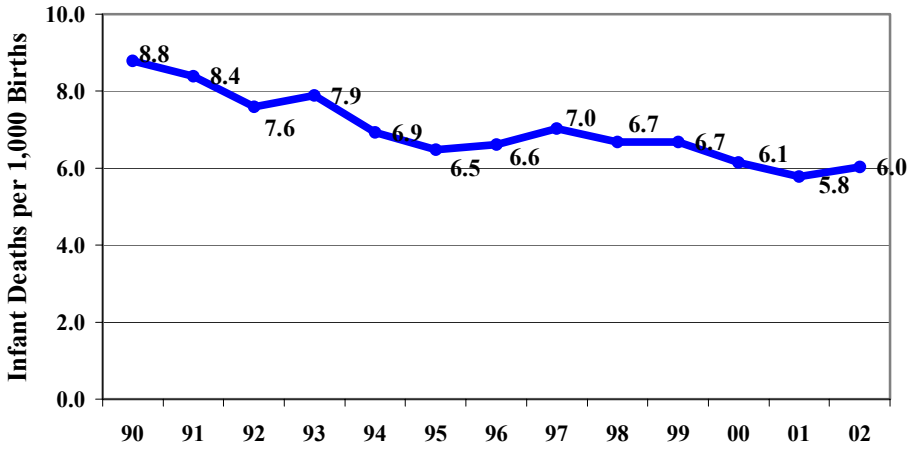
available county-level Vital Statistics and Pregnancy Monitoring Assessment System (PRAMS) survey data. The topics shown include areas that may be amenable to intervention. An analysis of these data will make it possible for county health officials to look at infant and fetal mortality in the context of specific maternal and infant risk factors. An examination of behavior prior to and during pregnancy, access to health care services, and unintentional injury rates are a few of the promising avenues for intervention available for reducing infant mortality.

Colorado Trends, 1990-2002

Infant Mortality

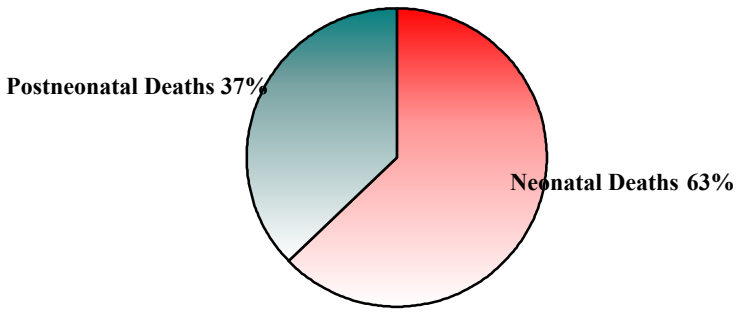
The infant mortality rate has steadily declined since 1990, from 8.8 deaths per 1,000 births, to 6.0 deaths in 2002 (Figure 2). State vital statistics show a decline from 470 deaths among 53,491 births in 1990 to 413 deaths among 68,420 births in 2002. Much of the decline occurred in the first half of the decade, but the lowest rates are found in the most recent three years.

Fig. 2 Infant Mortality in Colorado by Year, 1990-2002



Neonatal death rates have the greatest influence on the infant mortality rate, contributing approximately 63 percent of all infant deaths in Colorado during the 12-year period (Figure 3). Neonatal deaths take place prior to the 28th day of life.

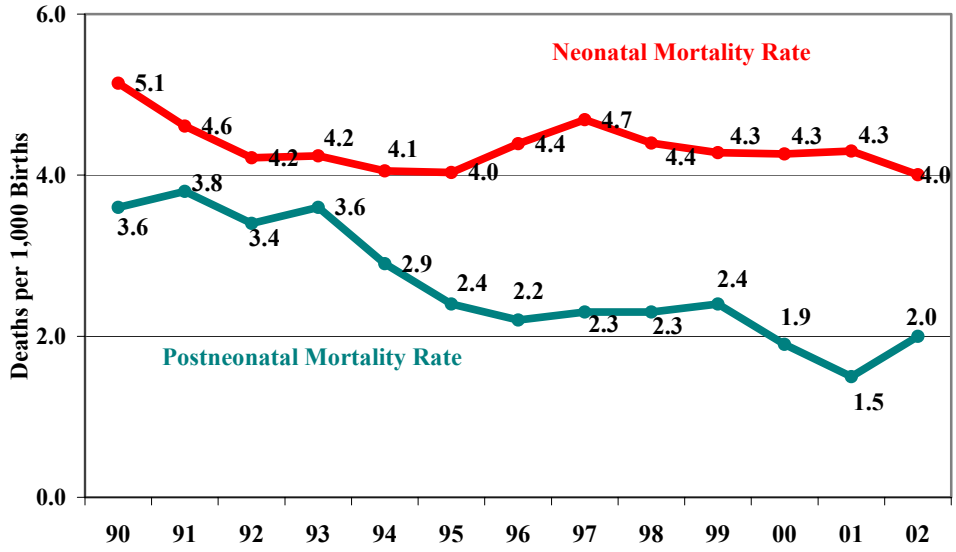
Fig. 3 Infant Mortality in Colorado by Period of Death 1990-2002



The neonatal mortality rate has fluctuated over time, with the lowest reported rate in 2002 of 4.0 deaths per 1,000 births, compared to 5.1 in 1990 (Figure 4). The postneonatal mortality rate (deaths age 28 days to one year), on the other hand, has consistently

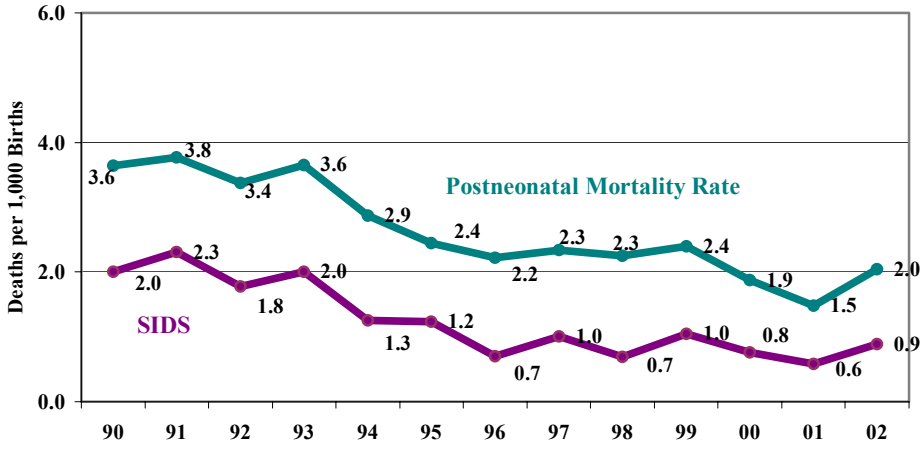
declined over the entire period. In 2002, the postneonatal mortality rate was 2.0 deaths per 1,000 births, down from 3.6 in 1990.

Fig. 4 Neonatal and Postneonatal Mortality Rates in Colorado by Year, 1990-2002



It appears that the reduction in the Sudden Infant Death Syndrome (SIDS) rate dramatically influenced the decline in postneonatal mortality (Figure 4). Since 1990, the rate of SIDS in Colorado has been reduced from 2.0 to 0.9 deaths per 1,000 births, with the sharpest one-year decline occurring between 1993 and 1994. The rates have remained at 1.0 or less since 1996. This is likely a result of the initiation of the "Back to Sleep" Campaign in the same time period, following the American Academy of Pediatrics recommendations first released in 1992.

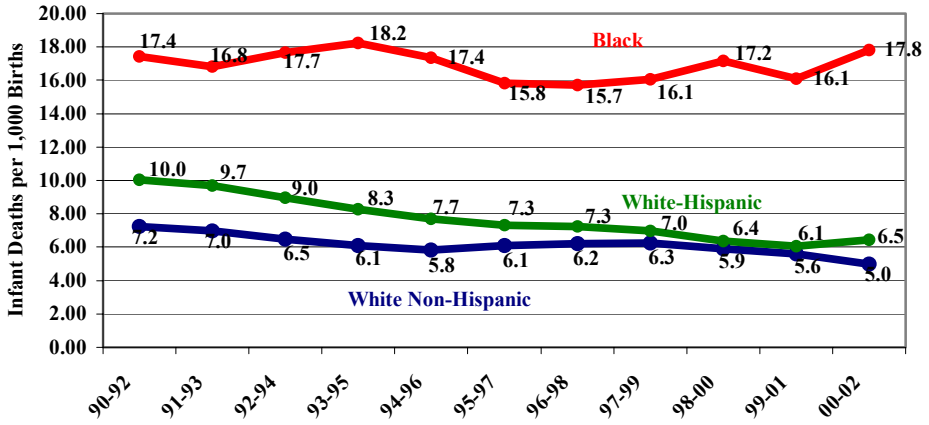
Fig. 5 Postneonatal Mortality Rates and SIDS Rates in Colorado by Year, 1990-2002



Infant Mortality by Race/Ethnicity

Infant mortality rates are sharply higher among Black infants than among White Hispanic or White non-Hispanic populations (Figure 6). Rates for other racial groups are not shown, since they comprise fewer than 2 percent of all infant deaths. Deaths among both White subgroups show a general pattern of decline between 1990-1992 and 2000-2002.[1] However, the Black infant mortality rate was consistently double the White Hispanic rate, and was more than triple the White non-Hispanic rate at the end of the decade. The Black rate shows little change over the 12-year period, with the 2002 rate of 17.8 virtually identical to the 1990 rate of 17.4.

Fig. 6 Colorado Infant Mortality Rate by Race/Ethnicity
1990-1992 to 2000-2002, 3 Year Averages



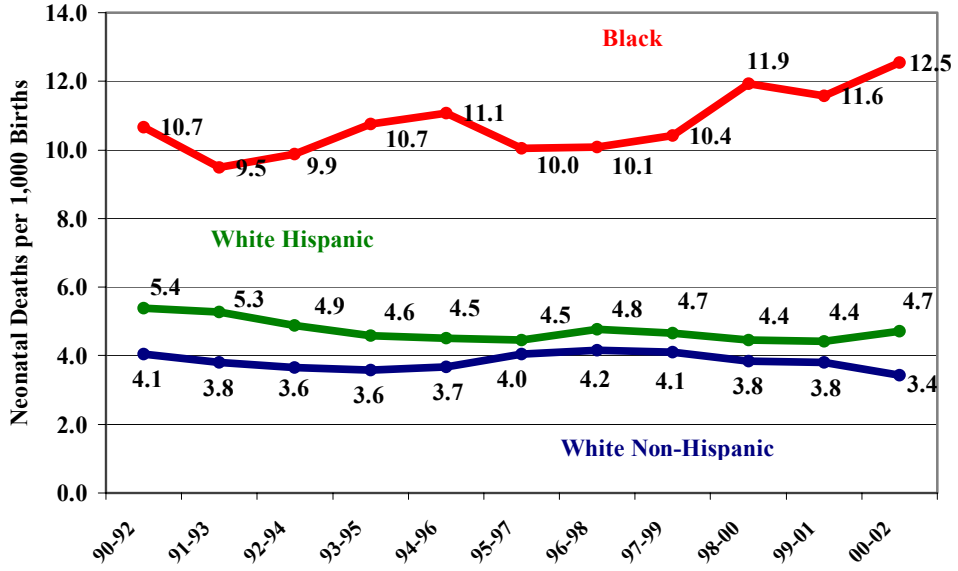
The White Hispanic rate declined by 35 percent, from 10.0 in 1990-1992 to 6.5 in 2000-2002. At the same time, the White non-Hispanic rate declined from 7.2 to 5.0, a drop which resulted in a rate in 2002 that is relatively close to the Healthy People 2010 goal of 4.5.

Neonatal Mortality by Race/Ethnicity

The neonatal mortality rate is the major component of the infant mortality rate in Colorado. Of the 5,115 infant deaths from 1990 through 2002 in the three major racial/ethnic groups, 3,201 occurred during the neonatal period. Neonatal mortality rates are highest among Blacks and are markedly lower among White Non-Hispanics and White Hispanics (Figure 7). Three-year averages show an overall increase over time among Blacks, with the highest rate of 12.5 deaths per 1,000 births for 2000-2002, compared to the lowest rate of 9.5 in 1991-1993. The rates of White non-Hispanics and Hispanics remained consistent around 4.0 and 5.0 respectively, resulting in slightly lower levels in 2002 than those experienced in 1990.

[1] Three-year average rates are provided for racial and ethnic subgroups to minimize fluctuations in annual rates due to small numbers.

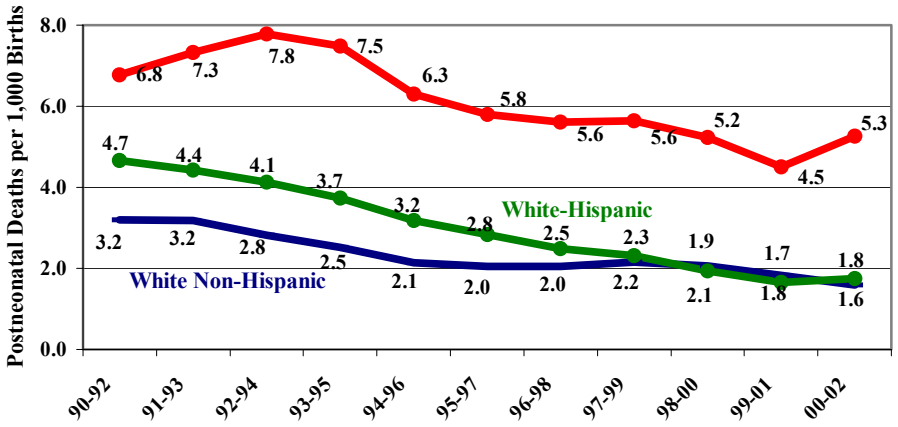
Fig. 7 Colorado Neonatal Mortality Rates by Race/Ethnicity
1990-1992 to 2000-2002, 3 Year Averages



Postneonatal Mortality by Race/Ethnicity

Postneonatal deaths have declined for Blacks, White Hispanics, and White non-Hispanics since 1990, and rates in 2002 are the lowest ever experienced by any of the population subgroups (Figure 8). While White non-Hispanic and Hispanic rates may be gradually approaching the Healthy People 2010 goal of 1.2 deaths per 1,000 births, the Black rate remains at a distinctly higher level of 5.3 in 2000-2002.

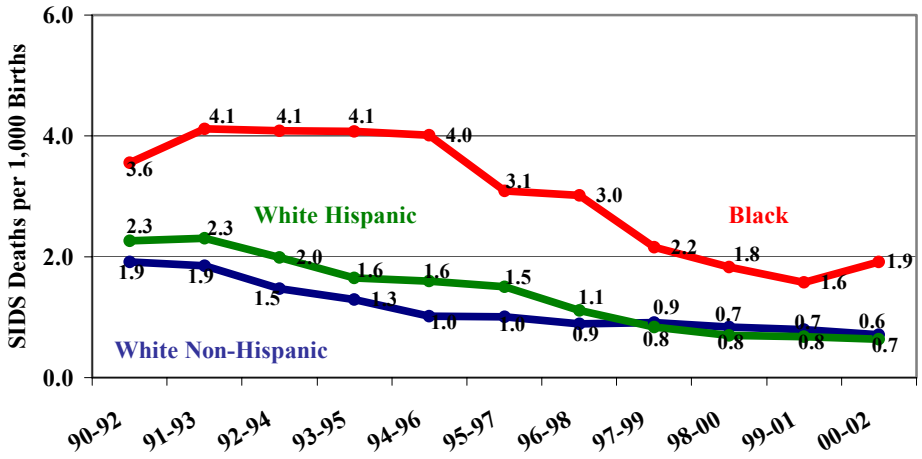
Fig. 8 Colorado Postneonatal Mortality Rates by Race/Ethnicity
1990-1992 to 2000-2002, 3 Year Averages



Because SIDS exerted a great influence on postneonatal death rates in the past, further analysis of the rates of SIDS by race/ethnicity was conducted (Figure 9). The greatest

decline in SIDS rates for each of the three racial/ethnic groups occurred around 1993-1997. A particularly sharp drop occurred among Blacks between 1994-1996 and 1995-1997. In 1990-1992, 53 percent of Black, 49 percent of White Hispanic, and 60 percent of White non-Hispanic postneonatal deaths were attributed to SIDS. These proportions declined to 36 percent for Blacks, 33 percent for White Hispanics, and 44 percent for White non-Hispanics in 2000-2002.

Fig. 9 Colorado SIDS Rates by Race/Ethnicity
1990-1992 to 2000-2002, 3 Year Averages

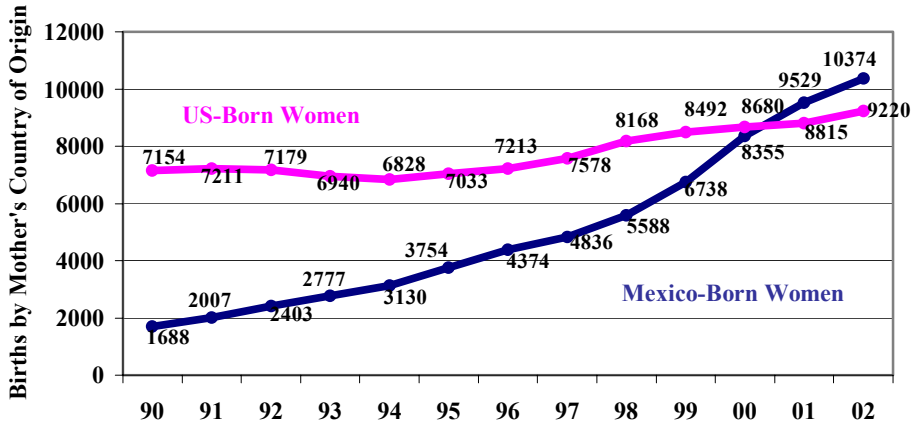


Classification of Hispanics by Mother's Country of Origin

In Colorado, the term "Hispanic" is used to refer to people from Mexico, Central America, South America, Puerto Rico, Cuba, or the United States. But the category does not provide an adequate picture of the different cultural groups that are included within this broad classification. We have therefore broken the category into two subgroups according to the birthplace of the mother. Because over 95 percent of the Hispanic births are to women who were born in either the United States or in Mexico, these two distinct groups, according to the mother's country of origin, were chosen for review and analysis.

Since 1990, the number of births to Hispanic women has steadily increased, but the most rapid growth occurred among births to women who themselves were born in Mexico (Figure 10). Births to Mexico-born Hispanic women grew from 1,688 to 10,374 from 1990 to 2002, while births to U.S.-born Hispanic women grew from 7,154 to 9,220. Births to Mexico-born Hispanic women now comprise the majority of all Hispanic births in Colorado. In 1990, only 1 in 5 Hispanic births was to a mother who had been born in Mexico, whereas in 2002, this proportion increased to 1 in 2 Hispanic births.

Fig. 10 Colorado Hispanic Births of US-Born and Mexico-Born Hispanic Women by Year, 1990-2002



Revealing the infant mortality experience of these two groups of Hispanic women, Figure 11 shows that US-born Hispanic women have experienced higher infant mortality rates than Mexico-born women. US-born Hispanic women's highest rates were in the early 1990's, but have since fallen and leveled off at a rate of 6.9 deaths per 1,000 births in 2002. Mexico-born women had rates above 4.0 between 1990 and 1993, rates slightly lower in the middle of the decade, and rates at a level greater than 5.0 since 1997. At the beginning of the decade the mortality gap between the two groups was much larger than the current difference. The overall mortality rate for US-born Hispanic women, however, still exceeds the rate for women born in Mexico.

Fig. 11 Colorado Infant Mortality Rates of US-Born and Mexico-Born Hispanic Women 1990-1992 to 2000-2002, 3 year averages

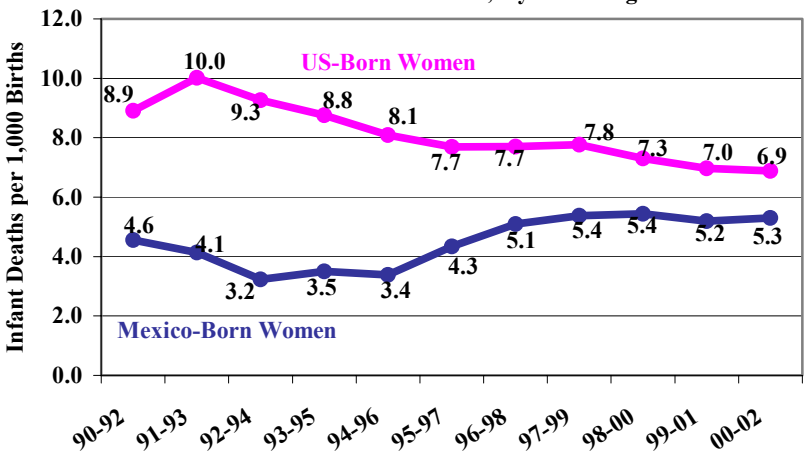
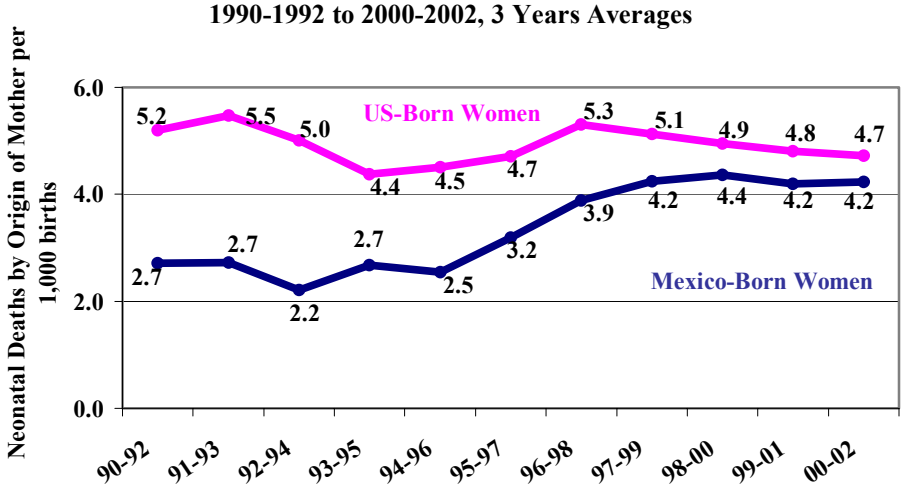


Figure 12 shows that the neonatal mortality rate increased each year for Mexico-born Hispanic women since 1994-1996, reaching the highest rate of over 4.0 deaths per 1,000

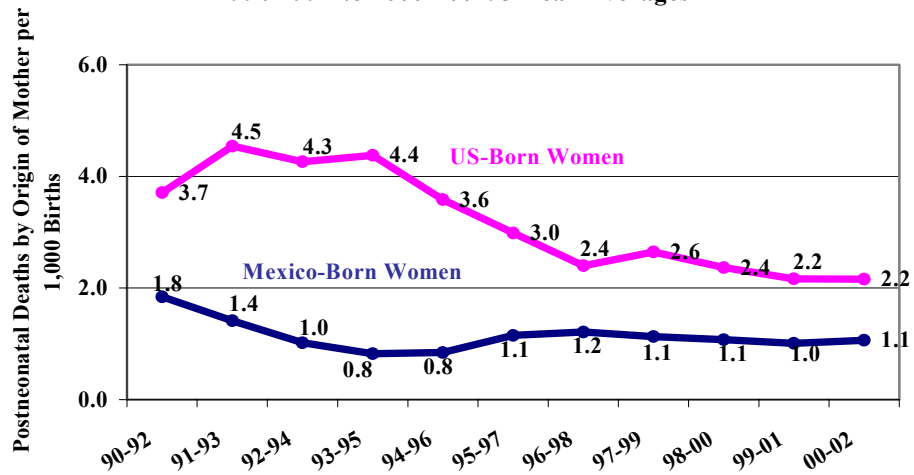
births since 1997-1999. While US-born Hispanic women overall have had higher rates of neonatal mortality compared to Mexico-born women, the rates have been decreasing since 1996-1998, and currently the rates for the two groups are very close.

Fig. 12 Colorado Neonatal Mortality Rates of US-Born and Mexico-Born Hispanic Women 1990-1992 to 2000-2002, 3 Years Averages



The postneonatal rate for all White Hispanics has gradually declined since 1990-1992 from 4.7 deaths per 1,000 births to 1.8 (Figure 8, page 8). During this period of time, however, the rates of U.S.-born women have been as much as three times greater than those of Mexico-born women (Figure 13). In 2000-2002, the postneonatal rate for U.S. born women was 2.2, two times higher than the level of 1.1 among women born in Mexico. It is important to note that the Healthy People 2010 goal for postneonatal mortality is 1.2, a level that has been met by the immigrant group.

Fig. 13 Colorado Postneonatal Mortality Rates for US-Born and Mexico-Born Hispanic Women 1990-1992 to 2000-2002. 3 Year Averages



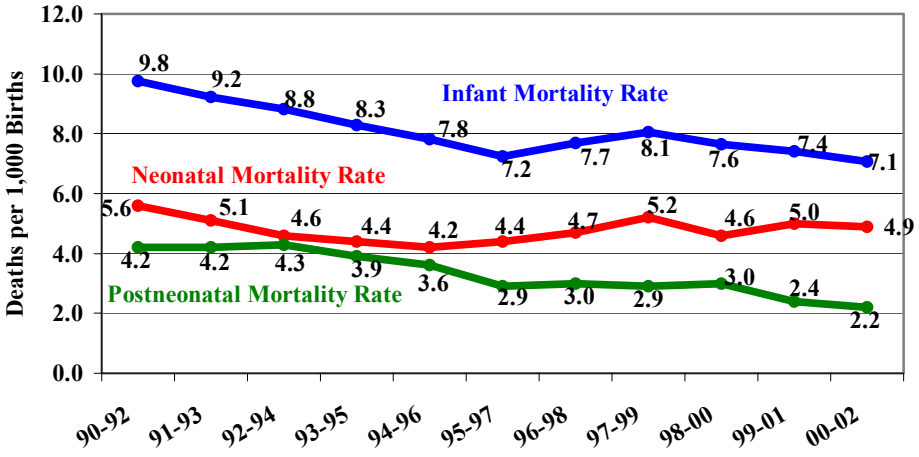
Infant Mortality by County or Region

An analysis of infant mortality for individual counties and regions in Colorado follows. The analysis is limited to the counties with the largest populations in the state, while smaller counties are grouped into regions (see page 2 for specific groupings). Infant mortality rates have fluctuated since 1990 in each of Colorado's largest counties and regions.

Adams County:

The infant mortality rate in Adams County fell from 9.8 in 1990-1992 to 7.1 in 2000-2002, a substantial overall decline. The neonatal mortality rate ended the period only slightly below the 5.6 1990 level, and demonstrates increases since the middle of the decade. The rates of postneonatal mortality, on the other hand, have decreased by nearly 50 percent since 1990, to the lowest rate of 2.2 in 2000-2002.

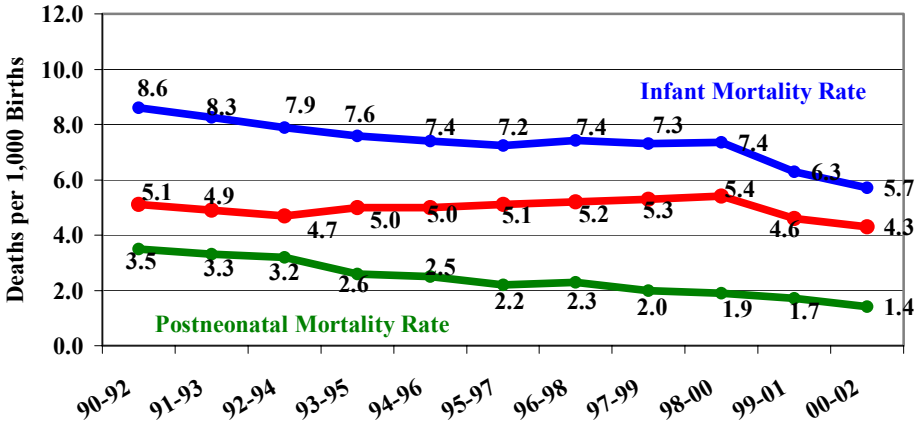
Fig. 14 Infant, Neonatal and Postneonatal Rates for Adams County 1990-1992 to 2000-2002, 3 Year Averages



Arapahoe County:

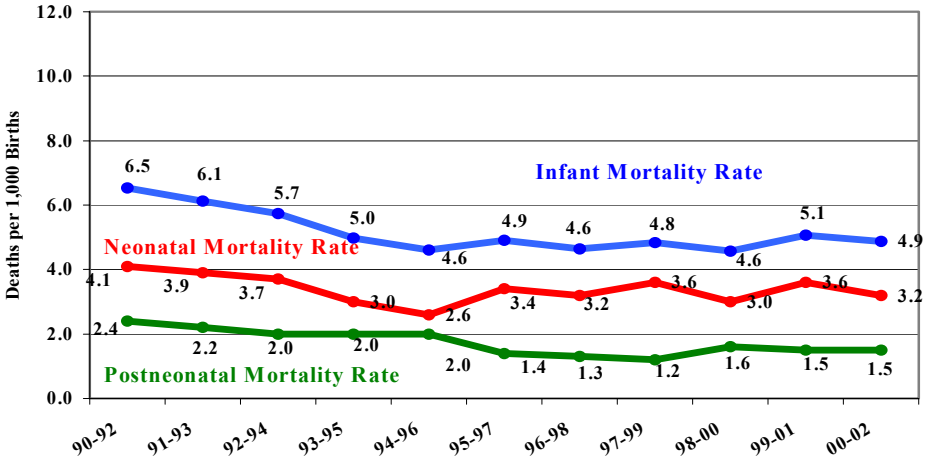
Infant mortality rates stayed above 7.0 deaths per 1,000 births until 1998-2000, before declining to 6.3 in 1999-2001 and 5.7 in 2000-2002. Although the postneonatal rates have slowly declined over time, from a high of 3.5 at the beginning of the period to a low of 1.4 in 2000-2002, the neonatal mortality rates remained essentially unchanged until 1998-2000, after which they dropped sharply to 4.3.

Fig. 15 Infant, Neonatal and Postneonatal Rates for Arapahoe County 1990-1992 to 2000-2002, 3 Year Averages



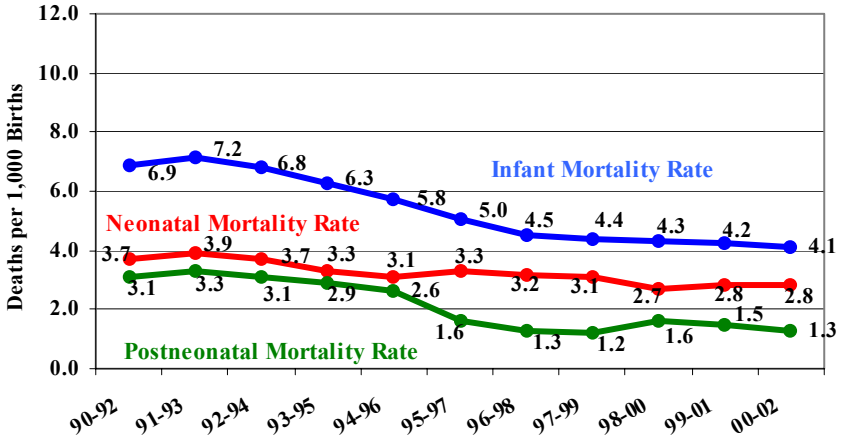
Boulder County:
Infant mortality in Boulder County has decreased by 25 percent since 1990-1992, consistently remaining between 4.6 and 5.1 deaths per 1,000 births since 1994-1996. Postneonatal mortality dropped by 50 percent in the mid-1990's to as low as 1.2, but increased to 1.5 by the end of 2002. Neonatal mortality shows a long-term downward trend until 1994-1996, but has actually increased since the mid-1990's.

Fig. 16 Infant, Neonatal and Postneonatal Rates for Boulder County 1990-1992 to 2000-2002, 3 Year Averages



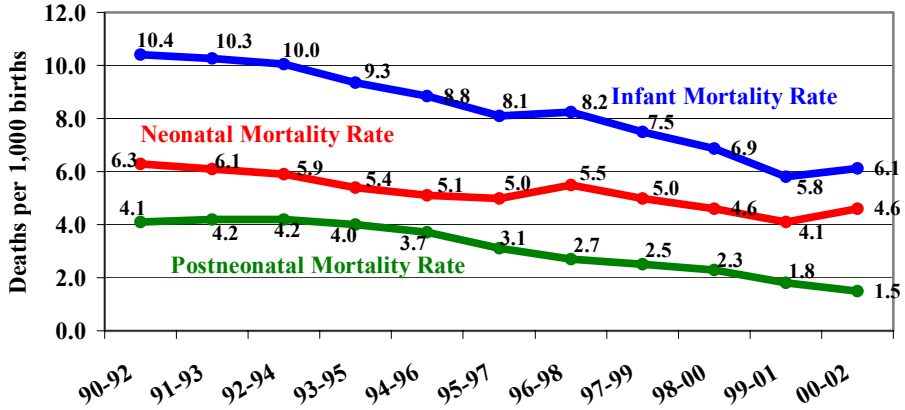
Central Region (Chaffee, Clear Creek, Custer, Douglas, Fremont, Gilpin, Lake, Park, and Teller counties):
The infant mortality rate peaked at 7.2 in 1991-1993 before rapidly and steadily decreasing to 4.1 in 2000-2002. The infant mortality rate reached the Healthy People 2010 goal of 4.5 deaths per 1,000 births in 1996-1998 and has remained consistently lower than the objective since that time. The neonatal infant mortality rate of the Central Region fell below the Healthy People 2010 goal of 2.9 per 1,000 in 1998-2000, while the postneonatal rate dropped in the mid-1990s to levels fairly close to or at the Healthy People 2010 goal of 1.2.

Fig. 17 Infant, Neonatal and Postneonatal Rates for the Central Region 1990-1992 to 2000-2002, 3 Year Averages



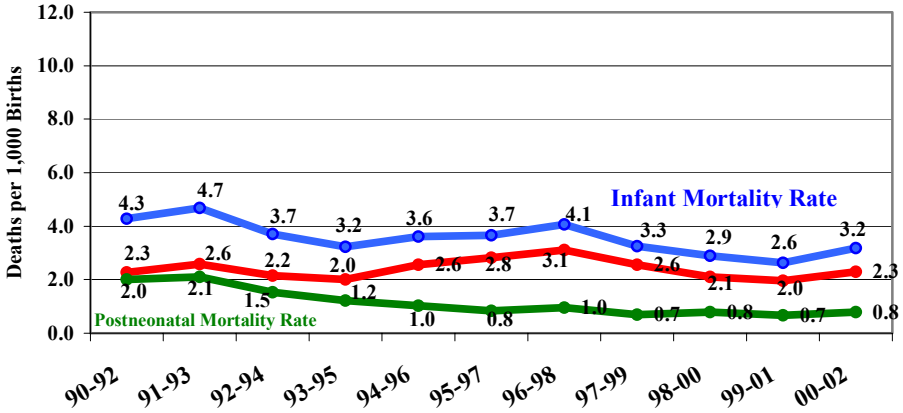
Denver County: The infant mortality rate declined by 40 percent between 1990-1992 and 2000-2002, from 10.4 deaths per 1,000 to 6.1. The reduction in infant mortality is mostly due to a major drop in postneonatal mortality rates starting in 1994-1996. While postneonatal rates were above 4.0 in the early 1990's, the rate reached an all-time low of 1.5 deaths per 1,000 births by 2002. The neonatal mortality rate shows a gradual pattern of decline over the period, with a slight uptick in 1996-1998. The present level of neonatal deaths is 4.6 per 1,000 births in 2000-2002.

Fig. 18 Infant, Neonatal and Postneonatal Rates for Denver County 1990-1992 to 2000-2002, 3 Year Averages



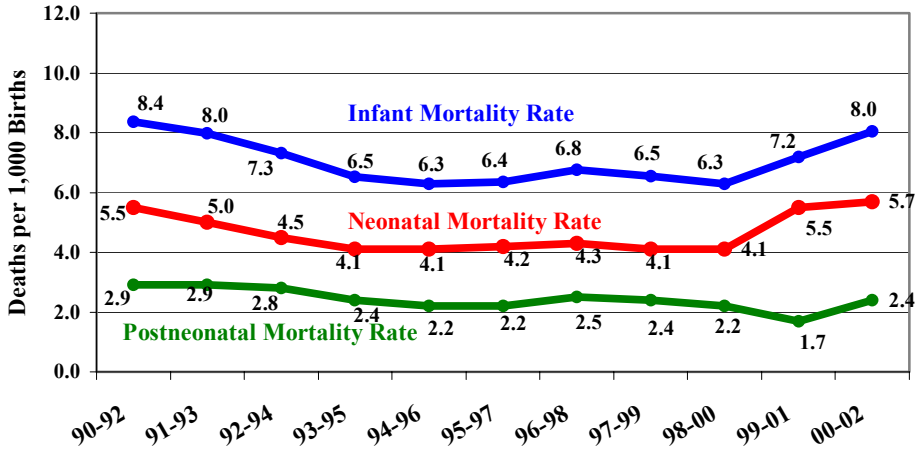
Douglas County: As the only large county in Colorado that has met all the Healthy People 2010 goals for infant (4.5), neonatal (2.9), and postneonatal (1.5) mortality rates beginning with the period 1997-1999, Douglas continues to show a pattern of declining mortality. The neonatal rate has varied over time, but has been below the Healthy People 2010 goal since 1997-1999. The postneonatal mortality rate, at its highest level in 1990-1992, dropped early in the decade and has remained well below 1.0 death per 1,000 births since 1998-2000.

Fig. 19 Infant, Neonatal, and Postneonatal Rates for Douglas County 1990-1992 to 2000-2002, 3 Year Averages



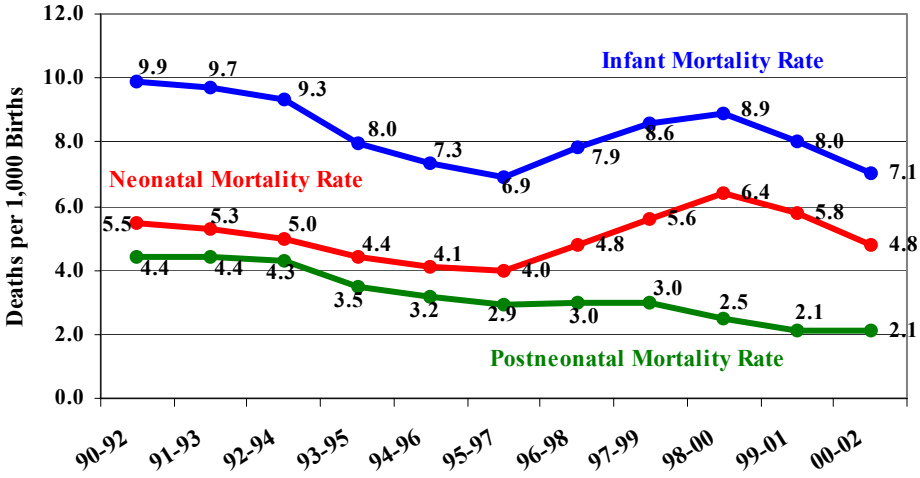
Eastern Region (Baca, Bent, Cheyenne, Crowley, Elbert, Kiowa, Kit Carson, Lincoln, Logan, Morgan, Otero, Phillips, Prowers, Sedgwick, Washington and Yuma counties): The Eastern Region presents a pattern of infant mortality that is clearly different from most other areas. In spite of declines in the early 1990's, the region's infant and neonatal mortality rates have climbed since 1998-2000, ending the period at levels comparable to or higher than those reported in 1990-1992. The postneonatal rate has fluctuated at around 2.0 deaths since the mid-1990s, and does not appear to be following the long-term downward trend found in most other counties of the state.

Fig. 20 Infant, Neonatal and Postneonatal Rates for the Eastern Region 1990-1992 to 2000-2002, 3 Year Averages



El Paso County: Rates of infant mortality have fluctuated considerably over the period, from 9.9 in 1990-1992 to as low as 6.9 in 1995-1997 before climbing back up to 8.9 in 1998-2000. Rates then fell to 7.1 deaths per 1,000 births in 2000-2002. Neonatal deaths, accounting for over one-half of the infant deaths, were at a low of 4.0 in 1995-1997. Since then, a rate of 6.4 deaths was reached in 1998-2000, followed by a decline to 4.8 in 2000-2002. The postneonatal mortality rate followed a steady decline throughout the decade, ending at 2.1 in 2000-2002, less than half the level of 4.4 found in 1990-1992.

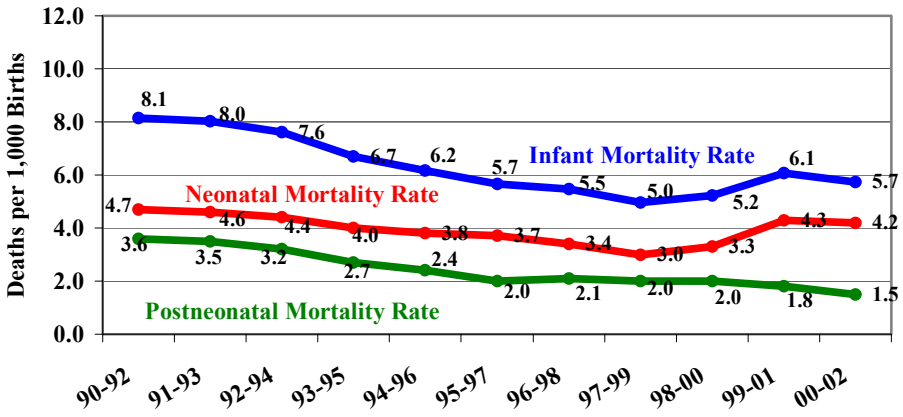
Fig. 21 Infant, Neonatal and Postneonatal Rates for El Paso County 1990-1992 to 2000-2002, 3 Year Averages



Jefferson County:

The infant mortality rate dropped quickly after 1990-1992, from 8.1 to 5.0 by 1997-1999. Since then the overall rate increased to 6.1 in 1999-2001 before declining to 5.7 deaths per 1,000 births in 2000-2002. Neonatal mortality appears to be contributing more to the overall infant death rate in recent years than at the beginning of the 1990's. The lowest neonatal rate of 3.0 in 1997-1999 gradually increased after that period before leveling off at 4.2 deaths per 1,000 births in 2000-2002. The postneonatal mortality rates are similar to other regions of the state, with the highest rates found in the early 1990's, and a general decline in rates occurring during the decade.

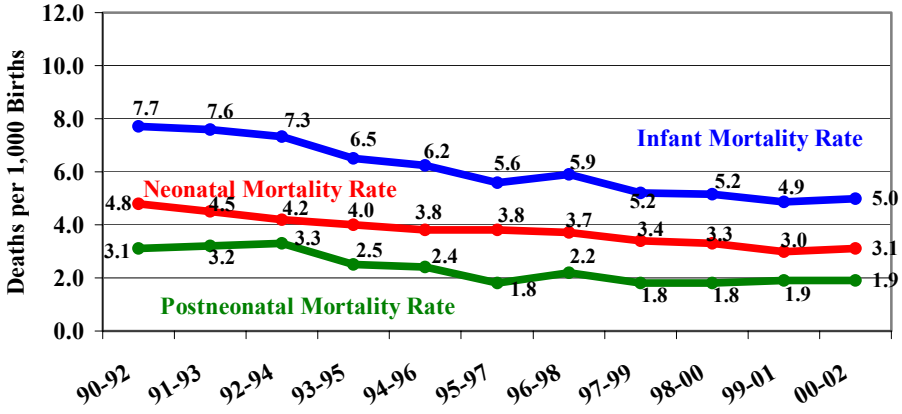
Fig. 22 Infant, Neonatal and Postneonatal Rates for Jefferson County 1990-1992 to 2000-2002, 3 Year Averages



Larimer County:

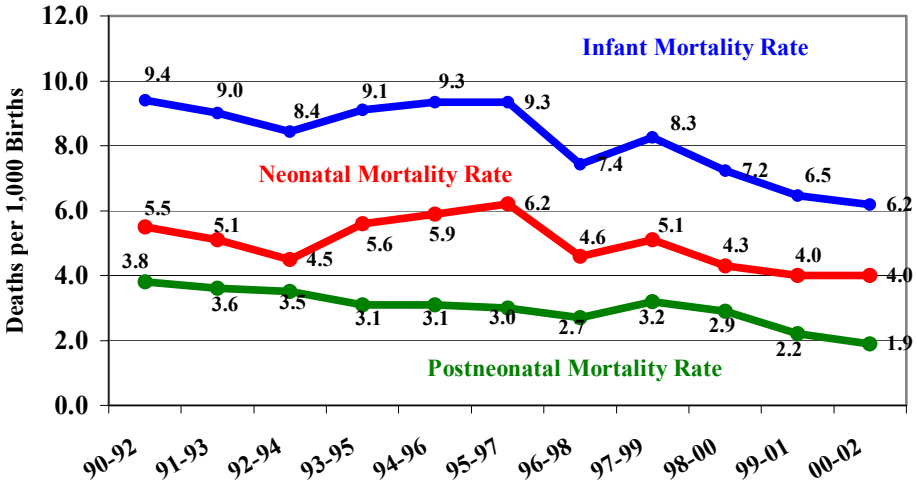
A 35 percent decline took place in infant mortality in Larimer County from 1990 to 2002, with a demonstrated rate during 2000-2002 of 5.0 compared to 7.7 at the beginning of the 1990's. A steady decline in neonatal rates, from 4.8 down to 3.1 deaths per 1,000, is paralleled by declining postneonatal rates. However, postneonatal rates appear to be unchanged since the mid-1990's.

Fig. 23 Infant, Neonatal and Postneonatal Rates for Larimer County 1990-1992 to 2000-2002, 3 Year Averages



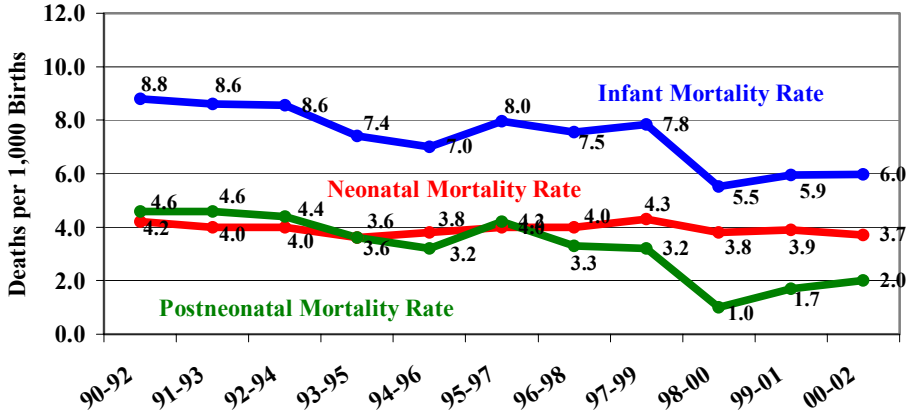
Northwest Region (Garfield, Mesa, Moffat, and Rio Blanco counties): **The infant mortality rates in the Northwest Region have declined over the period, dropping from 9.4 in 1990-1992 to 6.2 in 2000-2002. However, the rate rose in the mid-1990s after a decline early in the decade; then dropped again after 1997-1999. The neonatal rates follow the same pattern. The postneonatal rate steadily declined over the entire period.**

Fig. 24 Infant, Neonatal and Postneonatal Rates for the Northwest Region 1990-1992 to 2000-2002, 3 Year Averages



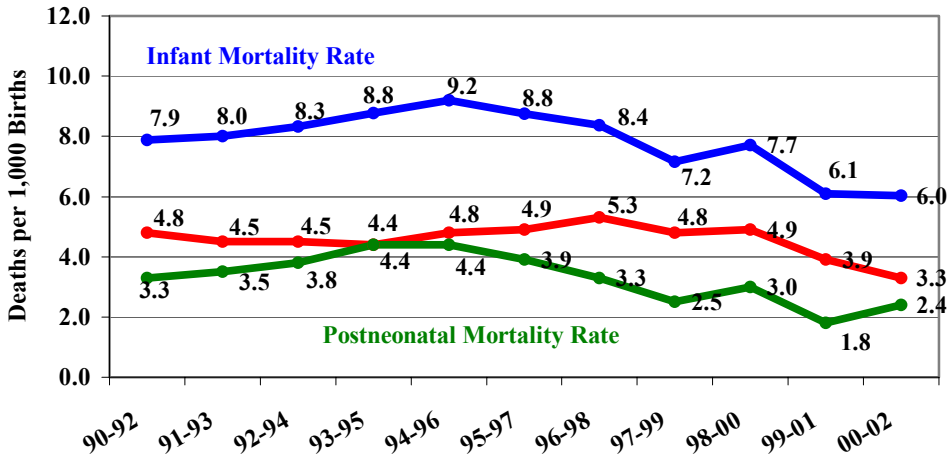
Pueblo County: Infant mortality has been reduced by 30 percent since 1990-1992. The rates were consistent between 7.0 and 8.0 until 1997-1999, when the rate declined to 5.5 deaths per 1,000 births in 1998-2000. The current rate for Pueblo County is 6.0 infant deaths per 1,000 births. The sharp decline in infant mortality in 1998-2000 appears to have been driven by the reduction in the postneonatal mortality rate (3.2 in 1997-1999 to 1.0 in 1998-2000). In general, the neonatal rates have not varied, ranging from 3.6 to 4.3 deaths per 1,000 births since 1990. An increase in postneonatal mortality since the 1998-2000 period stands in contrast to trends found in most other counties.

Fig. 25 Infant, Neonatal and Postneonatal Rates for Pueblo County 1990-1992 to 2000-2002, 3 Year Averages



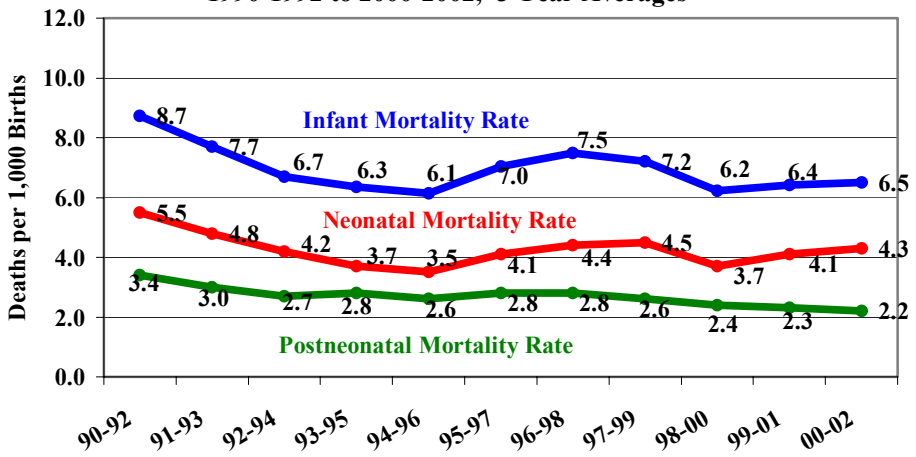
Southern Region (Alamosa, Archuleta, Conejos, Costilla, Dolores, Huerfano, La Plata, Las Animas, Mineral, Montezuma, Rio Grande, Saguache, and San Juan counties)**:** The 1990-1992 infant mortality rate of 7.9 rose to a noticeable peak of 9.2 deaths per 1,000 births in 1994-1996 before decreasing to 7.2 in 1997-1999. Rates then declined to 6.0 in 2000-2002. The neonatal rate remained essentially unchanged until 1997-1999, when it rapidly decreased to 3.3 in 2000-2002. The postneonatal rate rose in the early 1990s, and did not begin to decline until 1995-1997.

Fig. 26 Infant, Neonatal and Postneonatal Rates for the Southern Region 1990-1992 to 2000-2002, 3 Year Averages



Weld County: The infant mortality rate dropped rapidly in the early part of the decade, rose in the middle, and fell again at the end of the decade. Another increase appeared at the turn of the century. The rate of 6.5 in 2000-2002, however, was well below the 8.7 rate in 1990-1992. The neonatal rate showed the same fluctuating pattern, and indeed was responsible for the shape of the infant mortality trend. The postneonatal rate declined by 35 percent from 3.4 in 1990-1992 to 2.2 in 2000-2002.

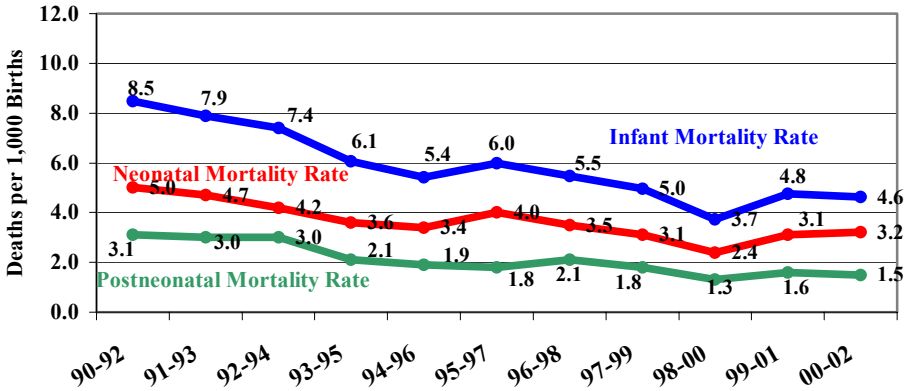
Fig. 27 Infant, Neonatal and Postneonatal Rates for Weld County 1990-1992 to 2000-2002, 3 Year Averages



Western Region (Delta, Eagle, Grand, Gunnison, Hinsdale, Jackson, Montrose, Ouray, Pitkin, Routt, San Miguel, and Summit):

The initial infant mortality rate of 8.5 in 1990-1992 showed marked improvement over the period, declining to a low of 3.7 in 1998-2000. This was primarily due to the decrease in the neonatal rate to 2.4 during the period. The postneonatal rate fell to an all-time low of 1.3 in 1998-2000. However, both the neonatal and the postneonatal rates have increased slightly since that time, driving the infant mortality rate back up to a level of 4.6 in 2000-2002.

Fig. 28 Infant, Neonatal and Postneonatal Rates for the Western Region 1990-1992 to 2000-2002, 3 Year Averages



Summary of Counties/Regions

Every county and region in the state showed a decline in infant mortality between 1990-1992 and 2000-2002. The overall rate was primarily driven by the neonatal mortality rate, which contributes the vast majority of all infant deaths. While neonatal mortality rate declined in nearly every county and region as well over the period, the decreases in the first part of the decade were often not continued in the second half. The postneonatal mortality rate fell in all areas of the state and was the consistent factor in the decline in the overall infant mortality rate.

It should be noted that over the period, multiple births rose statewide from 2.3 or 2.4 percent of all births between 1990 and 1994 to 2.9 to 3.2 percent between 1995 and 2002. Neonatal mortality among multiple births is six times higher than among singletons, and may have affected the neonatal mortality rates in some counties, especially after 1994. An in-depth examination of the impact of multiple births on the neonatal mortality rate is recommended for counties where there is a high proportion of multiple births (Appendix Table C). However, neonatal mortality rates are typically driven by singleton neonatal mortality rates, since 9 out of every 10 neonatal deaths are to singletons.

At the beginning of the decade, Adams, Denver, El Paso, and Pueblo counties had the highest rates of infant mortality. At the end of the decade, Adams, El Paso, and the Eastern Region had the highest rates compared to the other counties and regions.

The greatest declines in neonatal mortality were in Larimer County and the Western and Southern Regions, while the largest declines in postneonatal mortality were in Arapahoe, Denver, Jefferson and the Central Region. While reductions occurred in the neonatal mortality rates in Jefferson and Pueblo, these counties had the smallest amount of change in their rates. The neonatal mortality rate increased in the Eastern Region.

Perinatal Periods of Risk (PPOR), 1997-2002

Analysis of Perinatal Periods of Risk (PPOR) Methodology

An analysis of Colorado feto-infant mortality rates using the PPOR approach goes beyond the study of infant deaths, by including fetal deaths occurring at greater than 24 weeks of gestation with weights of at least 500 grams. Overall, during the six years between 1997 and 2002, Colorado women experienced 1,234 fetal deaths, in addition to 1,141 neonatal deaths and 760 postneonatal deaths. The combined number of fetal and infant deaths was 3,135.

The total feto-infant mortality rate using these numbers is 8.3 deaths per 1,000 live births plus fetal deaths. This rate is the sum of the three categories of deaths (fetal, neonatal, and postneonatal) divided by all live births (378,420) *plus* all fetal deaths (1,234), and multiplied by 1,000.

$$\frac{\text{Number of Deaths in each category}}{\text{Number of Live Births + Fetal Deaths}} = \frac{(1{,}234 + 1{,}141 + 760) * 1000}{(378{,}420+1{,}234)} = 8.3$$

The PPOR approach further divides each category into two groups according to the weight of the infant (Figure 29). Fetal, neonatal and postneonatal deaths of babies weighing between 500 grams and 1,499 grams are grouped into a single Maternal Health/Prematurity group (regardless of the time period of death). Next, the deaths of babies weighing 1,500 grams or more are grouped into three separate categories called Maternal Care (for fetal deaths), Newborn Care (for neonatal deaths), and Infant Health (for postneonatal deaths). The chart below provides an exact breakdown for Colorado for the six-year period.

Fig. 29 Perinatal Periods of Risk for Colorado, 1997-2002

	Fetal (24+weeks)	Neonatal (<28 days)	Postneonatal (>=28days-1 yr)
500-1499 grams N = 1,131	Maternal 416	Health/ 636	Prematurity 79
>=1,500 grams N = 2,004	Maternal Care 818	Newborn Care 505	Infant Health 681
Total = 3,135	1,234	1,141	760

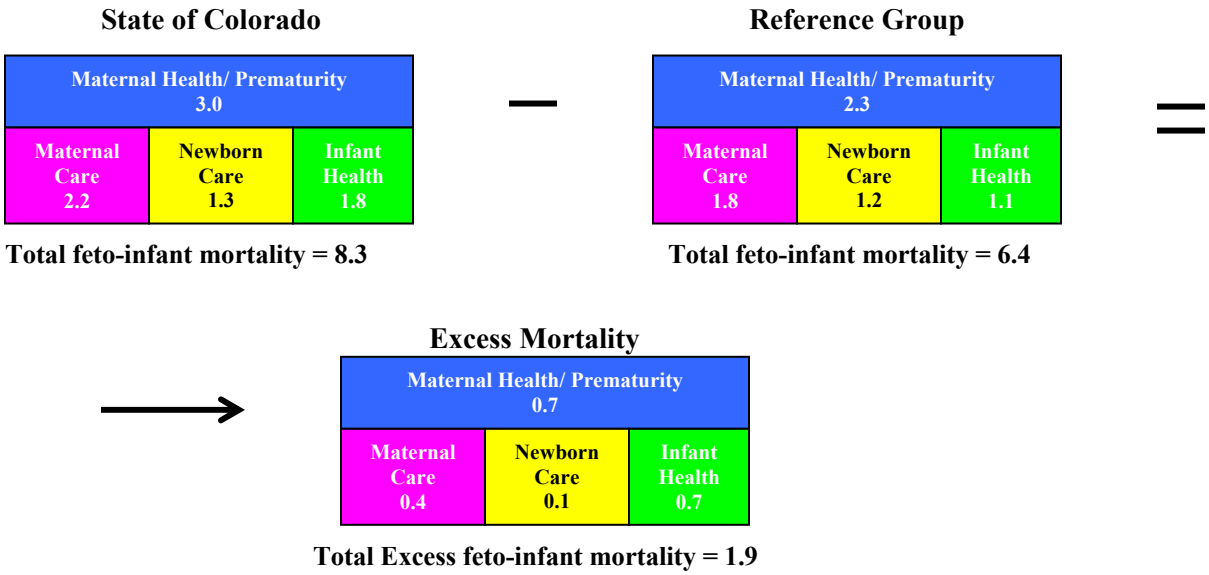
Rates for each category are then calculated, by dividing the number in each category by the total number of live births plus fetal deaths. This procedure results in a rate of 3.0 for Maternal Health/Prematurity, 2.2 for Maternal Care, 1.3 for Newborn Care, and 1.8 for Infant Health (Figure 30). The sum of the rates in the four categories equals 8.3.

The Maternal Health/Prematurity rate is based on 1,131 deaths (416 in the fetal period, 636 in the neonatal period and 79 in the postneonatal period) where the infant

weighed between 500 and 1,499 grams. The Maternal Health/Prematurity rate comprises all very small infants, regardless of whether they were live births or fetal deaths. The other rates are derived from larger infants according to the time of death. The Maternal Care rate is based on the fetal deaths of 818 larger infants (weighing at least 1,500 grams) where the death occurred at 24 or more weeks gestation. The Newborn Care rate is based on 505 deaths in the first 28 days of life (the neonatal period), and the Infant Health rate is based on 681 deaths in the postneonatal period (28 days to one year). The categories are labeled to suggest where intervention would be most effective. For example, interventions in the mother's lifestyle and health are considered the most appropriate means to reduce neonatal or postneonatal deaths among very small infants, while interventions in the care of the pregnant woman may be the most effective way to reduce fetal deaths among larger babies.

The PPOR approach also employs a reference group whose mortality experience provides a benchmark, or "gold standard" for comparison. Outcomes for Colorado White non-Hispanic women who are at least 20 years old and who have at least 13 years of education were utilized as the reference group for this PPOR analysis. Their mortality experience results in a rate of 6.4. The components of the total feto-infant mortality rate are also shown, and it is apparent that all rates (in all cells) are lower in the reference group than for the state as a whole. Furthermore, when the total state rate of 8.3 is compared to the reference group rate of 6.4, the "excess mortality," the state rate minus the reference group rate, is apparent. This excess consists of deaths that are theoretically preventable.

Fig. 30 Calculation of Excess Mortality in Colorado, 1997-2002



The total feto-infant excess mortality for Colorado is 1.9, with the greatest excess mortality demonstrated in both the Maternal Health/ Prematurity and Infant Health categories (0.7). Less is noted in Maternal Care (0.4), and least of all (0.1) in Newborn Care. Compared to the reference group in Colorado, approximately 1.9 of the 8.3 rate (23 percent), or 718 of the 3135 fetal and infant deaths, are considered preventable. The greatest potential for reduction is in both

the Maternal Health/Prematurity group and the Infant Health group (36 percent respectively), whereas the Newborn Care category demonstrates the lowest potential for reduction (5 percent).

PPOR Analysis of Colorado by Race/Ethnicity

The experience of the three major racial/ethnic groups in Colorado was analyzed next using the PPOR approach. [2] Overall, Black women have the highest feto-infant mortality rate with 13.9; White Hispanics are a distant second with 8.5, and White non-Hispanics are third with a rate of 7.4. The category with the highest potential for reduction in all three racial/ethnic groups is the Maternal Health/Prematurity group. Maternal Care ranks second, and the least need for reduction appears to be in both the Newborn Care and Infant Health categories.

Black

The total feto-infant mortality rate is 13.9, based on 82 fetal deaths plus 148 infant deaths (230 total) among 16,526 births plus fetal deaths. The excess mortality rate is 7.5, the difference between 13.9 and the reference group rate of 6.4 for White non-Hispanic women at least 20 years of age with 13 or more years of education. It is evident that the Black feto-infant mortality rate is more than double the reference group rate, so that at least half of Black fetal and infant mortality is considered to be preventable.

The Maternal Health/Prematurity category, with a rate of 6.2 contains about one-half (105/230) of the deaths that occurred during the six-year period. The next highest category is Maternal Care, with a rate of 3.6, where about one-quarter of the deaths are placed. Infant Health, after the postneonatal period, has the next highest rate (2.4), and Newborn Care, with a rate of 1.8, has the lowest rate of the four differently colored cells.

Fig. 31a PPOR for Black Women in Colorado, 1997-2002

Total feto-infant mortality rate= 13.9
Fetal Deaths = 82 Births = 16,444 Fetal Deaths + Births = 16,526

	Fetal (24+weeks)	Neonatal (<28 days)	Postneonatal (>=28days-1 yr)
500-1499 grams N = 105	Maternal n=26	Health/ 6.2 n=60	Prematurity n=19
>=1,500 grams N = 125	Maternal Care 3.6 n=56	Newborn Care 1.8 n=29	Infant Health 2.4 n=40
Total = 230	82	89	59

[2] Because of data collection limitations, the PPOR analysis could not be performed for any subgroup of Hispanics according to where the mother was born. The country of origin of the mother does not appear on the fetal death certificate.

White Hispanic

The total feto-infant mortality rate for White Hispanics is 8.5, based on 345 fetal deaths plus 511 infant deaths (856 total) among 101,099 births plus fetal deaths. The excess mortality rate is 2.1, the difference between 8.5 and the reference group rate of 6.4. Thus, about one out of every four (2.1/8.5) deaths is considered to be preventable for this group.

The Maternal Health/Prematurity category, with a rate of 3.3 contains about 40 percent of the deaths that occurred during the six-year period (338/856). The next highest category is Maternal Care, with a rate of 2.2, where about one-quarter of the deaths are found. Infant Health, after the postneonatal period, has the next highest rate (1.5), and Newborn Care, with a rate of 1.3, is just slightly lower. The Newborn Care rate is just one decimal point higher than the reference group rate. The largest difference lies in the Maternal Health/Prematurity category, which is more than one full point higher (3.3) than the reference group rate (2.3).

Fig. 31b PPOR for White Hispanic Women in Colorado, 1997-2002

Total feto-infant mortality rate = 8.5

Fetal Deaths = 345 **Births = 100,754** **Fetal Deaths + Births = 101,099**

	Fetal (24+weeks)	Neonatal (<28 days)	Postneonatal (>=28days-1 yr)
500-1499 grams N = 338	Maternal n=127	Health/ 3.3 n=194	Prematurity n=17
>=1,500 grams N = 518	Maternal Care 2.2 n=218	Newborn Care 1.3 n=140	Infant Health 1.5 n=160
Total = 856	345	334	177

White Non-Hispanic

The total feto-infant mortality rate for White non-Hispanics is 7.0, based on 630 fetal deaths plus 1,086 infant deaths (1,716 total) among 245,033 births plus fetal deaths. The excess mortality rate is 0.6, the difference between 7.0 and the reference group rate of 6.4. One out of every 11 or 12 (0.6/7.0) deaths is considered to be preventable for this group.

The Maternal Health/Prematurity category, with a rate of 2.4, contains one-third of the deaths that occurred during the six-year period (577/1,716). The next highest category is Infant Health, with a rate of 1.8, where about one-quarter of the deaths are found. Maternal Care has the next highest rate (1.6), and Newborn Care, with a rate of 1.3, is just slightly lower. Only one cell differs greatly from the reference group: Infant Health, with a 1.8 rate compared to the 1.1 found in the reference group.

Fig. 31c PPOR for White Non-Hispanic Women in Colorado, 1997-2002

Total feto-infant mortality rate = 7.0
Fetal Deaths = 630 Births = 244,403 Fetal Deaths + Births = 245,033

	Fetal (24+weeks)	Neonatal (<28 days)	Postneonatal (>=28days-1 yr)
500-1499 grams N = 577	Maternal n=244	Health/ 2.4 n=291	Prematurity n=42
>=1,500 grams N = 1,139	Maternal Care 1.6 n=386	Newborn Care 1.3 n=314	Infant Health 1.8 n=439
Total = 1,716	630	605	481

PPOR Data by County or Region

As explained on page 3 in the Methods section, it is necessary for a population to have a certain number of fetal and infant deaths for the PPOR approach to yield significant findings. Using the PPOR standard of at least 60 fetal or infant deaths and a frequency of 10 in each of the four cells of Maternal Health/Prematurity, Maternal Care, Newborn Care, and Infant Health, required limiting the analysis to the most populated counties, even when six years of data were combined. Table 1 on the following page contains the county rates that were determined through the analysis.

The state of Colorado contains 11 counties that were analyzed alone, in addition to 11 counties that were grouped into two regions. The counties that were examined separately include Adams, Arapahoe, Boulder, Denver, Douglas, El Paso, Jefferson, Larimer, Mesa, Pueblo, and Weld. The counties that made up the two regions were Eagle, Lake, Summit, Pitkin, and Garfield counties, which were assigned to the "Mountain West" Region, and Logan, Morgan, Philips, Sedgwick, Washington, and Yuma, which comprised the Northeast Region. When compared to the reference group, virtually all counties and regions[3] could implement strategies targeting the Maternal Health/Prematurity and Infant Health categories, while three-fourths of the counties could also target excess mortality in Maternal Care and Newborn Care.

[3] Douglas County is the exception.

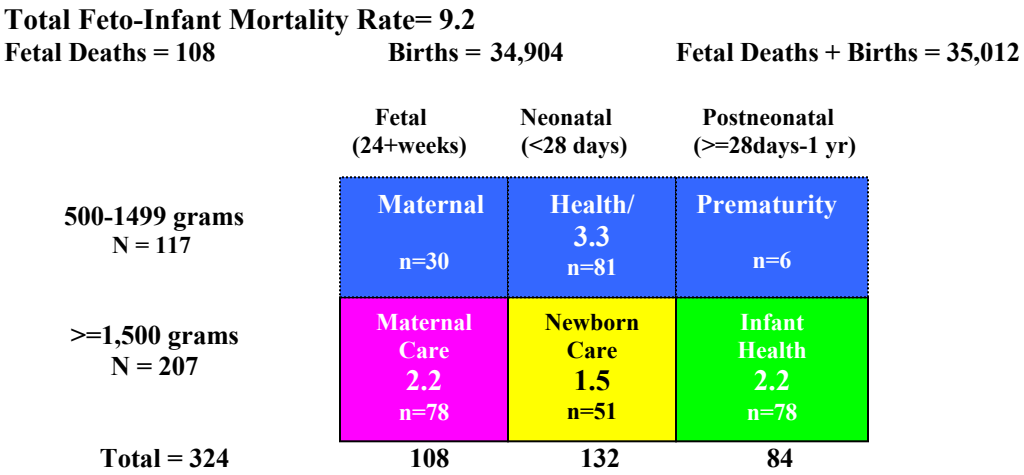
Table 1 PPOR and Excess Mortality Rates by County/Region, Colorado 1997-2002

County/Region	Total Feto-Infant-Mortality	Maternal Health/ Prematurity	Maternal Care	Newborn Care	Infant Health	Total Excess Mortality
Adams	9.2	3.3	2.2	1.5	2.2	2.8
Arapahoe	8.1	3.0	2.1	1.4	1.6	1.7
Boulder	7.7	2.4	2.9	1.2	1.3	1.5
Denver	8.6	3.3	2.4	1.2	1.7	2.2
Douglas	5.0	1.9	1.9	0.6	0.7	-1.4
El Paso	9.4	3.2	2.3	1.8	2.1	3.0
Jefferson	6.9	2.5	1.7	1.1	1.6	0.5
Larimer	7.6	2.6	2.2	1.2	1.6	1.3
Mesa	10.3	4.4	1.7	1.8	2.4	3.9
Pueblo	8.5	3.3	1.5	1.0	2.7	2.1
Weld	8.9	3.5	2.1	1.1	2.2	2.5
Mountain West*	8.8	3.0	2.3	1.5	2.0	2.4
Northeast**	10.9	3.5	3.3	2.0	2.1	4.5
Colorado	8.3	3.0	2.2	1.3	1.8	1.9
Reference Group* **	**6.4**	**2.3**	**1.8**	**1.2**	**1.1**	**0.0**

* Eagle, Garfield, Lake, Pitkin, Summit
** Logan, Morgan, Phillips, Sedgwick, Washington, Yuma
*** White Non-Hispanic, age 20 or more with more than 12 years of education.

Adams County: The total feto-infant mortality rate is 9.2, and exceeds the reference group rate of 6.4 by 2.8 deaths per 1,000 live births plus fetal deaths. The greatest need for reduction is in the Maternal Health/Prematurity and Infant Health categories when compared to the reference group. The Maternal Health/Prematurity rate of 3.3 was one of the highest of any of the counties or regions, and exceeds the reference group by 1.0. Maternal Care and Infant Health had equivalent mortality rates of 2.2, and Newborn Care was 1.5; both these rates exceed the reference group rates. Based on the reference group, 2.8 of the 9.2, or 30 percent of the mortality may be preventable. This is the equivalent of over 90 deaths between 1997 and 2002 that could possibly have been prevented. Forty-three were fetal or infant deaths weighing 500-1499 grams and 32 were postneonatal deaths weighing at least 1500 grams.

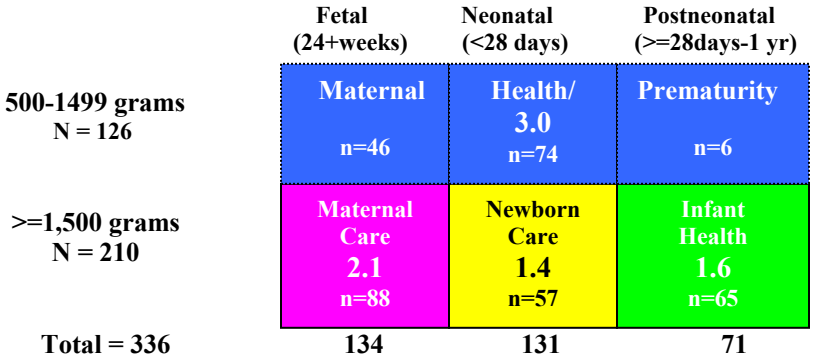
Fig. 32 PPOR for Adams County, 1997-2002



Arapahoe County: The total feto-infant mortality rate is 8.0, with the greatest need for reduction in the Maternal Health/Prematurity category. Excess mortality in Infant Health was 0.5 points above the reference group, while excess mortality in the other categories was slightly smaller. Excess mortality for all categories was 1.7, or 37 percent of all mortality. This amount is the equivalent of 71 deaths between 1997 and 2002 that could possibly have been prevented. An estimated 29 to 30 were fetal or infant deaths weighing between 500 and 1499 grams, and 20 were of postneonates weighing greater than 1,500 grams.

Fig. 33 PPOR for Arapahoe County, 1997-2002

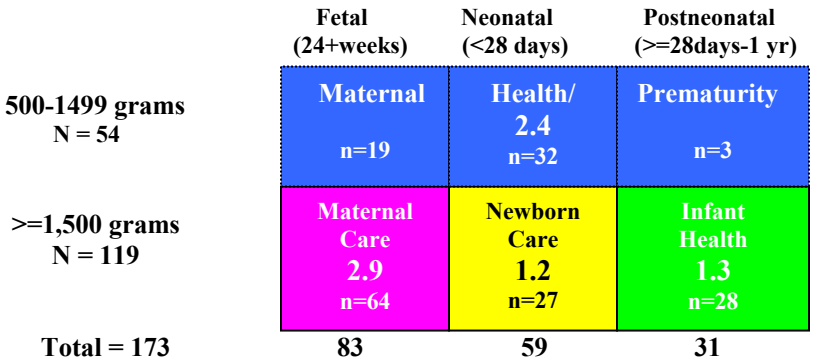
Total Feto-Infant Mortality Rate=8.0
Fetal Deaths = 134 Births = 41,780 Fetal Deaths + Births = 41,913



Boulder County: The Maternal Care category is the largest contributor to the overall feto-infant mortality rate of 7.7 in Boulder County. Overall excess mortality is 1.5, or 19 percent of all mortality, reflecting the highest county mortality rate of any county in the Maternal Care category. The total number of fetal and infant deaths for Boulder equaled 173 in the six-year period, of which 33 are considered to have been preventable.

Fig. 34 PPOR for Boulder County, 1997-2002

Total Feto-Infant Mortality Rate= 7.7
Fetal Deaths = 83 Births = 21,813 Fetal Deaths + Births = 21,896



Denver County: The feto-infant mortality rate of 8.6 is greatly affected by the rates of 3.3 in Maternal Health/Prematurity and 2.4 in Maternal Care. There is an excess of mortality in all categories except for Newborn Care, which is equal to the reference group. The category in need for greatest reduction, 45 percent, is in Maternal Health/Prematurity. Of the 208 fetal and infant deaths occurring between 1997 and 2002, 63 are considered preventable. Overall excess mortality is 26 percent (2.2/8.6) of all fetal and infant deaths in the county—about one in four**.**

Fig. 35 PPOR for Denver County, 1997-2002

Total Feto-Infant Mortality Rate= 8.6
Fetal Deaths = 238 **Births = 62,959** **Fetal Deaths + Births = 63,197**

	Fetal (24+weeks)	Neonatal (<28 days)	Postneonatal (>=28days-1 yr)
500-1499 grams N = 208	Maternal n=87	Health/ 3.3 n=109	Prematurity n=12
>=1,500 grams N = 333	Maternal Care 2.4 n=151	Newborn Care 1.2 n=74	Infant Health 1.7 n=108
Total = 541	238	183	120

Douglas County: The overall feto-infant mortality rate of 5.0 in Douglas County is the lowest in the state. When compared to the external reference group, the Maternal Care category is the only area with an excess of deaths. Of the 36 fetal deaths weighing greater than 1,500 grams, 3 were considered preventable between 1997 and 2002. The categories of Maternal Health/Prematurity, Newborn Care and Infant Health had lower rates of mortality than the reference group.

Fig. 36 PPOR for Douglas County, 1997-2002

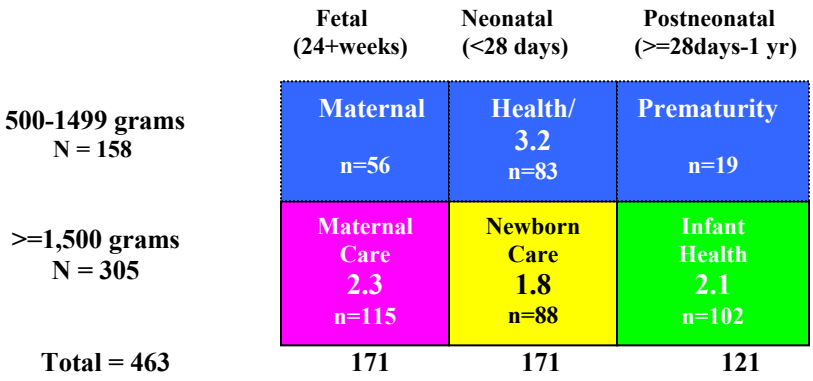
Total Feto-Infant Mortality Rate= 5.0
Fetal Deaths = 45 **Births = 19,279** **Fetal Deaths + Births = 19,324**

	Fetal (24+weeks)	Neonatal (<28 days)	Postneonatal (>=28days-1 yr)
500-1499 grams N = 36	Maternal n=9	Health/ 1.9 n=25	Prematurity n=2
>=1,500 grams N = 61	Maternal Care 1.9 n=36	Newborn Care 0.6 n=12	Infant Health 0.7 n=13
Total = 97	45	37	15

El Paso County: The feto-infant mortality rate of 9.4 consists of 3.2 in Maternal Health/Prematurity, 2.3 in Maternal Care, 1.8 in Newborn Care, and 2.1 in Infant Health. The excess mortality rate for El Paso County is greater than the reference group rate of 6.4, and suggests that one out of every three fetal or infant deaths in El Paso (3.0/9.4) is preventable.

Fig. 37 PPOR for El Paso County, 1997-2002

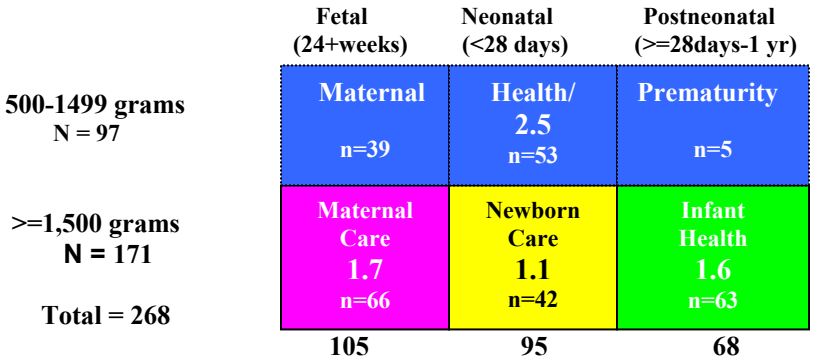
Total Feto-Infant Mortality Rate= 9.4
Fetal Deaths = 171 **Births = 48,994** **Fetal Deaths + Births = 49,165**



Jefferson County: The overall feto-infant mortality rate is 6.9, of which 1.5, or 22 percent may be preventable when compared to the reference group. These preventable deaths are found in the Maternal Health/Prematurity group (2.5 vs. 2.3 in the reference group), the Maternal Care (2.3 vs. 1.8) group and the Infant Health group (1.6 vs. 1.1). It is important to note that Jefferson County's Newborn Care rate is lower than the reference group rate, suggesting few problems in that area between 1997 and 2002. However, a total of 27 to 28 fetal and infant deaths overall may have been preventable in the six-year period.

Fig. 38 PPOR for Jefferson County, 1997-2002

Total Feto-Infant Mortality Rate= 6.8
Fetal Deaths = 105 **Births = 39,177** **Fetal Deaths + Births = 39,282**



Larimer: The county feto-infant mortality rate is 7.6 compared to the reference group rate of 6.4. This difference is a 1.2 excess mortality rate, or 16 percent of the total. An estimated one out of every six county fetal and infant deaths would therefore be considered preventable. The Maternal Care category shows an excess of 0.4. Efforts affecting Infant Health may yield the most benefit in Larimer County since 42 percent of the fetal and infant deaths are assigned to this category. Newborn Care does not appear to be an issue because the rate is equivalent to that of the reference group. If interventions had been established for the Infant Health and Maternal Care categories, 22 of the 70 deaths that occurred in these two categories may have been preventable.

Fig. 39 PPOR for Larimer County, 1997-2002

Total Feto-Infant Mortality Rate= 7.6
Fetal Deaths = 56 **Births = 18,638** **Fetal Deaths + Births = 18,694**

	Fetal (24+weeks)	Neonatal (<28 days)	Postneonatal (>=28days-1 yr)
500-1499 grams N = 48	Maternal n=15	Health/ 2.5 n=28	Prematurity n=5
>=1,500 grams N = 94	Maternal Care 2.2 n=41	Newborn Care 1.2 n=23	Infant Health 1.6 n=30
Total = 142	56	51	35

Mesa County: The total county teto-infant mortality rate is 10.3. The excess mortality rate is 3.9 fetal and infant deaths per 1,000 births and fetal deaths compared to the reference group, nearly the highest of any county or region shown. The greatest need for reduction lies in Maternal Health/Prematurity (4.4 vs. 2.3) and Infant Health (2.4 vs. 1.1). Maternal Care does not appear to present any problems, since the county's rate of 1.7 is lower than the reference group rate of 1.8. The Newborn Care difference is 1.8 vs. 1.2 for the reference group. During the period 1997-2002, a total of 91 fetal and infant deaths occurred to residents of Mesa County, 35 to 36 of which may have been preventable. A total of 18 to 19 can be attributed to Maternal Health/Prematurity issues, while 11 to 12 are in the Infant Health category.

Fig. 40 PPOR for Mesa County, 1997-2002

Total Feto-Infant Mortality Rate= 10.3
Fetal Deaths = 36 **Births = 8,801** **Fetal Deaths + Births = 8,837**

	Fetal (24+weeks)	Neonatal (<28 days)	Postneonatal (>=28days-1 yr)
500-1499 grams N = 39	Maternal n=21	Health/ 4.4 n=16	Prematurity n=2
>=1,500 grams N = 52	Maternal Care 1.7 n=15	Newborn Care 1.8 n=16	Infant Health 2.4 n=21
Total = 91	36	38	23

Mountain West Region: The overall feto-infant mortality rate is 8.8, with an excess mortality rate of 2.4 compared to the reference group. The Infant Health category has the greatest potential for reduction with 0.9 of the total excess of 2.4 (38 percent) found in this cell. During the six-year period, there were a total of 106 fetal and infant deaths, of which 36 to 37 may have been preventable.

Fig. 41 PPOR for Mountain West Region , 1997-2002

Total Feto-Infant Mortality Rate= 8.8
Fetal Deaths = 44 **Births = 12,086** **Fetal Deaths + Births = 12,130**

	Fetal (24+weeks)	Neonatal (<28 days)	Postneonatal (>=28days-1 yr)
500-1499 grams N = 36	Maternal n=16	Health/ 3.0 n=15	Prematurity n=5
>=1,500 grams N = 70	Maternal Care 2.3 n=28	Newborn Care 1.5 n=18	Infant Health 2.0 n=24
Total = 106	44	33	29

Northeast Region: The feto-infant mortality rate for this region of the state is 10.9, 4.5 points above the reference group rate, resulting in the highest excess mortality of all the counties and regions studied. The Maternal Health/Prematurity and Maternal Care are especially high, and exceed the reference group rates for these categories by 1.2 and 1.5, respectively. While the Maternal Care rate, in fact, is the highest of all the counties, all four categories are in need of intervention efforts in the Northeast Region. Between 1997 and 2002, it is estimated that 37 out of 66 fetal and infant deaths could have been prevented.

Fig. 42 PPOR for the Northeast Region, 1997-2002

Total Feto-Infant Mortality Rate= 10.9
Fetal Deaths = 107 **Births = 6,050** **Fetal Deaths + Births = 6,076**

	Fetal (24+weeks)	Neonatal (<28 days)	Postneonatal (>=28days-1 yr)
500-1499 grams N = 64	Maternal n=6	Health/ 3.5 n=12	Prematurity n=3
>=1,500 grams N = 207	Maternal Care 3.3 n=20	Newborn Care 2.0 n=12	Infant Health 2.1 n=13
Total = 217	107	80	84

Pueblo: With an overall feto-infant mortality rate of 8.5, and an excess mortality of 2.1, Pueblo County presents a different picture from most of the counties with excess mortality of 2.1 or more. There are just two categories with excess mortality -- Maternal Health/Prematurity and Infant Health. The county's rates in Maternal Care and Newborn Care are lower than the reference group rates. The excess Maternal Health/Prematurity rate is relatively high at 1.0 (3.3 vs. 2.3), and the excess Infant Health rate is 1.6, the greatest amount of any county shown. During the six-year period, there were 101 fetal and infant deaths in Pueblo. A total of 30 are considered to have been preventable.

Fig. 43 PPOR for Pueblo County, 1997-2002

Total Feto-Infant Mortality Rate= 8.5
Fetal Deaths = 37 Births = 11,612 Fetal Deaths + Births = 11,649

	Fetal (24+weeks)	Neonatal (<28 days)	Postneonatal (>=28days-1 yr)
500-1499 grams N = 39	Maternal n=19	Health/ 3.3 n=18	Prematurity n=2
>=1,500 grams N = 62	Maternal Care 1.5 n=18	Newborn Care 1.0 n=12	Infant Health 2.7 n=32
Total = 101	37	30	34

Weld County: The feto-infant mortality rate in Weld is 8.9, an excess of 2.5 deaths per 1,000 live births plus fetal deaths. The Maternal Health/Prematurity rate of 3.5 exceeds the reference group rate by 1.2 points, and the Infant Health rate exceeds the reference group rate by 1.1 points. The Maternal Care rate of 2.1 exceeds the reference group rate by 0.3 points, but the Newborn Care rate of 1.1 for the county is lower than the reference group by 0.1. Between 1997 and 2002, there were 161 fetal and infant deaths to Weld County mothers. As many as 47 are considered to have been preventable.

Fig. 44 PPOR for Weld County, 1997-2002

Total Feto-Infant Mortality Rate= 9.0
Fetal Deaths = 57 Births = 17,874 Fetal Deaths + Births = 17,931

	Fetal (24+weeks)	Neonatal (<28 days)	Postneonatal (>=28days-1 yr)
500-1499 grams N = 63	Maternal n=19	Health/ 3.5 n=42	Prematurity n=2
>=1,500 grams N = 98	Maternal Care 2.1 n=38	Newborn Care 1.1 n=20	Infant Health 2.2 n=40
Total = 161	57	62	42

Summary of PPOR Data by County/Region
In this analysis of Colorado's 14 largest counties and regions, all but one county (Douglas) had feto-infant mortality rates that exceeded the reference group overall rate of 6.4. The other county rates ranged between 7.6 (Larimer) and 10.9 (Northeast),

exceeding the reference group rate by 0.8 to 4.5 deaths per 1,000 live births plus fetal deaths.

Within the Maternal Health/Prematurity category, where the reference group rate was 2.3, the rates ranged from 2.5 (Boulder and Jefferson) to 4.4 (Mesa). In the Maternal Care cell, rates ranged from 1.5 (Pueblo) and 1.7 (Jefferson), below the reference group rate of 1.8, to 3.3 in the Northeast Region of Colorado. In the Newborn Care category, rates were lowest in Jefferson and Weld, at 1.1, below the reference group rate of 1.2. However, rates ranged to 1.8 in El Paso and Mesa, and up to 2.0 in the Northeast. Finally, in the Infant Health cell, the lowest rate was in Boulder, at 1.3, but still above the reference group rate of 1.1, and the highest rate was in Pueblo, at 2.7.

It appears that virtually all large counties in Colorado have excess fetal and infant mortality, and that most must make improvements in all four of the categories in the PPOR model. For a few counties, it is clear that efforts should focus on Maternal Care, Newborn Care, or Infant Health, but the Maternal Health/Prematurity category stands out as the area where all counties need strong intervention efforts in order to reduce their feto-infant mortality rates.

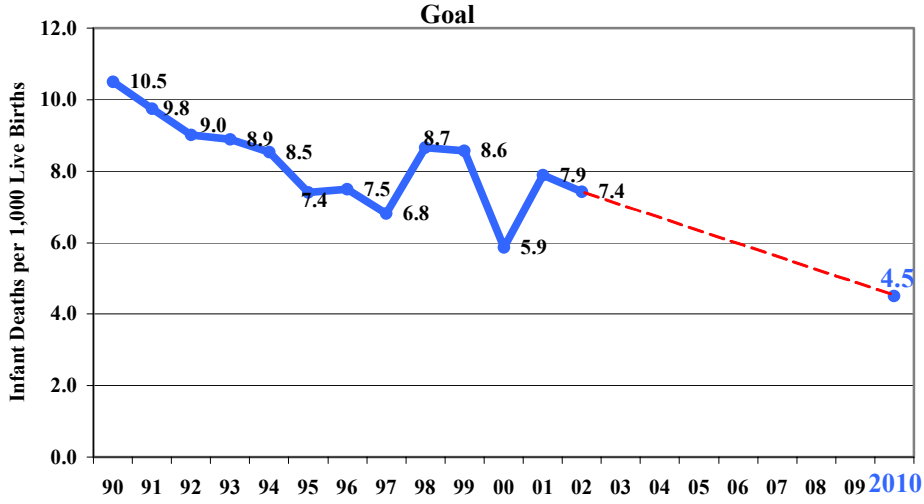
Recommendations/Strategies

It is the intent of the Colorado Department of Public Health and Environment to collaborate with local stakeholders to reduce the infant mortality rate to the recommended Healthy People objective by 2010. In order to successfully reach this goal, the trends at the county or subpopulation level were examined by the state health department. The infant mortality rates from the last decade for the counties with the largest populations in Colorado are shown below, along with an illustration of the trend line required to meet the 2010 goal. The counties of Adams, Arapahoe, Boulder, Denver, El Paso, Jefferson, Larimer, Mesa, Pueblo, and Weld were analyzed because in 2002 they made up approximately 80 percent of the births in Colorado (55,000 of the 68,420) and about 83 percent of the infant deaths. In addition, all but one of these counties has yet to accomplish the goal of reducing the infant mortality to 4.5 deaths per 1,000 live births.

Infant Mortality Rate 2010 Goals

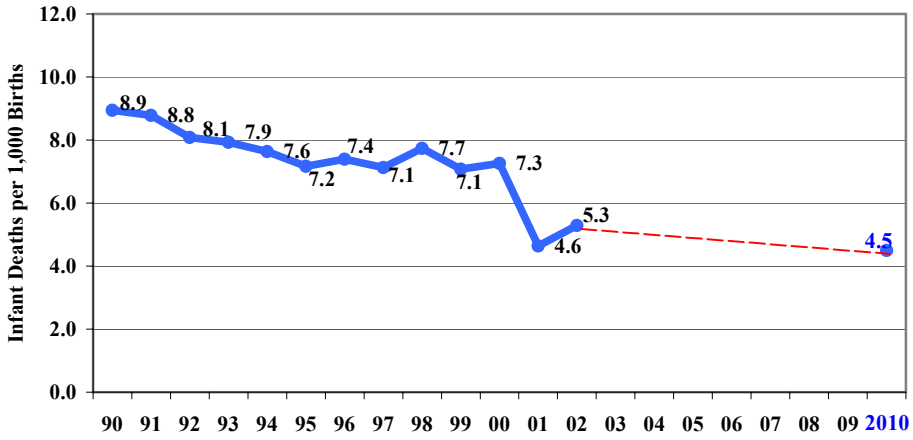
Adams County: While the county was closest to achieving the 2010 goal in 2000, the infant mortality rate increased to over 7.0 in 2001 and 2002. As a result, a 40 percent decline is needed in the next eight years to reach the Healthy People objective (4.5) from the current level of 7.4.

Fig. 45 Infant Mortality Rates, Adams County, 1990-2002, and Required Decline to Meet Healthy People 2010 Goal



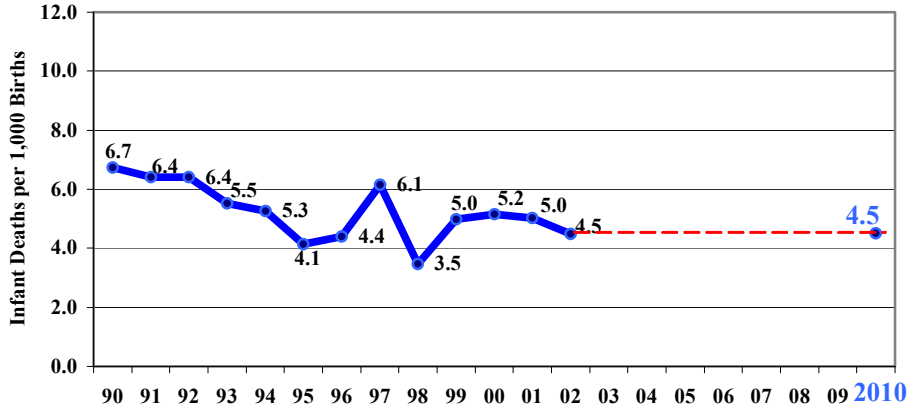
Arapahoe County: Arapahoe virtually met the 2010 goal in 2001, with the lowest infant mortality rate demonstrated by the county in over a decade. The 5.3 level in 2002 must be reduced by 0.8 points, or 15 percent over the next eight years to reach the Healthy People goal of 4.5 in 2010.

Fig. 46 Infant Mortality Rates, Arapahoe County, 1990-2002, and Required Decline to Meet Healthy People 2010 Goal



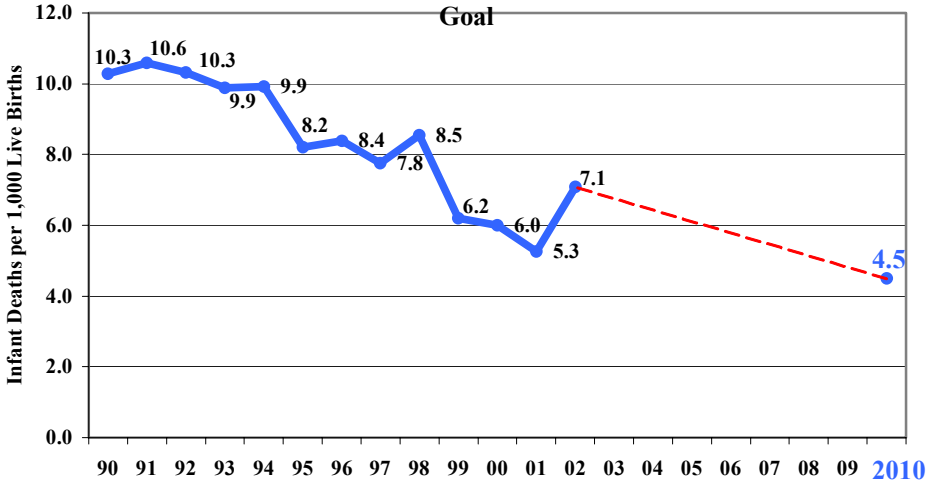
Boulder County: After a rapid decline in the early 1990's, Boulder County was poised to meet the Healthy People 2010 goal, which it did three times by 1998. Since that year, the 4.5 goal has been met only once. It appears possible for Boulder to again reach the Healthy People 2010 goal in the near future.

Fig. 47 Infant Mortality Rates, Boulder County, 1990-2002, and Required Decline to Meet Healthy People 2010 Goal



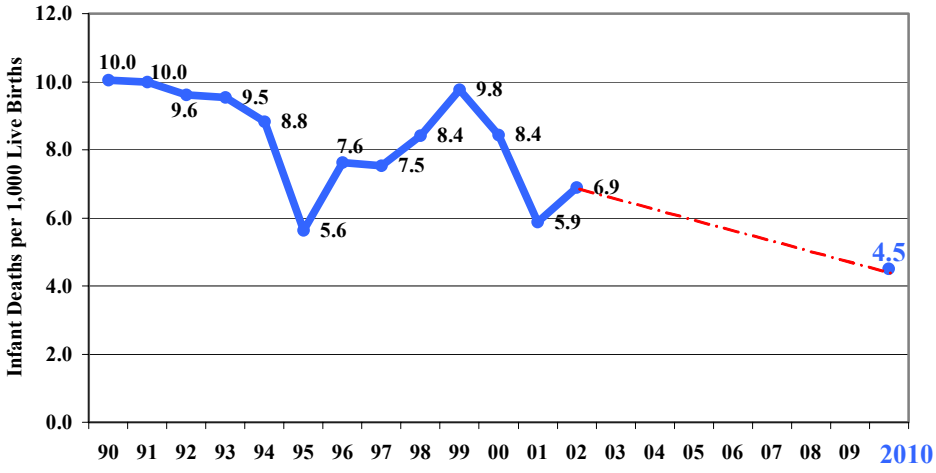
Denver County: Although the infant mortality rate in Denver has declined dramatically in the last decade, the fact remains that a 37 percent decline in infant deaths is still needed to achieve the 2010 goal. This decrease, from 7.1 to 4.5, must be accomplished in the next eight years, at a projected decline of about 5 percent each year.

Fig. 48 Infant Mortality Rates, Denver County, 1990-2002, and Required Decline to Meet Healthy People 2010 Goal



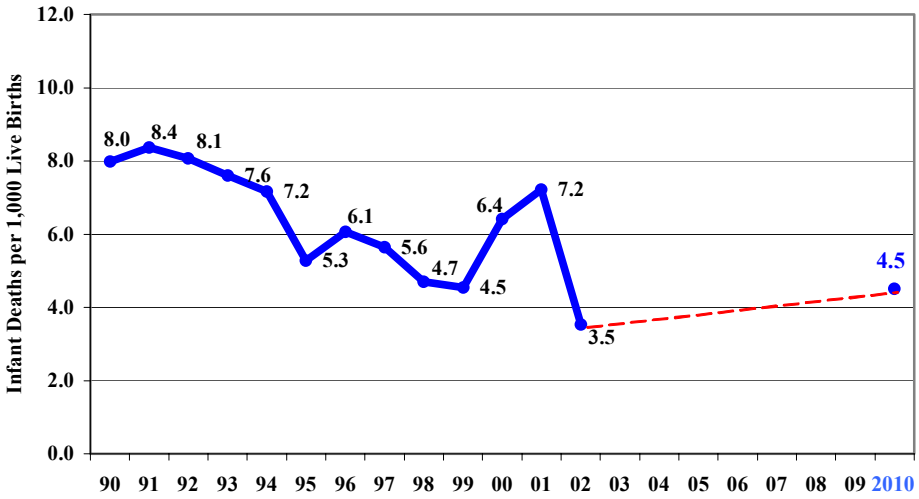
El Paso County: The infant mortality rate in El Paso County has shown an irregular pattern in recent years, with reduction in infant mortality in the first half of the 1990s nearly erased in the second half of the decade. Progress since 1999 suggests that the 2010 goal of 4.5 can be attained, but the required decline is 35 percent between 2002 and 2010.

Fig. 49 Infant Mortality Rates, El Paso County. 1990-2002, and Required Decline to Healthy People 2010 Goal



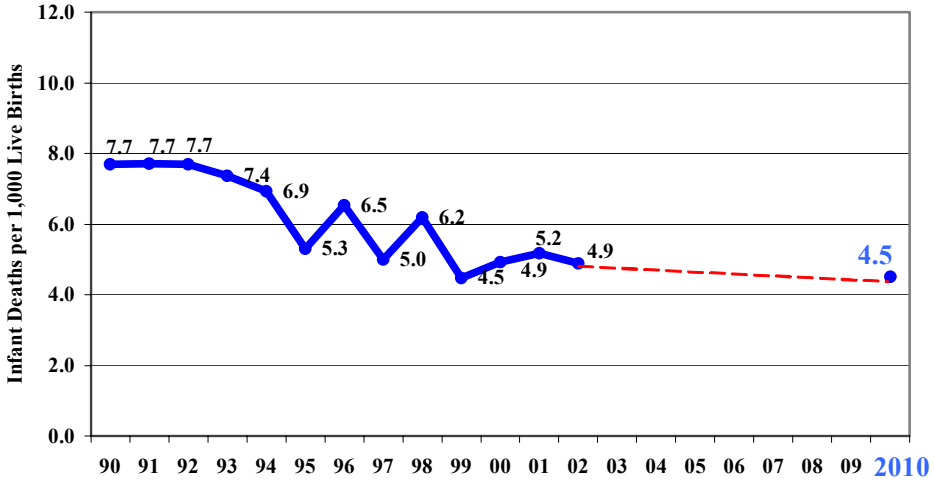
Jefferson County: The infant mortality rate in Jefferson County reached the Healthy People 2010 goal in 1999, and again in 2002, but the rates in 2000 and 2001 were substantially higher. It is not yet clear whether the 2002 rate of 3.5 or the desired rate of 4.5 can be sustained.

Fig. 50 Infant Mortality Rates, Jefferson County, 1990-2002, and Required Decline to Meet Healthy People 2010 Goal



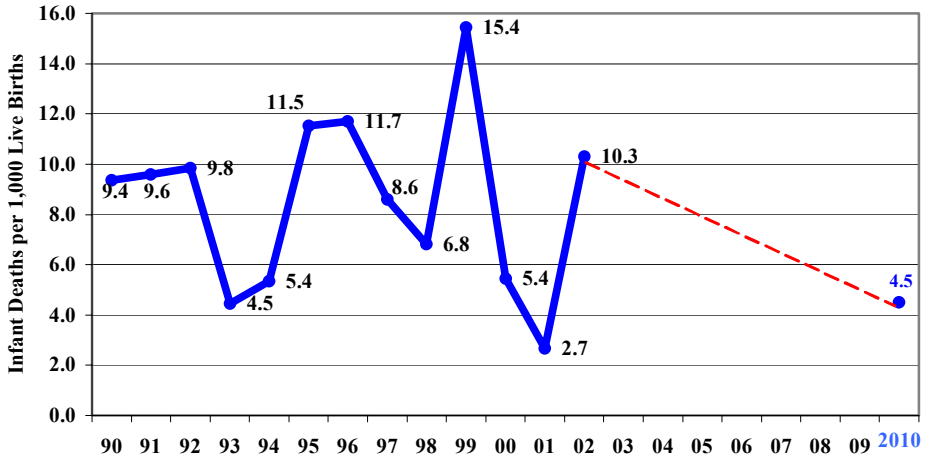
Larimer County: The infant mortality rate in Larimer County has declined in recent years, and the Healthy People 2010 goal was met once in 1999. It seems likely that the 4.5 goal can again be reached by 2010.

Fig. 51 Infant Mortality Rates, Larimer County, 1990-2002, and Required Decline to Meet Healthy People 2010 Goal



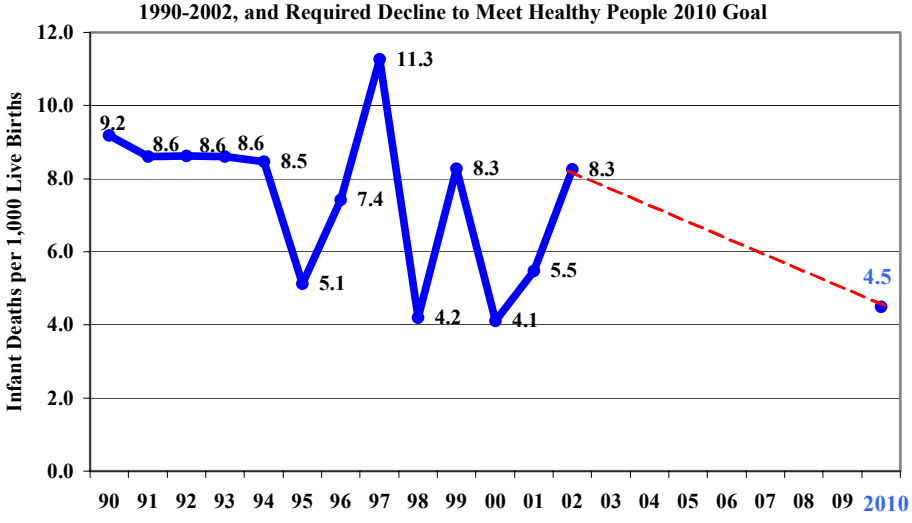
Mesa County: The infant mortality rate in Mesa County varied a great deal from year to year between 1990 and 2002, with no apparent pattern. Meeting the 4.5 goal presents a challenge, but appears to be possible, especially if new efforts are undertaken to address the problem.

Fig. 52 Infant Mortality Rates, Mesa County, 1990-2002, and Required Decline to Meet Healthy People 2010 Goal



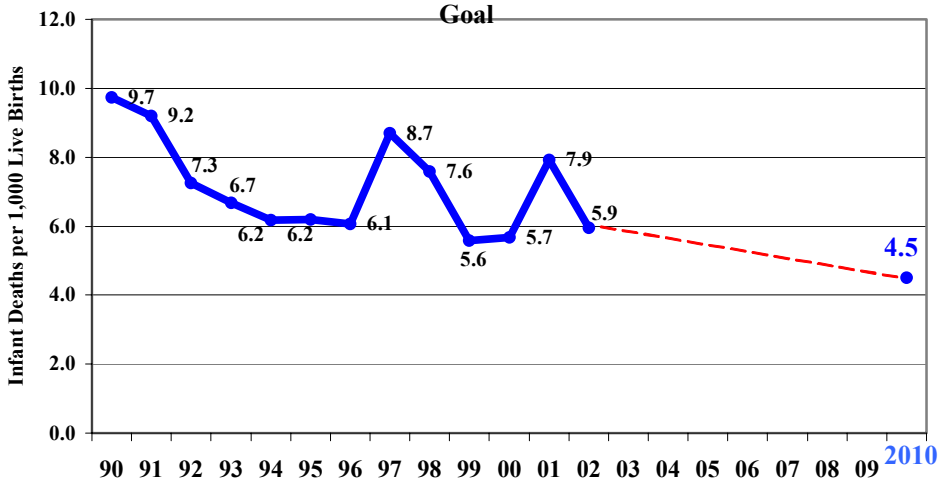
Pueblo County: Pueblo's rates range between low and high values on an annual basis since the mid-1990's. A decline of nearly 50 percent is required to reduce the 2002 rate of 8.3 to the Healthy People 2010 rate of 4.5 deaths per 1,000 live births.

Fig. 53 Infant Mortality Rates, Pueblo County, 1990-2002, and Required Decline to Meet Healthy People 2010 Goal



Weld County: Weld County enjoyed a dramatic decline in infant mortality in the early 1990's, but the pattern since 1996 has revealed no real improvement. To reach the 2010 goal of 4.5, the infant mortality rate must be reduced by 1.4 points in the next 8 years.

Fig. 54 Infant Mortality Rates for Weld County, 1990-2002, and Required Decline to Meet Healthy People 2010 Goal



Summary of Infant Mortality Rate 2010 Goals

This section has outlined the extent of the declines that are necessary for each of the large counties to meet the Healthy People 2010 goal for infant mortality. While some counties face a large gap between the current level and the desired level (Adams, Denver, El Paso, and Pueblo), other counties (Arapahoe, Boulder, Larimer and Weld) are much closer to the goal. Eight years lie ahead in which to accomplish a reduction in the rates from 2002, the most recent year for which data are available, to 2010.

To reach the Healthy People 2010 goal from the current state average of 6.0, a decline of 25 percent is required. It is worth noting that between 1994 and 2002, the most recent eight-year period on record, a decline of 13 percent was realized, as the infant mortality rate dropped from 6.9 to 6.0. The 4.5 rate is within reach, theoretically attainable if efforts are doubled. The data presented in this section, combined with the in-depth analysis that the Perinatal Periods of Risk Approach provides, can be used by all counties to begin to systematically address the factors underlying infant mortality.

Collaborative Efforts

Thus far, the role of the Colorado Department of Public Health and Environment has been to present data on infant mortality at the state and county level and to analyze trends. This report constitutes the first comprehensive analysis of infant mortality undertaken in recent years. The use of the Perinatal Periods of Risk methodology has also facilitated a deeper analysis at the local level. There is a great deal of information provided in this report that can be used as a catalyst for local areas to both understand infant mortality and to develop appropriate strategies.

In October 2003, a workshop was conducted in Denver by Magda Peck, CEO/Executive Director of CityMatCH, to encourage interest in the PPOR methodology and to orient qualified counties to the process involved in the approach. Presentations focused on the PPOR model and on assessing community readiness. While it is important for each county to be prepared to perform the required data analysis, it is crucial for ownership to be taken of the issues related to infant mortality at the community level. Now that the approach has been presented, it will be the responsibility of each county to embrace the principles of the PPOR approach and to determine if sufficient resources are available to initiate and carry forward the process. Because the PPOR methodology requires a community-based approach to infant mortality, the state health department will serve as a resource for technical assistance and support. This function includes assisting with secondary data analysis and with the development of interventions at the county level. Furthermore, the state will offer support on how county-specific activities can be funded through the Maternal and Child Health Block Grant.

County Worksheets by PPOR Category

In addition to the data provided in the text portion of this report, worksheets for each large county are provided in Appendix B. Perinatal Periods of Risk data, Vital Statistics data, and Pregnancy Risk Assessment Monitoring System (PRAMS) survey data are provided at the county level, grouped according to the PPOR categories: Maternal Health/Prematurity, Maternal Care, Newborn Care, and Infant Health. The data provided (unintended pregnancy rates, maternal smoking rates, infant sleep position, etc.) are relevant to each of the categories and should help each county institute interventions that will ultimately affect mortality rates. Data are shown for the state as well and comparisons are made between the county and the state and Healthy People 2010 goals. In addition, maps are provided in Appendix C, which show PPOR data for each category by county. The survey questions used in PRAMS are listed in Appendix D.

Conclusions

The current infant mortality rate in Colorado of 6.0 must decrease or be reduced by 25 percent in order to meet the Healthy People 2010 goal of 4.5 deaths per 1,000 births. For this to occur, a focused effort must take place at the local level. Reducing excess mortality by using interventions recommended for each of the four components of the Perinatal Periods of Risk model will enable each county to begin to approach the goal. (Indeed, wherever a county is especially successful in fully eliminating excess mortality, it may exceed the 4.5 goal, since the experience of the group of births to women used as the reference group is already better than the goal.) But reducing mortality to the Healthy People goal by 2010 will require at least doubling the efforts of what transpired between 1994 and 2002, the most recent eight-year period. The level of postneonatal mortality is already quite low (2.0), and there are limits to how much lower the current rate can fall. The neonatal mortality rate of 4.0 is twice as high as the postneonatal rate, so reducing this rate, which has changed little since the mid-1990's, will be the principal challenge.

Appendix E. Definitions and References

Definitions

Birth Rate: The number of births that occur within a certain population or geographical area, over a specified time period, in relation to the total population of the group or area. Specifically, the number if births per 1,000 total population.

Birth Weight: The first weight of the fetus or newborn obtained after birth. This weight preferably is measured within the first hour of life, before significant postnatal weight loss has occurred.

Calculated gestational age: Number of completed weeks from the first day of the mother's last normal menstrual period until the date of delivery or termination of pregnancy.

Clinical gestational age: A rating scale based on the Ballard Score, which examines the neuromuscular and physical maturity of the neonate immediately following delivery.

Colorado Health Information Dataset (CoHID): A Colorado Department of Public Health and Environment website that provides health, environmental, and demographic information, such as birth and death certificate data, PRAMS survey data, and injury statistics for the state of Colorado (http://www.cdphe.state.co.us/cohid/index.html)

Fertility Rate (age-specific): The number of births for a specified age group of females within a certain population or area per 1,000 total females in the age group.

Infancy: The period between live birth and 1 year of age. A child ceases to be an infant on its first birthday.

Infant Death: Death in the first year of life.

Kotelchuck Index: An index of the adequacy of prenatal care based on month of entry into care, number of prenatal visits, and the gestational age of the infant at birth. The index is categorized as adequate plus, adequate, intermediate, inadequate or unknown based on these criteria. It is expected that prenatal care is termed adequate if the visits are greater than or equal to 80 percent of the recommended number. The index is also known as the Adequacy of Prenatal Care Utilization Index.

Live Birth: The complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes, or shows any other evidence of life, such as beating of the heart, pulsation, of the umbilical cord, or definite movement of voluntary muscles, whether or not the umbilical cord has been cut or the placenta is attached; each product of such a birth is considered live born.

Low Birth Weight: Birth weight of less than 2,500 grams (less than or equal to 5 lb 8 oz).

Multiple Birth: More than one child born resulting from a single pregnancy. Also called a plural birth.

Neonatal Death: Death prior to the 28th day of life.

Perinatal: Pertaining to or occurring in the period shortly before or after birth. In this report, perinatal refers to the period of 24 weeks gestation to 27 days of life.

Postneonatal Death: Death of a child occurring from the age of 28 days to 1 year.

Pregnancy Risk Assessment Monitoring System (PRAMS): A surveillance project of the Centers of Disease Control and Prevention (CDC) and state health departments. PRAMS collects state specific, population-based data on maternal attitudes and experiences prior to, during, and immediately following pregnancy. Data for Colorado can be found on CoHID (www.cdphe.state.co.us/cohid/index.html)

Premature Birth: Birth occurring prior to 37 completed weeks of gestation, but after the stage of viability (20 weeks gestation).

Prenatal: Existing or occurring before birth.

Preterm: Births occurring prior to 37 completed weeks of gestation.

Term: Births occurring between 37 and 41 completed weeks of gestation (259-293 days).

Trimester: A 3-month period of time. First trimester care, for example, refers to care initiated in the first three months of pregnancy.

Very Low Birth Weight: Birth weight of less than 1,500 grams (less than or equal to 3 lbs. 5 oz).

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