

Infant Mortality Trends among
Georgia Residents, 1995 – 2003:
Targeting Healthy People's 2010
Goals

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ABSTRACT

Population-based trends in infant mortality among Georgia Residents between 1995 and 2003 were assessed on characteristics such as race, birth weight, neonatal and post-neonatal periods, and cause of death. A statistical analysis was conducted to show that the Georgia infant mortality rate (IMR) remained constant throughout the study period and averaged 8.67 per 1,000 live births. The analysis revealed racial disparities, with an IMR ranging from 6.03 in white infants to 13.76 in black infants, with less than one percent (0.86%) change, on average, among the differences between black and white mortality rates across the nine-year period. The disparities were also evident in infants with low birth weight (LBW) and very low birth weight (VLBW). Black infants born with LBW (12.9%) and VLBW (9.98%) have more than twice the rate of infant mortality compared to white infants born with LBW (6.64%) and VLBW (1.12%). Mortality in the neonatal period accounted for more than half (67.96%) of all infant deaths and exhibited considerable ethnic differences. Among all groups, black male neonates (10.7) have the highest mortality rates. The average neonatal mortality rate across the entire study period is 5.89 (SD=0.20); the average post-neonatal mortality rate across the entire study period is 2.78 (SD=0.22). The five leading causes of death among Georgian infants in descending order were: birth defects, prematurity and low birth weight, Sudden Unexplained Infant Deaths (SUID), other perinatal conditions and respiratory conditions with racial differences in the ordering.

INTRODUCTION

Infant mortality rate (IMR) is a worldwide indicator of health status and social well-being and an important measure of a nation's health. IMR is defined as death in children under one year per 1,000 live births within a given time period and is divided into two categories: neonatal death (the period from birth to 27 days of age) and post-neonatal death (the period from 28 to 364 days of age) (WHO, 2004). Throughout the 20th century, the infant mortality rate in the United States declined by 90% reaching record lows in the early 2000s (CDC, MMWR, 1999). It declined from 7.6 in 1995 to 6.8 in 2003, with the only increase occurring in 2002 when the IMR was 7.0 (MMWR, 2005). During the same time period (1995-2003), the neonatal mortality and post-neonatal mortality rate declined from 4.9 to 4.6 and 2.6 to 2.23, respectively (CDC, MMWR, 2006). However, the U.S. still exhibits a higher IMR than many other countries and in 2003 ranked 28th among countries or geographic areas with a population of at least one million (Health, United States, 2006). While the overall national IMR declined, the IMR in specific subgroups that included low birth weight (LBW) infants weighing < 2500 grams, black infants, neonates, infants with certain conditions such as birth defects, prematurity & low birth weight and Sudden Infant Death Syndrome (SIDS) and infants living in the southern states of the U.S. (i.e. Georgia, Alabama, Mississippi, North Carolina, South Carolina, Florida, Arkansas, Tennessee and Louisiana) remained high (CDC, MMWR, 2002, Petrini et al., 2002, Goldhagen et al., 2005).

During 2003-2004, Georgia ranked 44th in the nation with respect to children's health status (Kids Count Data Book: State Profiles of Child Well-being, 2006). The ranking was based, among other factors, on the IMR of 8.5 (overall U.S. rate of 6.8) and the relatively high percentage of low birth weight babies of 9% in Georgia (overall U.S. rate of 7.9%). Participants from seven local communities around Georgia that took part in the Public Dialogues organized by the Governor's Council on Maternal and Infant Health voiced infant mortality, low birth weight and premature births as priority health issues affecting Georgia's mothers and infants. (Public Dialogues: Report on Findings, 2004).

Several studies examining infant mortality in the 1970s and 1980s in Georgia indicated similarities with national trends. Infant mortality rates decreased in white and black infants and included an increase in neonatal and post-neonatal survival due to birth-weight-specific mortality (Buehler, Hogue & Zaro, 1985; Buehler, McCarthy, Holloway & Sikes, 1986). Despite the overall decrease, mortality was in excess among black infants with the crude black-to-white infant mortality rate ratio above two (Sung et al., 1994). The highest mortality rates were seen in black male neonates due to higher rates of LBW neonate (twice the rate for white infants) and to higher birth-weight-specific mortality rates among normal birth weight black neonates (Binkin, Williams, Hogue, Chen, 1985). During 1980-1985, more than 60% of infant deaths in Georgia were LBW infants and 69% of deaths among blacks were associated with LBW (Sung et al., 1993, Sung et al., 1994). The three most frequent causes of death for Georgia infants in 1989 were respiratory distress syndrome, congenital anomalies and SIDS (Dean, 1996). A more recent report, *A Mid-Decade Look at Maternal and Child Health in Georgia*, by the Perinatal Epidemiology Unit of the Georgia Department of Human Resources examined the IMR in Georgia and the major causes of death for the time period 1990-1995 (Perinatal Epidemiology Unit, Division of Public Health, Georgia Department of Human Resources). The IMR continued to decline from 12.4 in 1990 to 9.4 in 1995, the LBW rate in Georgia remained rather constant from 8.6% to 8.8%, respectively, while the VLBW had a stable rate of 1.7% of all live births. However racial disparities still existed with the rate for black infants twice the rate for white infants. The top five leading causes of death among Georgian infants were birth defects, SIDS, respiratory distress syndrome, LBW and prematurity, and other perinatal conditions. Birth defects accounted for an average of 19% of all deaths between 1995-1998, at a rate of 170.4/100,000 live births compared to the national rate of 162.8/100,000 live births, placing Georgia 25th in the nation on birth defects-specific mortality (Petrini, 2002). SIDS decreased 20% from 1.5 deaths in 1994 to 1.2 in 1995. Respiratory distress syndrome showed the most dramatic decline (about

50%) in the same time period, from 192 infants in 1990 to 92 infants in 1995 (Perinatal Epidemiology Unit, Division of Public Health, Georgia Department of Human Resources).

The objectives of this study are to identify the trends in infant mortality in Georgia during 1995-2003 and to assess progress toward meeting the Healthy People 2010 Goals to reduce infant deaths to 4.5 (objective 16-1c), neonatal deaths to 2.9 (objective 16-1d), post-neonatal deaths to 1.2 (objective 16-1e), LBW to 5.0 (objective 16-10a) and VLBW to 0.9 (objective 16-10b) (Healthy People, 2010). In this respect, the study analyzes the overall crude rates in the state and percent changes from 1995 through 2003, including race and gender combinations; percent of LBW and VLBW of total live births; neonatal and post-neonatal mortality; and causes of death.

METHOD

The data for this study was provided by the Georgia Division of Public Health, Maternal and Child Health Epidemiology Unit and consists of two data sets: (1) a dataset containing information on all births in Georgia between 1995 and 2003, and (2) a linked death-cohort dataset containing information on infant deaths during the same time frame. Linked files are commonly used in studies of infant mortality, since additional information can be obtained by combining both files (Buehler, 2000). The death-cohort file consists of observations (deaths in a given year) which are linked back to the original birth file (births from the same year or the previous year). Data analysis was conducted using SAS 9.1, SPSS 15.0, and Microsoft Excel. The original death-cohort file consisted of 10,086 observations. By excluding non-Georgia residents (414 observations) and infants of races other than black or white (183 observations), there were 9,489 observations remaining on which to conduct the analysis. The overall original birth file consisted of 1,267,202 observations. Once non-Georgia residents (28,087 observations) and infants other than black or white in race (32,491 observations) were omitted, there were 1,206,624 observations remaining in the birth file used to calculate mortality rates of Georgia residents between 1995 and 2003. Mortality rates were computed using ratios of deaths to births, utilizing both datasets, for the various race-gender combinations of infants, as well as overall. Descriptive statistics were used to analyze the data.

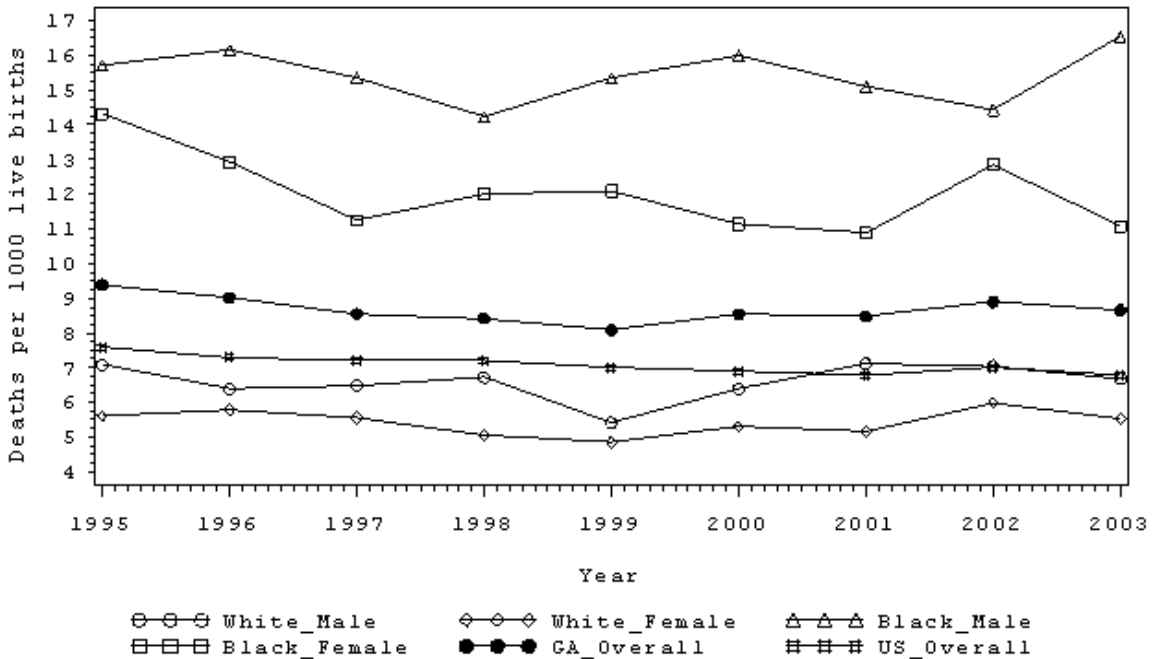
RESULTS AND DISCUSSION

Figure 1 shows the infant mortality rates (deaths per 1,000 live births) of Georgia residents by gender and race between 1995 and 2003, with comparison to the overall U.S. rates during this period obtained from the Linked Birth/Infant Death Data Sets of the National Center for Health Statistics (NVSR, 1995-2003). There appear to be greater differences, within a given year, between races rather than differences within races. The average IMR for blacks overall is 13.76 with a standard deviation of 0.65 between 1995 and 2003. The largest percent change among blacks occurred between 1996 and 1997, with a decrease of -8.41% from 14.56 to 13.33 deaths. The smallest percent change among blacks was between 1999 and 2000, indicating a decrease of 1.10% in the IMR between 1999 and 2000 among black infants. On average, across the nine-year period, there is a decrease of 0.92% in mortality rates among black infants overall and a decrease by 0.19% among white infants. The mean overall IMR among whites is 6.03 (9SD = 0.39). The greatest percent change in IMR among whites occurred between 1999 and 2000, with an increase of 13.72% from 5.15 to 5.86. The smallest percent change among whites occurred between 1996 and 1997, with a decrease of 0.97% from 6.10 to 6.04.

The greatest difference of 8.65 between black and white infants occurred in 1995, while the smallest difference of 6.85 occurred in 2001. The average difference in IMR between blacks and whites across the nine-year period is 7.74 (SD = 0.68). Differences were computed using overall race-specific mortality rates. The percent change in the difference between overall black and overall white mortality rates ranges from as small as 1.21% between the years 1997 and 1998 to as large as 19.20% between 1998 and 1999. With a difference of 7.29 and 7.21 in

IMR between blacks overall and whites overall for 1997 and 1998, respectively, the percent change is calculated to be -1.21% $((7.21 - 7.29) / 7.29 * 100\%)$. This change between 1997 and 1998 is the smallest in magnitude. Notice that the direction of this change is decreasing (indicated by the negative value) over time since the difference for 1998 is smaller than that corresponding to 1997. The largest percent change among the differences between overall black and overall white mortality rates occurs between 1998 and 1999.

Figure 1: Mortality rate by gender and race in Georgia, including Georgia overall and the U.S. overall, 1995 – 2003



The percent change is computed to be 19.20% $((8.59 - 7.21) / 7.21 * 100\%)$ where the percent change increases by this amount between 1998 and 1999. Across the nine-year period, the average percent change among the differences between black and white IMR is positive indicating less than one percent increase, 0.86%, between 1995 and 2003.

With respect to gender, male infant deaths were more common than female infant deaths during this time. The largest difference in IMR between genders occurred in 2001, with a difference of 2.68 deaths; while the smallest difference was in 2002, with a difference of 1.20 deaths. The average difference in IMR between males and females across the nine-year period is 1.88 (SD = 0.55). Differences were computed using overall gender-specific mortality rates. Certainly gender differences in IMR are not as large as racial differences. Among black infants, the average difference in mortality rates between males and females across time is 3.37 (SD = 1.43). Among whites, the mean difference in IMR between male and female infants is 1.17 (SD = 0.47).

While the overall Georgia and U.S. rates remained the most constant over this nine-year period, IMR of Georgia residents by gender and race appear to experience greater fluctuation throughout this time, as evidenced by the greater deviations across time such as those mentioned above. The average overall Georgia IMR across time is 8.67 (SD = 0.38). This rate greater than the average overall U.S. mortality rate of 7.09 (SD = 0.26) across the nine-year period (See Figure 1).

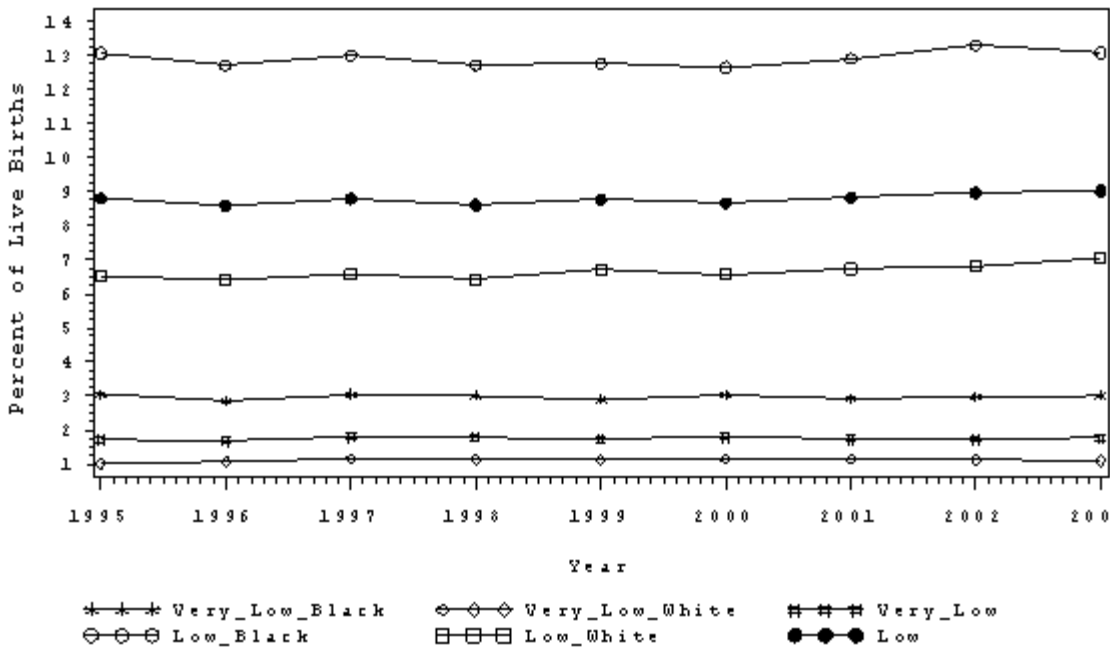
Regarding IMRs among race-gender combinations, rates for black females appear to have the greatest fluctuations with an average percent change of -2.64%, indicating an average decrease of 2.64% across the years 1995 to 2003. IMRs for black males possess an average percent change over nine years of 0.92%, while whites have the smaller average percent changes of 0.13% and -0.09% for females and males respectively. The average percent change for Georgia overall is -0.94%, while the overall U.S. IMRs during this time period have an average decrease of 1.36%. While black males and white females experienced an increase in the average percent change in IMR between 1995 and 2003, all other groups' average percent change in IMRs declined.

Figure 2 portrays the percent of live births among Georgia residents having LBW (< 2500 grams) and VLBW (< 1500 grams), by race. On average, over the study period, approximately 8.78% (N = 96,264; SD = 0.15%) of live births among Georgia residents were LBW; while 1.76% (N = 19,308; SD = 0.22%) of live births were VLBW. Accounting for race, blacks have a larger average percentage than whites of LBW infants, comprising 12.90% (N = 48,223; SD = 0.22%) of live births: LBW white infants comprise 6.64% (N = 48,041; SD = 0.20%) of live births, on average, over the nine-year period. The final year in the study, 2003, contains the highest percentage of LBW white infants at 7.04% (N = 6,188) as well as overall at 9.02% (N = 11,785). The highest percentage of LBW black infants occurred in 2002 at 13.30% (N = 5,678), with 2003 having the second largest percentage among this group at 13.07% (N = 5,597). Each trajectory in Figure 2 appears somewhat stable with little variation in percentages across time. The percent change in the percentage of LBW infants ranges from 0.00% (i.e., no change) for VLBW white infants from 2000 to 2001 to 6.62% from 1995 to 1996, also for VLBW white infants. Percent changes averaged across 1995 to 2003 range from 0.03% (SD = 2.23%) among LBW black infants to 1.10% (SD = 3.40%) among VLBW white infants. With the exception of a 0.04% decrease (SD = 4.63%) in the average percent change among VLBW blacks, all groups have an increase in the average percent change from 1995 to 2003. Independent t-tests were conducted to determine whether there exists a statistically significant difference in birth weight by race within each year of the study. All nine tests produced highly significant results ($p < 0.001$). A similar result exists for an independent t-test on birth weight by race across all nine years combined ($p < 0.001$).

The largest mean difference in birth weight between blacks and whites occurred in 1996 with an average difference of 543.41 grams between black (N = 561; Mean = 1,358.09 grams; SD = 1,113.04 grams) and white (N = 446; Mean = 1,901.49 grams; SD = 1,282.36 grams) infants. In contrast, 2003 is the year in which the smallest, yet still highly significant, mean difference occurred with 306.57 grams between black (N = 593; Mean = 1,452.36 grams; SD = 1,192.98 grams) and white (N = 538; Mean = 1,758.93 grams; SD = 1,255.40 grams) infants. Whites have the larger average birth weight each year, with the largest average birth weight occurring in 1995 for white infants with 1,977.83 grams (N = 457; SD = 1,260.18 grams). In 2003, the smallest average birth weight for whites occurred with a weight of 1,758.93 grams (N = 538; SD = 1,255.40 grams). Likewise for black infants, the highest average birth weight occurred in 1995 with 1,527.86 grams (N = 578; SD = 1,215.46 grams): the smallest average birth weight among blacks occurred in the following year, 1996, with 1,358.09 grams (N = 561; SD = 1,113.04 grams). Furthermore, significance tests were performed, by year (each $p > 0.10$) and over nine years combined ($p = 0.328$), indicating that birth weight is not significantly affected by gender.

The overall neonatal mortality shows a steady decrease from 1995 (with the highest rate for the entire study period at 6.25) to 1999 (with the lowest rate for the study period at 5.59) and these decreases in percent changes range from 1.97% to 3.46%. Between 2000 and 2003, the overall neonatal mortality ranges from 5.81 in 2001 to 5.85 in 2002. The largest percent change occurs between 1999 and 2000 with an increase of 4.00% reaching a rate of 5.82. Similarly to neonatal mortality rates, the highest post-neonatal mortality rate occurs in 1995 (at a

Figure 2: Percent of live births with low birth weight by race in Georgia, 1995-2003



rate of 3.14), while the smallest rate occurs in 1999 (at a rate of 2.50). Percent changes are higher among post-neonatal mortality, ranging from a decrease of 1.87% between 2000 and 2001 to an increase of 13.98% from 2001 to 2002.

When controlling for race among neonatal mortality, rates range from 3.50 in 1999 to 4.15 in 2001 among white infants and from 9.05 in 2001 to 10.33 in 1996 among black infants. However, neonatal mortality rates among blacks fluctuate less than among whites with percent changes ranging from a decrease of 7.68% between 1996 and 1997 to an increase of 3.21% between 1998 and 1999 among blacks; with a range from a decrease of 10.45% between 1998 and 1999 to an increase of 14.57% between 1999 and 2000 for whites. Similarly for post-neonatal mortality when controlled for race, percent changes range from a decrease of 12.02% between 1995 and 1996 to an increase of 9.30% between 2001 and 2002 among blacks; and a range among whites from a decrease of 18.15% between 1998 and 1999 to an increase of 19.48% between 2001 and 2002. Racial differences were not as large among post-neonatal mortality rates with a range from 1.66 in 1999 to 2.41 in 2002 among whites and from 3.80 in 1997 to 4.81 in 1995.

Further controlling for race and gender, black male infants have the highest neonatal mortality rates, with a peak at 11.53 in 1996 and the smallest rate for this group at 9.81 in 2002. These rates are at least twice as large as those for white males, whose rates range from 3.55 in 1999 to 4.70 in 2001. Similar trends are observed for post-neonatal mortality. Among black males, post-neonatal mortality rates range from 4.09 in 1998 to 5.58 in 2003. Among white males, such rates range from 1.85 in 2000 to 2.60 in 2002. Finally, differences among females by race also show differences at least twice as large. For neonatal mortality, rates range from 3.32 in 1998 to 3.84 in 2003 among white females, while black females' rates range from 7.62 in 2003 to 9.43 in 1995. Post-neonatal rates show a similar difference in magnitude. Among black females, post-neonatal mortality rates range from 3.10 in 2001 to 4.87 in 1995, while white females' rates range from 1.43 in 1999 to 2.20 in 2002 (See Figure 3).

Figure 3: Percent of live births by neonatal stage in Georgia, 1995-2003
 Average neonatal mortality = 5.89 (SD=0.20); average post-neonatal mortality = 2.78 (SD=0.22).

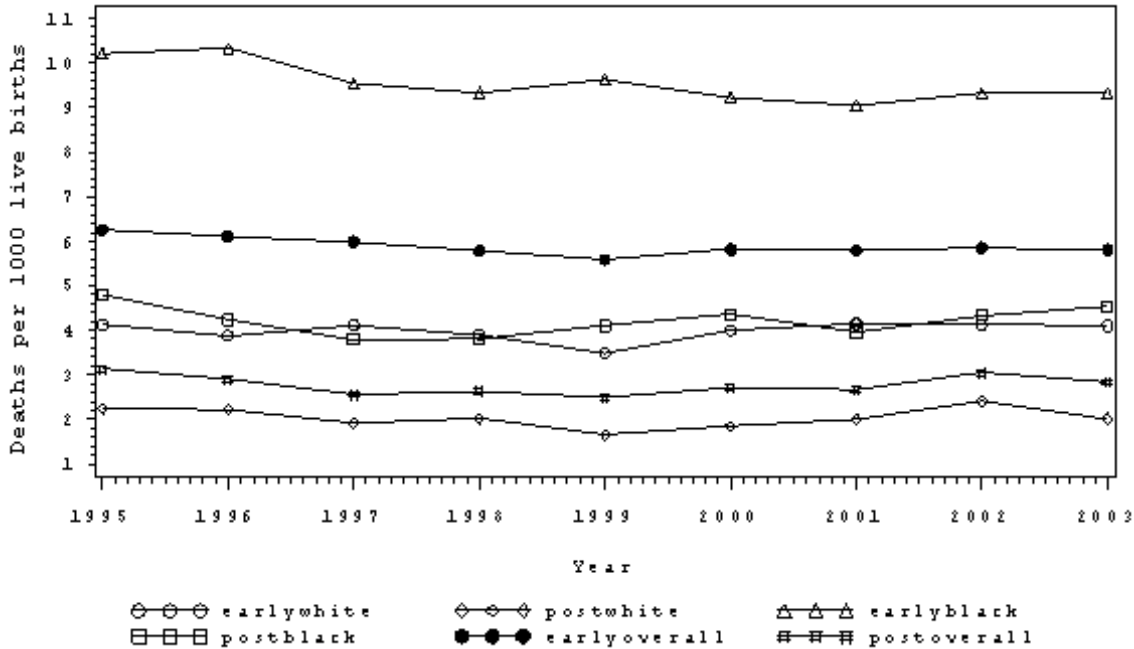


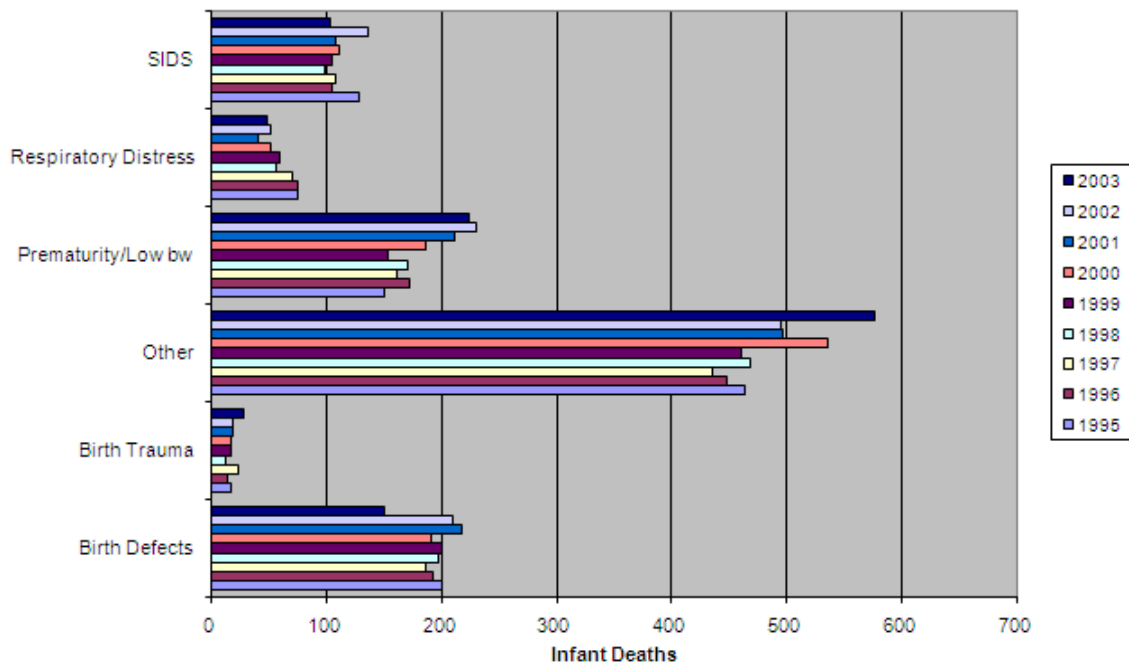
Figure 4 identifies the six leading causes of infant deaths in Georgia between 1995 and 2003. Table 1 also identifies these causes, providing an overall ranking of the causes in addition to a ranking of causes by race. Causes of death were based on the International Classification of Diseases (ICD-9 and ICD-10 codes). ICD-9 codes were used for four years from 1995 through 1998, and ICD-10 codes were used from 1999 through 2003. The ICD-10 classification took affect January 1, 1999 (NCHS, 2007).

The leading causes of death among Georgia infants between 1995 and 2003 are, in descending order: birth defects, prematurity/low birth weight, sudden unexplained infant deaths, other conditions originating in the perinatal stage, respiratory conditions of the perinatal stage, and intrauterine hypoxia/birth asphyxia/birth trauma. Among white infants, birth defects were the leading cause of death; sudden unexplained infant deaths were the second leading cause, while prematurity/low birth weight was the third leading cause of death. Among black infants, prematurity/low birth weight was the leading cause of death, while birth defects were the second leading cause of death in infants.

Cause of death is significantly associated with race as shown through chi-square tests of independence for each year of the study ($p < 0.001$) and across all nine years combined ($p < 0.001$). In contrast, gender is not significantly associated with cause of death for each year ($p > 0.112$ for all nine tests): over the entire study period gender shows trends toward significance ($p = 0.05$). Figure 4 portrays clear increases in prematurity/low birth weight throughout the study period. There also appear to be increases over time in other perinatal conditions. In contrast, respiratory conditions originating in the perinatal period is the sole cause of death that has a clear decrease over time. While the number of birth defects in 2003 (N = 151) is much less than any other year with a decrease of 28.10% from the previous year, there is not a clear trend in the

number of deaths associated with birth defects due to the fluctuations in cases throughout the years. Average percent changes over time and between specific years are perhaps better indicators of the trends in causes of death. Overall, respiratory conditions and birth defects indicate an average decrease of 3.90% (SD = 15.53%) and 2.73% (SD = 12.05%), respectively, in the deaths associated with these conditions over time. Likewise among black infants, respiratory conditions and birth defects have decreases in average percent change throughout the study period at 4.47% (SD = 22.92%) and 3.79% (SD = 18.14%). Among white infants, birth defects are the only cause of death with an average decrease in the percent change at 1.39% (SD = 14.22%) while all other causes have average percent changes indicating increases in cases, on average, over the nine-year period.

Figure 4: Six leading causes of infant death in Georgia, 1995-2003



CONCLUSIONS

While the overall IMR for Georgia remained rather constant during the study period at an average of 8.67, it was still above the national average of 7.09. Great differences were seen between races. The average IMR for black infants (13.7) was slightly over twice the IMR for white infants (6.03). Although mortality rates among blacks (0.92%) showed a slightly higher decrease when compared to whites (0.19%) over the study period, the racial disparity remained largely unchanged with less than one percent change among differences between black and white IMR. Average birth weight was also significantly affected by race ($p < 0.001$), with the mean difference in birth weight between black and white infants ranging from 306.57

Table 1: Causes of death of GA residents, overall and by race, based on the International Classification of Diseases (ICD), 1995 – 2003

Ranking (Total Deaths)			Cause of Death	ICD-9 Codes	ICD-10 Codes
Overall	White	Black			
1 (1746)	1 (1062)	2 (684)	Birth defects (congenital malformations, chromosomal abnormalities)	740.0 - 759.9	Q00.0 - Q99.9
2 (1659)	3 (545)	1 (1114)	Prematurity/low birth weight	765.0 - 765.29	P07.0 - P07.3
3 (1086)	2 (551)	3 (535)	Sudden unexplained infant death, including Sudden Infant Death Syndrome (SIDS)	798.0 - 798.2; 798.9	R95; R96.0; R96.1; R98; R99
4 (779)	4 (351)	4 (428)	Other perinatal conditions (maternal factors and complications of pregnancy, labor, & delivery; infections specific to perinatal period, including congenital syphilis, gonococcal infection, & congenital pneumonia)	090.0 - 090.9; 098.0 - 098.8; 760.0 - 760.9; 770.0; 771.0 - 771.89	A50.0 - A50.9; A54.0 - A54.9; P00.0 - P04.9; P23.0 - P23.9; P35.0 - P39.9
5 (538)	5 (220)	5 (318)	Respiratory conditions originating in the perinatal period: Respiratory Distress Syndrome and Bronchopulmonary Dysplasia	769.0; 770.6 - 770.7	P22.0 - P22.1; P22.8 - P22.9; P27.0 - P27.9
6 (200)	6 (97)	6 (103)	I/uterine Hypoxia Birth Asphyxia Birth Trauma	767.0 - 768.9	P10.0 - P15.0; P15.9; P20.0 - P20.1; P20.9; P21.0 - P21.1; P21.9; P91.6

grams in 2003 to 543.41 grams in 1996. The percentage of black infants with LBW (12.9%) and VLBW (9.98%) is more than twice the percentage of white infants with LBW (6.64%) and VLBW (1.12%). The highest percentage of LBW black infants (13.3%) was seen in 2002, while the highest percentage of white LBW infants (7.04%) was seen in 2003. Throughout the study period, the increase in rates is seen in all groups with the exception of VLBW black infants.

Mortality in the neonatal period accounted for more than half (67.96%) of all infant deaths and exhibited considerable ethnic differences. Neonatal and post-neonatal mortality rates among black infants overall (9.55 and 4.22 respectively) are more than twice the rates for white infants overall (3.99 and 2.04 respectively). Across the entire study period the average neonatal mortality rate (5.89) is more than twice the average post-neonatal mortality rate (2.78) and is highest among black male neonates (10.70).

Among the five leading causes of death, respiratory conditions and birth defects showed an average decrease over time, while other perinatal conditions and prematurity/low birth weight appear to increase. Despite a significant reduction of birth defects from 2002 to 2003 (28%), birth defects still remain the major cause of death for infants in Georgia. The cause of death is significantly associated with race ($p < 0.001$). In white infants, birth defects are the leading cause of death, followed by SUID and prematurity/low birth weight. In black infants, prematurity/low birth weight is the leading cause of death, followed by birth defects and SUID. The remaining leading causes of death show no racial disparities.

While our further research endeavors will examine birth weight specific mortality, the influence of maternal factors and place of residence on the IMR of Georgia residents, our current analysis indicates that if the current trends in IMR (average percentage 8.67), LBW (8.78%), VLBW (1.76%), neonatal mortality (5.89) and post-neonatal mortality (2.78) continue, Healthy People 2010 goals are unattainable for Georgia residents.

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