Overview of the National Infant Mortality Surveillance (NIMS) Project—Design, Methods, Results

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This research was supported in part by the National Institute of Child Health and Human Development, the Health Resources and Services Administration, and the National Center for Health Statistics, all agencies of the Public Health Service.

The findings were presented in part at the annual meeting of the Population Association of Amercia, San Francisco, CA, April 3, 1986, at the National Infant Mortality Surveillance Conference, Atlanta, GA, May 1, 1986, and at the annual meeting of the American Public Health Association, Las Vegas, NV, September 29, 1986.

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Synopsis

The recent slowdown in the decline of infant mortality in the United States and the continued high risk of death among black infants (twice that of white infants) prompted a consortium of Public Health Service agencies to collaborate with all States in the development of a national data base from linked birth and infant death certificates. This National Infant Mortality Surveillance (NIMS) project for the 1980 U.S. birth cohort provides neonatal, postneonatal, and infant mortality risks for blacks, whites, and all races in 12 categories of birth weights. (Note: Neonatal mortality risk = number of deaths to infants less than 28 days of life per 1,000 live births; postneonatal mortality risk = number of deaths to infants 28 days to less than 1 year of life per 1,000 neonatal survivors; and infant mortality risk = number of deaths to infants less than 1 year of life per 1,000 live births.)

Separate tabulations were requested for infants born in single and multiple deliveries. For single-delivery births, tabulations included birth weight, age at death, race of infant, and each of these characteristics: infant's live-birth order, sex, gestation, type of delivery, and cause of death; and mother's age, education, prenatal care history, and number of prior fetal losses at 20 weeks' or more gestation. An estimated 95 percent of eligible deaths were included in the NIMS tabulations. The analyses focus on three components of infant mortality: birth weight distribution of live births, neonatal mortality, and postneonatal mortality.

The most important predictor for infant survival was birth weight, with an exponential improvement in survival by increasing birth weight to its optimum level. The nearly twofold higher risk of infant mortality among blacks was related to a higher prevalence of low birth weights and to higher mortality risks in the neonatal period for infants weighing 3,000 grams or more, and in the postneonatal period for all infants, regardless of birth weight. Regardless of other infant or maternal risk factors, the black-white gap persisted for infants weighing 2,500 grams or more.

EACH YEAR, APPROXIMATELY 40,000 U.S. infants die before reaching their first birthday. In 1984 the infant mortality rate was 18.4 per 1,000 live-born black infants and 9.4 per 1,000 live-born white infants (*1*). Within 6 years, the rate for black infants must be reduced by 34.8 percent if the United States is to achieve its 1990 objective of 12 infant deaths per 1,000 live births (*2*). It is unlikely that the 1990 objective will be attained for black infants, since there was only a 14.0 percent reduction in black infant mortality rates from 1980 (*3*) to 1984.

These slow, recent declines in infant mortality stand in sharp contrast to three observations that indicate the necessity and attainability of the 1990 objective for infant mortality: First, success in improving survival for low birth weight infants has not been accompanied by a parallel decrease in the frequency of low birth weight—the most important determinant of infant survival (*4–11*). Of all infants born in 1980 who died, more than 60 percent were born with low birth weights (less than 2,500 grams (g)) (*12*). Second, other industrialized nations have already achieved lower infant mortality rates (*11,13,14*). Third, although mortality rates have decreased for both white and black infants, black infants continue to suffer neonatal and postneonatal mortality rates that are approximately twice the rates for white infants (*8,15,16*).

Epidemiologic analyses of low birth weight and infant mortality can guide health planners in developing and assessing interventions to reduce infant mortality. By identifying problems in maternal and infant care, health planners can target high-risk groups for more intensive interventions. Calculation of mortality risks by birth weight and other characteristics, which is essential to such analyses, requires linkage of individual birth and death certificates. Despite the importance of linking birth records with death records, it has not been done since the national linkage of records for infants born in 1960 (*17*).

Recently the National Center for Health Statistics (NCHS) completed a pilot project in nine States to prepare for the introduction of an annual, national, linked birth-infant death file beginning with the 1983 birth cohort (*18*). To provide a more immediate data source between 1960 and future national linkages and to identify issues to be addressed before a national linked file can be implemented, the Centers for Disease Control (CDC) undertook the 1980 National Infant Mortality Surveillance (NIMS) project. This overview paper presents the history and rationale of the NIMS project, its design and methods, and basic analyses of differences in infant mortality for blacks and for whites.

History and Rationale

In May 1983, CDC sponsored a meeting with representatives of the Association for Vital Records and Health Statistics, State Directors of Maternal and Child Health, the American Academy of Pediatrics, the American College of Obstetricians and Gynecologists, NCHS, and the National Institute of Child Health and Human Development (NICHD). The participants agreed to the assembly of a national, birth-weight-specific infant mortality data base by means of collecting data from all States in which linked birth-death records were already available. CDC received partial funding from NICHD, NCHS, and the Health Resources and Services Administration (HRSA). Key to this project was the full cooperation we at CDC received from all States and other vital registration reporting areas.

Participating States incurred costs—they were partially reimbursed by CDC—for programming, computer use, and professional and clerical time. To minimize the workload for approximately half the States that had linked certificates but in which the data were not in machine-readable records, we requested tabular data rather than individually linked records on computer tape. This data collection method also offered the advantages of relative speed of national data compilation and the opportunity to include the maximum number of States in the final report.

The planning group decided to collect birth-weight-specific infant mortality data for the cohort of infants born in 1980. Selection of that year allowed sufficient time for linkages to have been completed, as well as a 20-year followup from the most recent national linkage.

Finally, the planning participants agreed to disseminate the information as quickly as possible. The mechanisms used or to be used include a National Infant Mortality Surveillance (NIMS) Conference (May 1–2, 1986), preliminary data analyses (*12,19*), a NIMS Report (*20*) with detailed tabulations and methods, scientific reports (including those in this issue and others in progress), and a public use tape (to be released in 1987).

Design and Methods

Fifty-three vital statistics reporting areas participated in the NIMS project: 50 States, New York City, the District of Columbia, and Puerto Rico (subsequently referred to as States). These national-level tabulations do not include Puerto Rico. All States were able to link birth and death certificates for infants who were born alive in 1980 and who died within the first year of life in 1980 or 1981. Since States are primarily concerned with their residents, we asked each State to provide tables of all infant deaths for resident births in 1980, regardless of State of residence at death. State of residence was defined as State of mother's

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residence at the time she gave birth. This request was limited to live births with birth weights at least 500 g.

Information on all resident births for each State serves as the denominator for infant mortality risks. To reduce the reporting burden for each State, CDC generated denominators from the computer tape of 1980 natality records produced by NCHS, with exceptions for Maine and New Mexico as described elsewhere (*20*). We also used the NCHS natality tape for information on live births under 500 g. Assuming that all infants weighing less than 500 g died during the neonatal period, we added those births—infants less than 500 g—to the death data provided by the States to arrive at the total infant deaths.

Because the NIMS data are for deaths occurring to a birth cohort, rather than for births and deaths occurring in a given year, we use the term mortality "risk" instead of "rate." The neonatal mortality risk (NMR) was defined as the number of neonatal deaths (less than 28 days) per 1,000 live births, the postneonatal mortality risk (PNMR) as the number of postneonatal deaths (28 days to under 1 year) per 1,000 neonatal survivors, and the infant mortality risk (IMR) as the number of infant deaths (less than 1 year) per 1,000 live births.

Birth weights were divided into 250-gram intervals for infants weighing from 500 to 1,499 g, 500-gram intervals from 1,500 to 4,499 g, one interval for 227 to 499 g, and one interval for infants weighing 4,500 to 8,165 g (the highest acceptable birth weight). Birth weights less than 227 g (8 oz), more than 8,165 g (18 lb, 0 oz), and missing values were included with unknowns.

States provided CDC with the number of infant deaths by birth weight, age at death (neonatal and postneonatal) for single deliveries, race (blacks, whites, and all races), and plurality. Race of infant was based on the race of both parents, using the NCHS algorithm (*21*). Hispanics have emerged as a major ethnic group in the United States having distinct reproductive life histories (*22–26*). However, because States use a variety of methods to define Hispanics (*22–24*), a national study of Hispanics could not be launched with the NIMS data. Puerto Ricans are described in a separate report (*27*), and information on Hispanics in California and New York City is provided as an appendix to the NIMS Report (*20*). Native Americans, Asians, and Pacific Islanders in selected States have also been analyzed (CDC, unpublished data).

We requested separate tabulations for infants born in single and in multiple deliveries. For single deliveries, we obtained tabulations by birth weight, age at death, race, and each of the following characteristics: infant's live-birth order, sex, gestation, type of delivery (vaginal or cesarean section), and the specific underlying cause of death (using the International Classification of Deaths, Ninth Revision) (*28*); mother's age, education, prenatal care history, and number of previous fetal losses at 20 or more weeks' gestation. Type of delivery is not recorded on the NCHS natality tape; therefore, we have death data only for type of delivery.

Definitions used for the tabulation of these characteristics paralleled as much as possible those for natality statistics used by NCHS. Details of the definitions for each characteristic are provided in the NIMS Report (*20*). Occasionally, States had some difficulty using the definitions (*20,29*). Presentation of mortality risks for individual characteristics includes only those of States that reported the given variable substantially like the definitions provided (*20*). The number of States excluded from particular tables varied from 2 for infant's sex to 18 for gestational age of infants born in multiple deliveries (*20*).

We tabulated information on the number of prenatal care visits and the month prenatal care began by birth weight rather than by gestational age. Although number and timing of prenatal care visits are confounded by duration of gestation, gestational age is one of the least reliable variables obtained from birth certificates and is missing for approximately 20 percent of births (*30*).

Although States are the source of NCHS natality data, NCHS does some processing of State data, such as imputation of unknown or extreme values for selected variables. For births in 1980, NCHS assigned a value by imputation for unknown race and maternal age. In obtaining data for deaths by these characteristics from individual States, we could not recreate this imputation procedure. However, we did use the NCHS method of assigning unknown plurality to single delivery. In NIMS, unknown race was included only in tabulations of all races, without distribution to other race groups. We assigned unknown maternal age to known categories proportional to the distribution of known values. Unknown values of other maternal and infant characteristics were handled similarly (*20*). Unknown race is rare, since race for both parents must be unknown before the child's race is classified as unknown. Exclusive of data of New Mexico (*20*), NCHS imputed race for only 0.36 percent of births.

For calculation of mortality risks, we assigned infants with unknown birth weight (0.2 percent of births and 3.3 percent of infant deaths) to birth weight categories according to the proportion of births and deaths with known birth weight (*20*). The NIMS Report includes details of the procedure used (*20*).

To promote uniformity in reporting and tabulating deaths, we prepared a detailed set of instructions for the States and provided extensive telephone assistance (*29*). After receiving the data, we conducted editing checks that included visual examination and graphing of birth weight distributions, birth-weight-specific neonatal mortality, and birth-weight-specific postneonatal mortality for each State. States provided information regarding the death certificates that they could not link (*31,32*). To estimate State-specific and total underreporting of infant mortality related to failure to link death certificates with corresponding birth certificates, we produced a synthetic cohort of deaths to infants born in 1980 (*20,31,32*). We obtained the expected number of deaths by selecting from NCHS annual mortality tapes for deaths in 1980 and 1981 those deaths that occurred among U.S. residents less than 1 year of age who were born in 1980 (*20*). The infant death certificate does not have the infant's residence at birth, but does include the infant's residence at death and place of birth and death. Several estimates of unreported deaths by State of residence at birth can be obtained by using different assumptions of the correlation of each of these three items to residence at birth (*20,31,32*). One such analysis is presented in this paper.

Our analyses of U.S. infant mortality focus on these three components: birth weight distribution of live births, neonatal mortality, and postneonatal mortality. We divide infant mortality into these three components for description and analysis because interventions aimed at improving each one differ substantially. For example, reducing low birth weight requires identification of risk factors for low birth weight before pregnancy and during the prenatal period. On the other hand, reducing neonatal mortality focuses not only on improving birth weight but also on improving intrapartum and newborn care, including regionalization of perinatal services and identification of infants at high risk of mortality after their release from the hospital. Intervention to reduce postneonatal mortality focuses on improvement of well- and sick-child care and intensive followup of infants at high risk of postneonatal mortality. We also examine the birth weight distribution of neonatal, postneonatal, and infant deaths, to determine how deaths of smaller and larger infants contribute to overall infant mortality risk. This analysis can focus attention on those groups of infants for whom improvement in survival would have the most overall impact on infant mortality.

In this paper, we present results for single-delivery births only. Deaths of infants born in multiple deliveries, who are included in the NIMS Report (*20*), comprised 10 percent of both black and white infant deaths (*19*) and will be the subject of a forthcoming report.

Results

Birth weight distribution. In 1980, there were 3,542,995 single deliveries (table 1). Infants less than 1,500 g were 1.0 percent of all live births, but 2.1 percent of black live births. Likewise, infants in the intermediate low birth weight category of 1,500 to 2,499 g comprised 5.0 percent of all births but 9.2 percent of black births. This birth weight discrepancy indicated that while blacks comprised 16.2 percent of single-delivery births, among lower weight infants blacks comprised 39.8 percent of those weighing less than 500 g, 35.3 percent of those 500 to 1,499 g, and 29.8 percent of those weighing 1,500 to 2,499 g. Within each birth weight category of less than 2,500 g, the relative risk for black infants being born with low birth weight, compared with whites, was over 2.0. At the higher birth weight extreme, 1.9 percent of all births, but only 0.8 percent of black births were 4,500 g or more.

Birth-weight-specific infant mortality.

Neonatal mortality. Neonatal mortality decreased sharply with increasing birth weight up to

Table 1. Number and percentage distribution of live births, by birth weight and race, single-delivery infants born during 1980

Race	Less than 500 g	500 to 999 g	1,000 to 1,499 g	1,500 to 1,999 g	2,000 to 2,499 g	2,500 to 2,999 g	3,000 to 3,499 g	3,500 to 3,999 g	4,000 to 4,499 g	4,500 g or more	Unknown	Total
						Number						
Blacks	1,128	4,815	6,090	12,093	40,638	138,935	224,234	116,282	25,139	4,702	1,250	575,30
Whites	1,630	7,775	11,364	25,046	92,947	405,910	1,051,300	897,828	286,208	59,908	5,941	2,845,85
All races[1]	2,832	12,920	17,999	38,302	138,510	568,680	1,325,476	1,045,360	319,086	66,279	7,551	3,542,99
						Percent						
Blacks	0.2	0.8	1.1	2.1	7.1	24.1	39.0	20.2	4.4	0.8	0.2	100.0
Whites	0.1	0.3	0.4	0.9	3.3	14.3	36.9	31.5	10.1	2.1	0.2	100.0
All races[1]	0.1	0.4	0.5	1.1	3.9	16.1	37.4	29.5	9.0	1.9	0.2	100.0

[1] All races includes unknown race and infants of races other than white and black.

SOURCE: Data are from NCHS natality tape except for Maine and New Mexico (see reference *20*).

Table 2. Infant mortality risk by birth weight[1], age at death, and race, single-delivery infants born during 1980

Race	Less than 500 g	500 to 999 g	1,000 to 1,499 g	1,500 to 1,999 g	2,000 to 2,499 g	2,500 to 2,999 g	3,000 to 3,499 g	3,500 to 3,999 g	4,000 to 4,499 g	4,500 g or more	Total
						Neonatal deaths per 1,000 live births					
Blacks	1,000.0	615.6	131.3	36.1	10.6	3.6	2.4	2.5	2.8	8.7	12.5
Whites	1,000.0	660.8	212.1	61.6	18.3	4.2	1.8	1.3	1.4	3.0	6.2
All races[2]	1,000.0	647.6	186.5	53.9	16.0	4.0	1.9	1.4	1.5	3.5	7.3
						Postneonatal deaths per 1,000 neonatal survivors					
Blacks	...	157.1	49.8	24.2	11.6	6.5	4.4	3.2	3.3	4.1	6.5
Whites	...	115.0	43.7	18.9	9.4	4.4	2.5	1.8	1.7	2.0	3.1
All races[2]	...	135.2	45.8	20.7	10.2	4.9	2.9	2.0	1.9	2.2	3.7
						Infant deaths per 1,000 live births					
Blacks	1,000.0	676.0	174.6	59.4	22.1	10.0	6.8	5.7	6.1	12.8	18.9
Whites	1,000.0	699.8	246.5	79.3	27.5	8.5	4.3	3.1	3.1	5.1	9.3
All races[2]	1,000.0	695.2	223.7	73.5	26.0	8.9	4.8	3.5	3.4	5.7	11.0

[1] Number of infants with unknown birth weight were redistributed according to percentage of infants with known birth weight.

[2] All races includes unknown race and infants of other races.

SOURCE: National Infant Mortality Surveillance Report.

4,000 g for both blacks and whites (table 2). When we used data with unknown values distributed among known values, the neonatal mortality risk (NMR) for single-delivery infants less than 1,500 g at birth was 431.2 deaths per 1,000 live births, compared with 2.1 deaths per 1,000 live births for single-delivery infants weighing 2,500 g or more. There was an almost 400-fold relative risk for infants weighing 500 to 999 g compared with those weighing 3,000 to 3,999 g. Compared with whites, black infants less than 3,000 g experienced a lower birth-weight-specific neonatal mortality, and heavier black infants experienced a much higher birth-weight-specific neonatal mortality (table 2 and fig. 1).

Postneonatal mortality. Postneonatal mortality decreased with increasing birth weight up to 4,000 g, although the slope was not as steep as for neonatal mortality (table 2 and fig. 2). Within all birth weight categories, blacks experienced higher postneonatal mortality than did whites. The overall relative risk of 2.1 is higher than all birth-weight-specific relative risks because of the greater preponderance of black neonatal survivors in the lower birth weight ranges.

With respect to neonatal mortality, optimal birth weight for blacks was in the 3,000 to 3,499 g category, while optimal birth weight for whites was in the 3,500 to 3,999 g category. For postneonatal mortality, the optimal survival categories were 500

Figure 1. Neonatal mortality risks by race and birth weight, United States, 1980 live birth cohort

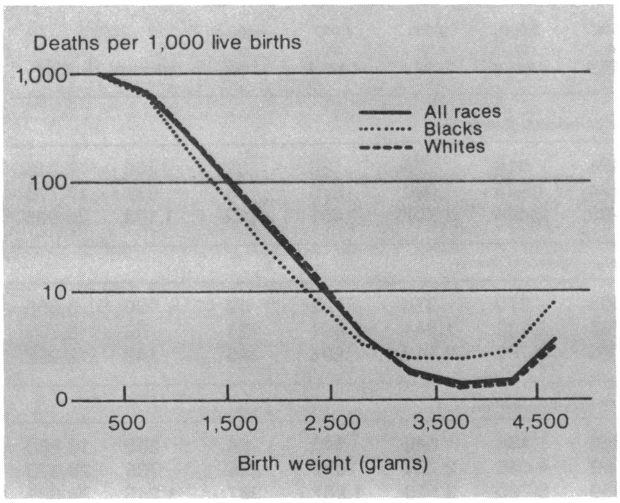
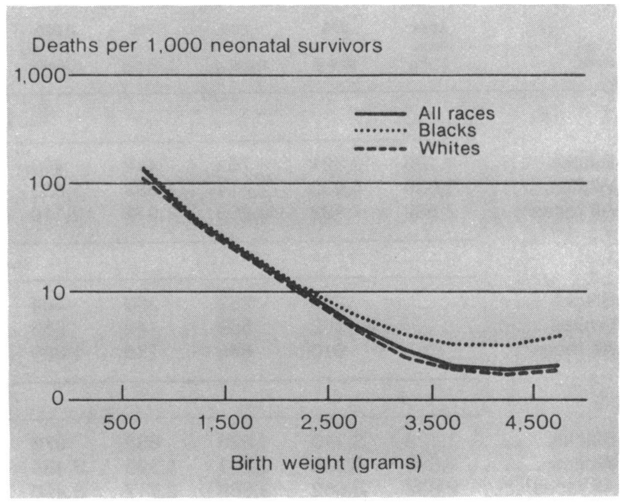


Figure 2. Postneonatal mortality risks by race and birth weight, United States, neonatal survivors of 1980 live birth cohort



g more for both blacks and whites (that is, 3,500 to 3,999 g for blacks; 4,000 to 4,499 g for whites). A comparison of these optimal groups showed that infant mortality risk (IMR) for blacks (3,000–3,999 g) was 2.1 times the risk for whites (3,500–4,499 g). This risk is slightly higher than the overall relative risk of infant mortality for black infants (2.0). This overall risk reflects higher birth-weight-specific neonatal mortality for black infants weighing 3,000 g or more, higher postneonatal mortality for black infants of all birth weights, and the greater proportion of black infants weighing less than 3,500 g. Optimal birth weights in table 2 differ somewhat from those reported elsewhere (*30*), because unknown gestational ages and birth weights were included in table 2, and they were distributed proportionately to known birth weights and gestational ages (*20*).

Birth weight distribution of deaths. Two-thirds of infant deaths occurred during the neonatal period (table 3). Of those, more than half occurred to infants weighing less than 1,500 g. Those infants, who comprised less than 1 percent of all live births, accounted for almost 40 percent of all infant deaths. Another two-fifths of infant deaths occurred to the 94 percent of infants weighing 2,500 g or more. In the postneonatal period, infants with birth weights of 2,500 g or more represented about three-fourths of deaths. Infants weighing less than 500 g accounted for 10.7 percent of all black infant deaths and 6.3 percent of all white infant deaths with known birth weight.

States differ in the race-specific proportions of deaths of infants weighing less than 500 g (*20,33*). This difference may be due to varying practices of recording such deliveries as live births or fetal deaths. If all recorded live-born infants weighing less than 500 g are excluded, the NMR for white infants weighing less than 1,500 g is reduced 10.7 percent, from 441.9 to 394.4 per 1,000 live births. The NMR for black infants is reduced 15.1 percent, from 406.5 to 345.1 per 1,000 live births. Postneonatal mortality is not affected, since all infants less than 500 g are assumed to have died during the neonatal period. Infant mortality is reduced 7.2 percent overall, representing a 6.1 percent reduction for whites (from 9.3 to 8.7 per 1,000 live births) and a 10.2 percent reduction for blacks (from 18.9 to 17.0 per 1,000 live births).

Risk factors for infant mortality.

Gender. Regardless of race, males experienced higher birth-weight-specific infant mortality than did females (table 4). However, the female advantage was proportionately somewhat higher for infants weighing 1,500 g or more and for white infants.

Gestational age. For each reported gestational age, infant mortality decreased with increasing birth weight. At virtually all gestational ages, blacks weighing less than 2,500 g had lower infant mortality than did whites. The exceptions were infants weighing less than 1,500 g whose gestational ages were reported as 40 and 42–45 weeks (table 4)—gestational ages that most likely represent misclassified values that are mentioned subsequently. White infants weighing 2,500 g or more but who were born with gestation less than 37

Table 3. Number and percentage distribution of infant deaths among single-delivery infants born during 1980, by birth weight, age at death, and race.

Race	Less than 500 g	500 to 999 g	1,000 to 1,499 g	1,500 to 1,999 g	2,000 to 2,499 g	2,500 to 2,999 g	3,000 to 3,499 g	3,500 to 3,999 g	4,000 to 4,499 g	4,500 g or more	Unknown	Total
						Number of neonatal deaths						
Blacks	1,128	2,821	761	418	409	471	518	275	66	39	309	7,215
Whites	1,630	4,933	2,314	1,483	1,630	1,624	1,843	1,090	376	175	677	17,775
All races[1]....	2,832	7,992	3,203	1,972	2,110	2,189	2,444	1,407	461	222	1,103	25,935
						Number of postneonatal deaths						
Blacks	...	289	262	280	464	895	970	374	82	19	30	3,665
Whites	...	302	389	442	856	1,768	2,632	1,644	491	121	58	8,703
All races[1]....	...	610	665	745	1,380	2,770	3,786	2,113	596	145	142	12,952
						Number of infant deaths						
Blacks	1,128	3,110	1,023	698	873	1,366	1,488	649	148	58	339	10,880
Whites	1,630	5,235	2,703	1,925	2,486	3,392	4,475	2,734	867	296	735	26,478
All races[1]....	2,832	8,602	3,868	2,717	3,490	4,959	6,230	3,520	1,057	367	1,245	38,887
						Percent of neonatal deaths						
Blacks	15.6	39.1	10.5	5.8	5.7	6.5	7.2	3.8	0.9	0.5	4.3	100.0
Whites	9.2	27.8	13.0	8.3	9.2	9.1	10.4	6.1	2.1	1.0	3.8	100.0
All races[1]....	10.9	30.8	12.4	7.6	8.1	8.4	9.4	5.4	1.8	0.9	4.3	100.0
						Percent of postneonatal deaths						
Blacks	...	7.9	7.1	7.6	12.7	24.4	26.5	10.2	2.2	0.5	0.8	100.0
Whites	...	3.5	4.5	5.1	9.8	20.3	30.2	18.9	5.6	1.4	0.7	100.0
All races[1]....	...	4.7	5.1	5.8	10.7	21.4	29.2	16.3	4.6	1.1	1.1	100.0
						Percent of infant deaths						
Blacks	10.4	28.6	9.4	6.4	8.0	12.6	13.7	6.0	1.4	0.5	3.1	100.0
Whites	6.2	19.8	10.2	7.3	9.4	12.8	16.9	10.3	3.3	1.1	2.8	100.0
All races[1]....	7.3	22.1	9.9	7.0	9.0	12.8	16.0	9.1	2.7	0.9	3.2	100.0

[1] All races includes unknown race and infants of other races.

SOURCE: National Infant Mortality Surveillance project.

weeks also had higher gestation-specific infant mortality. From 37 weeks on, however, black infants 2,500 g or more experienced higher gestation-specific infant mortality. Several combinations of birth weight and gestational age undoubtedly include a large proportion of infants whose gestational age was incorrectly reported. Gestation- and birth-weight-specific measures of infant mortality risk for these categories will be misleading because of this misclassification. These categories are noted in table 4. Racial differences in birth-weight- and gestation-specific infant mortality are explored in greater detail elsewhere (*30*).

Live birth order. Second-born infants experienced lower infant mortality (10.2 per 1,000 live births) than infants of other birth orders (table 4). However, among infants weighing 2,500 g or more, first-born infants experienced the lowest infant mortality among both blacks and whites. Infant mortality increased steadily with increasing birth order among those heavier infants, except for lower mortality for black infants of birth order 6 or higher. For specific birth orders, infant mortality risks for those blacks were 58 to 77 percent higher than for whites of the same birth order.

Maternal age. Infant mortality decreased with increasing maternal age through 30–34 years of age but increased for infants born to women 35 years of age and older (table 4). Optimal maternal age was 25–29 years for black mothers and 30–34 years for white mothers. Differences in infant mortality by maternal age were most pronounced for infants weighing 2,500 g or more. Larger black infants experienced higher mortality than whites, regardless of their mothers' ages. Infant mortality risks associated with young maternal age primarily re-

Table 4. Infant mortality risk per 1,000 live births by race, birth weight[1], and selected characteristics[2] of single-delivery infants born during 1980

Characteristics	*Blacks* Less than 1,500 g	*Blacks* 1,500 to 2,499 g	*Blacks* 2,500 g or more	*Blacks* Total	*Whites* Less than 1,500 g	*Whites* 1,500 to 2,499 g	*Whites* 2,500 g or more	*Whites* Total	*All races* Less than 1,500 g	*All races* 1,500 to 2,499 g	*All races* 2,500 g or more	*All races* Total
Total	452.6	30.6	7.5	18.9	475.3	38.5	4.4	9.3	469.4	36.3	5.0	11.0
Infant's sex:												
Male	490.6	36.4	8.4	20.6	511.1	46.5	5.0	10.4	505.0	43.5	5.6	12.1
Female	416.0	26.0	6.5	17.2	439.2	31.6	3.8	8.2	432.7	30.0	4.3	9.7
Gestation:												
17–27 weeks	*673.6*	*60.1*	*32.1*	*467.0*	*720.1*	*114.7*	*34.9*	*529.0*	*706.5*	*90.7*	*34.6*	*509.3*
28–31 weeks	257.9	52.9	*15.5*	*103.0*	294.1	84.9	*16.9*	*136.7*	283.4	73.2	*16.1*	*125.0*
32–35 weeks	197.1	33.9	10.3	25.0	266.3	40.2	11.3	29.4	244.9	38.6	11.2	28.3
36 weeks	*234.4*	24.0	7.8	12.8	*257.6*	33.1	8.6	14.0	*250.2*	30.6	8.6	13.9
37 weeks	*216.1*	23.7	8.4	11.2	*298.1*	30.1	6.5	9.3	*279.4*	28.0	7.1	9.9
38–39 weeks	*261.7*	21.8	6.1	7.4	*311.1*	26.7	3.9	4.8	*300.6*	25.3	4.3	5.3
40 weeks	*359.9*	31.7	7.3	8.6	*343.3*	34.3	3.9	4.5	*353.0*	33.6	4.4	5.1
41 weeks	*221.5*	33.7	6.9	8.1	*390.2*	34.8	3.6	4.1	*334.1*	34.6	4.1	4.7
42–45 weeks	*331.2*	26.3	9.0	10.2	*293.4*	45.6	4.8	5.6	*299.7*	40.4	5.4	6.3
Live birth order:												
First	465.2	26.0	6.5	19.2	460.0	33.7	4.1	9.5	463.4	31.7	4.5	11.0
Second	455.5	32.5	7.5	18.7	500.4	44.3	4.3	8.8	489.9	41.0	4.8	10.4
Third	426.4	33.3	7.9	17.5	495.3	40.4	5.0	9.2	471.8	38.0	5.6	10.8
Fourth	440.4	37.4	8.6	18.8	473.9	46.0	5.2	9.8	459.2	43.4	6.0	11.9
Fifth	429.0	38.3	11.0	22.2	508.9	54.8	6.2	11.6	459.8	48.3	7.3	14.2
Six or higher	416.5	37.6	10.1	20.3	489.3	54.9	6.3	12.1	460.6	48.0	7.5	14.6
Age at death:												
Neonatal	406.5	16.4	2.8	12.5	441.9	27.5	2.0	6.2	431.2	24.2	2.1	7.3
Postneonatal[3]	77.6	14.4	4.6	6.5	59.9	11.4	2.5	3.1	67.0	12.4	2.9	3.7
Mother's age:												
10–14 years	535.8	38.9	13.1	36.0	529.0	65.7	7.1	25.0	531.2	47.6	10.6	31.5
15–19 years	439.2	30.8	8.8	21.2	482.6	37.7	6.4	13.6	463.9	35.0	7.1	15.8
20–24 years	458.8	28.4	7.3	18.5	476.3	40.5	4.6	9.4	473.3	36.8	5.1	11.1
25–29 years	459.6	31.9	6.2	17.0	488.7	37.7	3.8	8.0	482.2	36.4	4.1	9.2
30–34 years	461.4	30.1	6.4	17.1	462.2	35.2	3.6	7.8	461.5	34.1	4.0	9.0
35–39 years	445.6	38.8	7.8	19.3	450.9	39.3	4.3	9.3	449.1	40.1	4.8	10.8
40–44 years	351.3	41.0	9.4	19.6	502.3	66.2	5.9	14.1	457.1	58.5	6.6	15.1
45–49 years	...	106.6	23.7	35.0	385.5	111.4	10.0	21.1	286.4	116.9	10.4	22.6
Mother's education:												
0–8 years	481.7	42.6	11.1	25.6	495.2	45.6	7.5	15.1	485.6	44.8	8.2	17.2
9–11 years	426.2	33.8	10.0	22.5	477.7	37.9	6.7	13.7	454.6	36.0	7.7	16.3
12 years	467.7	29.9	6.6	18.1	475.3	40.4	4.2	8.9	473.7	37.4	4.6	10.6
13–15 years	472.4	24.2	5.9	16.2	490.0	39.4	3.4	7.4	484.2	34.6	3.8	8.8
16 years and older	443.9	27.8	3.9	13.6	476.9	38.3	3.0	6.7	467.5	36.1	3.1	7.3
Month prenatal care began:												
1–3	445.0	29.0	6.3	17.3	475.5	37.5	4.0	8.5	467.5	35.3	4.3	9.7
4–6	401.9	31.1	8.3	17.6	470.8	40.7	5.7	11.0	444.7	37.0	6.3	12.6
7–9	317.9	35.1	11.1	16.4	343.6	40.8	7.6	10.8	342.1	39.0	8.6	12.4
None	580.1	42.2	16.8	67.7	572.1	49.4	9.9	38.3	576.1	48.3	12.1	48.7

[1] Number of infants with unknown birth weight were redistributed according to percentage of infants with known birth weight.
[2] Number of infants with a characteristic unknown were distributed according to percentage of infants with known values for that characteristic.
[3] Deaths per 1,000 neonatal survivors.

NOTE: Italicized numbers indicate that mortality risk is not reliable in this gestation- and birth-weight-specific category because a substantial portion of infants included in it had incorrectly reported gestational age.
SOURCE: National Infant Mortality Surveillance Report.

late to a lower birth weight distribution, especially for neonatal mortality differentials (*34*).

Maternal education. Infant mortality declined with increasing maternal education for both races, but declined more steeply for infants born to white women and, for both races, for infants born weighing 2,500 g or more (table 4). Larger black infants also experienced higher mortality, regardless of their mothers' educational level.

Prenatal care. Infants born to mothers who obtained prenatal care beginning in the first trimester experienced substantially lower infant mor-

Table 5. Estimated number of unlinked deaths: distribution of numbers of States[1] and infant deaths by difference between the National Infant Mortality Surveillance (NIMS) and synthetic cohort

	Difference between number of births in NIMS and synthetic cohort				
Category	NIMS the same as or greater than synthetic cohort	NIMS = 95.0–99.9 percent of synthetic cohort	NIMS = 90.0–94.9 percent of synthetic cohort	NIMS = 76.6–89.9 percent of synthetic cohort	Total
Number of States	9	24	10	8	51
Number of deaths in synthetic cohort	4,702	26,372	7,217	7,030	45,321
Number of deaths in NIMS	4,757	25,611	6,762	6,087	43,217
Difference	(55)	761	455	943	2,104

[1] New York City is included with upstate New York; District of Columbia is included separately; Puerto Rico is excluded.

NOTE: The synthetic cohort includes U.S. resident deaths during 1980 to 1981 of infants born in 1980. Data are from the NCHS mortality tapes. State of residence in synthetic cohort is at death; State of residence in NIMS is at birth.

SOURCE: National Infant Mortality Surveillance Report.

tality (table 4). This trend was most pronounced for infants weighing 2,500 g or more but was also present for infants weighing between 1,500 and 2,499 g. In part, because of differences in birth weight distributions for black infants whose mothers received late prenatal care, the IMR for those infants was lower than for infants whose mothers received prenatal care beginning during the first trimester. Black-white differences in birth-weight-specific mortality persisted for infants of women obtaining prenatal care beginning in the first trimester.

Completeness of NIMS data. There were 2,104 fewer deaths in NIMS than were predicted using the synthetic cohort derived from 1980 and 1981 mortality tapes (table 5). This represents an estimated underreporting of 4.6 percent. However, the impact varied among the States. In seven States, NIMS reported more deaths by residence at birth than the synthetic cohort number of deaths by residence at death. There was exact agreement in 2 States and 2,159 fewer deaths in the NIMS data among 42 States. Eight States reported at least 10 percent fewer deaths than were predicted from the synthetic cohort. These eight States include 44.8 percent of all estimated unreported deaths but only 15.5 percent of all deaths in the United States.

We asked States to report the number of death certificates that they were unable to link with birth certificates. Because State of residence at birth is not reported on death certificates, we could not estimate directly the effect of these unlinked certificates on State-specific data concerning resident infant mortality risks. However, we could approximate the impact by examining unlinked certificates for deaths that occurred to infants who were likely to have resided in the given State at birth. The likelihood that an unlinked death certificate is for an infant who resided at birth in the given State is higher if the State of residence at death is also the State in which both the birth and death occurred. Of the 2,604 reported unlinked certificates, 1,202 of those met these criteria of birth and death occurrence and residence in the State of residence at death. Using the number of these deaths in the numerator and the number of expected deaths (from the synthetic cohort) in the denominator, six States reported 5 percent or more of expected resident deaths as unlinked. Three of these six States were also among the eight with 10 percent or more fewer linked deaths reported than expected from the synthetic cohort, suggesting that their chief problem with unlinked certificates may be one of in-State linkage. The other five States with 10 percent or more discrepancy between linked and predicted infant deaths reported very few unlinked certificates of any kind. This suggests (*a*) that the States may need to revise their definition of what kind of death to link, (*b*) that they are unaware of interstate linkage gaps or do not have the resources to improve interstate linkage efforts, or (*c*) that the synthetic cohort estimate of expected deaths may be relatively invalid for those States.

Discussion

During 1980, there were 3,542,995 single-delivery births and 69,912 multiple-delivery infants in the United States. From 1980 to 1981, there were 43,217 deaths among these infants, for a total infant mortality risk of 12.0 per 1,000 live births. This number can be compared with the infant mortality rates reported by NCHS of 12.6 and 11.9 infant deaths per 1,000 live births in 1980 and 1981, respectively (*3*). The difference in infant mortality risk as measured in the NIMS project and the infant mortality rates for 1980 and 1981 results in part from the inherent difference between risk and rate. The former is based on the experience of a birth cohort, while the latter is a period measure based on occurrences of deaths in a given year divided by births in that year. In times with a fairly steady birth rate and declining infant mortality risk, the period rate will overestimate the risk of mortality for that year's birth cohort. However, because two-thirds of the infant deaths occurred in the neonatal period, the 1980 infant mortality rate should closely approximate the infant mortality risk for the 1980 birth cohort. If a correction factor for the estimated underreporting of infant deaths in NIMS of 4.6 percent is added to the NIMS total, the infant mortality risk for the 1980 birth cohort would be 12.5 per 1,000 live births, just 0.1 per 1,000 lower than the 1980 infant mortality rate.

Factors which increased the risk of infant mortality for single-born infants included lower (and very high) birth weight, black race, male gender, short (and long) gestation, birth order (first and third or higher), maternal age (younger and older), lower maternal education, and lack of prenatal care during the first trimester. Of these, the most important predictor for infant survival was birth weight, with an exponential improvement in survival by increasing birth weight to its optimum level (3,500 to 4,499 g for whites and 3,500 to 3,999 g for blacks).

Overall, blacks had over twice the risk of dying in their first year as did whites. This risk was related both to a higher prevalence of low birth weight and to higher mortality risks in the neonatal period for infants weighing 3,000 g or more and in the postneonatal period for all infants, regardless of birth weight. These results parallel State-specific analyses of black-white differences in neonatal and infant mortality (*15,16*).

Proportionately more than three times as many black as white newborns have birth weights less than 500 g. Compared with white infants, the relative risk of neonatal mortality for black infants is 2.01. If infants weighing less than 500 g are excluded, the relative risk drops to 1.87. Some live births of infants less than 500 g are classified as fetal deaths, but the tendency to classify such deliveries as fetal deaths is probably no more frequent for white than for black deliveries. Thus the true risk of neonatal death for small black infants is probably even higher than the reported risk, which would make the true black-white gap even greater.

Characteristic-specific analyses of black-white differences in infant mortality reveal that, regardless of other infant or maternal risk factors, black infants were up to twice as likely to die within their first year of life as were white infants. This gap is most pronounced for infants weighing 2,500 g or more. The exceptions to this general finding were lower neonatal mortality among black infants less than 3,000 g and lower infant mortality for black infants less than 37 weeks' gestation. (*30*).

Overall infant mortality risks are associated with maternal characteristics that reflect social class differentials in access and availability of care. Both prenatal factors affecting birth weight and postnatal factors affecting infant care contribute to increased infant mortality for socially disadvantaged infants, although the relative contributions of prenatal and postnatal components of infant mortality vary among different groups of infants. Part of the black-white gap is related to the relatively disadvantaged status of blacks in the United States. However, the widespread differences between black and white infant mortality across all maternal characteristics reported on the birth certificates suggest that there may also be a further problem with access to effective health care for black infants and pregnant black women.

National black-white differences in infant mortality are explored in other articles in this issue with respect to the composite effect of birth weight and gestation on the excess black infant mortality (*30*), regional variations in race-specific infant mortality (*35*), differences in cause-specific mortality (*36,37*), the effect of maternal age on black-white differences in infant mortality (*34*), and the change in race-specific infant mortality between the two national surveys of 1960 and 1980 (*38*). With the exception of deaths resulting from congenital anomalies, all analyses point to the same conclusion: Far more effective strategies need to be developed and applied (*a*) to decrease the incidence of low birth weight, especially among black infants; (*b*) to increase neonatal survival for black infants 3,000 g or more, and (*c*) to increase postneonatal survival for all black infants.

There are three potential sources of bias in the NIMS data. These are underestimation of cohort mortality risk through failure to link deaths and births, underascertainment of death through failure to file death certificates, and lack of congruity between the numerator data (from State tabulations) and denominator data (from the NCHS natality tape). The first two are inherent biases with vital records analyses; the third is unique to the NIMS methodology.

As to the extent of underestimated mortality relative to unlinked deaths, the NIMS data include an estimated 95.4 percent of all reported infant deaths to U.S. resident infants born in 1980. The 4.6 percent estimated underreporting of known deaths is related in part to State-level linkage issues, including the following problems: First, when vital events do not occur within the State of residence, linkage requires transfer of certificates to the proper State for recording and linking. Since death certificates do not include information on residence at birth, appropriate transfer may be difficult. Second, there may not be a birth certificate for a reported infant death, especially for an early neonatal death to a very small infant. Third, when information necessary for the linkage is inaccurately recorded, linkage is less likely to occur. When linkage does not occur for any of these reasons, the death cannot be included in cohort mortality risks.

The extent of underestimating infant mortality risks is not uniform throughout the States. Eight States reported at least 10 percent fewer deaths than expected through the synthetic cohort, comprising nearly half of all the estimated underreporting. Also, postneonatal deaths, especially out-of-State events, are proportionately more underreported (*31,32*). Deaths of black infants may also be more underestimated (*31*). Because the extent of underreporting was small for the United States as a whole, these State-level biases probably do not affect national results in measurable ways. However, for specific States, the difference between NIMS estimates and true State-specific risks could be substantial. For this reason, it will be important for persons examining State-level NIMS data to examine the estimated extent of underreporting (*20,39*).

Regarding the underestimation of cohort mortality resulting from unreported infant deaths, we point out that neither NIMS data nor NCHS data include deaths for which there were no death certificates. Among infants less than 1,500 g, unregistered deaths have been traced to problems in vital records registration (*40*); however, such underreporting has been lower in more recent reports (*41,42*). Perhaps as States have become more aware of the need to track infants whose birth weights are very low, their reporting of infant deaths may have improved. Another registration problem is the failure to report deaths of live-born infants who die very soon after birth. These infants are sometimes reported as fetal deaths. The perinatal mortality risk that includes fetal deaths will include those infants, and an examination of birth-weight-specific perinatal mortality risks reveals patterns similar to those found for NIMS infant mortality risks (*38*).

With respect to the potential bias caused by using different data sources for births and deaths of infants weighing 500 g or more, the number of deaths was provided by States and the number of births was obtained from NCHS computer tapes. NCHS birth reporting could be less complete than State death reporting because NCHS uses an earlier cutoff date for inclusion in its birth file than that used by some States for inclusion of death reports. On the other hand, NCHS reporting of births for a given State may be more complete because NCHS is not dependent on the interstate exchange of vital records. For nine States for which we had access to both NCHS and State birth tapes, we investigated the differences between State and NCHS reports of births of infants weighing 500 g or more as a proxy for estimating the differences in the two sources of data for births and deaths. We found that the differences between States' reported births and births reported by NCHS for those States were small (*20*).

Examination of all these potential sources of bias suggests that when bias does occur, it probably results in an underestimation of the black-white infant mortality differential. Thus, conclusions regarding the black-white gap are somewhat conservative. Biases related to analyses of specific characteristics are discussed elsewhere (*20*).

The National Infant Mortality Surveillance project represents Phase I of a two-stage process to develop routine reporting of national birth-weight-specific infant mortality data. Phase II will be the annual microlevel tape to be produced by the National Center for Health Statistics that probably will begin with the 1983 birth cohort. A report on the pilot stage of Phase II is presented elsewhere in this issue (*18*). In addition to compiling interim national data, NIMS has provided insight into the development and improvement of this ongoing system. We have identified States with particular linkage problems. Also, problems with definitions of vital records variables have been isolated (*20,29*).

Through NIMS, we have explored the usefulness of linked birth and infant death record data for program planning and evaluation (*43*). The NIMS conference brought together representatives from all States, including vital registrars, health statisticians, and maternal and child health directors, to discuss problems of linkage as well as uses of linked vital records for program planning, targeting, and evaluation (*43*). The examination of birth weight distributions, birth-weight-specific infant mortality, and birth weight distributions of infant deaths can provide insight into targeting programs more effectively and identifying problem areas for more intensive program evaluation.

In this paper, we have presented an overview of the design, methods, and results of the National Infant Mortality Surveillance project. More details on each of these topics are available in the NIMS Report (*20*). The public use tape and documentation will be available through the National Technical Information Service, Springfield, VA.

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Regional Differences in Birth Weight-Specific Infant Mortality, United States, 1980

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This research was supported in part by the National Institute of Child Health and Human Development, the Health Resources and Services Administration, and the National Center for Health Statistics, all Agencies of the Public Health Service. The findings were presented in part at the annual meeting of the American Public Health Association, Las Vegas, NV, September 29, 1986.

Contributing to the research were the following persons from the Research and Statistics Branch: Jeanne C. Gilliland, J. Patrick Whitaker, and Evelyn L. Finch, who worked on systems design and assisted in computer programming, aggregating data from 53 vital statistics reporting areas; Sara W. Gill and Merrell Ramick, who assisted in preparing the data for processing; and Phyllis A. Wingo, who coordinated data management.

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***Synopsis*................................**

To describe regional differences in birth weight-specific infant mortality in the United States, we used data from the National Infant Mortality Surveillance project. The infant mortality risk (IMR) for the nation was 11.0 deaths per 1,000 live births. The risk (with 95 percent confidence intervals [CI]) for the four U.S. Census regions were West 9.9 (9.7 to 10.1), Northeast 10.4 (10.1 to 10.6), North Central 10.8 (10.6 to 11.0), and South 12.1 (11.9 to 12.3).

In all regions, the IMR for blacks was approximately twice that of whites. Seventy-two percent of the higher IMR in the South was due to a higher proportion of black births compared with the remainder of the nation, reflecting the higher mortality rates suffered by black infants, and 28 percent to higher mortality among southern whites.

The IMR for whites in the South was significantly higher than in the remainder of the nation: 9.8 versus 9.1 (relative risk = 1.09, CI = 1.06 to 1.11). Thirty-six percent of this excess in IMR was due to a higher frequency of low birth weight (less than 2,500 grams), 18 percent was due to higher IMR in infants with birth weight less than 2,500 grams, and 46 percent due to higher IMR in infants with birth weights of 2,500 g or more.

Black infants born in the West had a lower risk of death than black infants in the other regions.