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Birth Weight-Specific Infant Mortality, United States, 1960 and 1980

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Synopsis

National statistics on the risk of infant mortality by birth weight were collected most recently in 1980 and 1960. (Infant mortality risk is the number of deaths of infants under 1 year of age per 1,000 live births.) In this 20-year period, the infant mortality risk (IMR) for single-delivery infants declined 53 percent, from 23.3 deaths per 1,000 live births to 11.0; 91 percent of this decline was due to lower IMRs within birth weight categories, and 9 percent was due to reduced frequency of low birth weight. The greatest reduction in neonatal mortality (under 28 days)—73 percent—occurred among infants of 1,500-1,999 grams (g) birth weight, whereas the greatest reductions in postneonatal mortality (28 days to under 1 year)—51 percent to 54 percent—occurred among infants of 3,500 g or more birth weight.

Trends in IMR for black and white infants were similar, and the twofold gap between the races in IMR persisted from 1960 to 1980. For whites, reductions in the frequency of low birth weights contributed to the decline in the IMR. For blacks, the percentage of infants with birth weights of less than 1,500 g increased, and the total reduction in the IMR was attributable to lower birth weight-specific mortality risks. In some regions of the United States, failure to observe an increase in birth weight for blacks may be a reporting artifact, reflecting improved reporting of births of very small black infants in 1980.

Examination of changes in perinatal mortality risks (from 20 weeks gestation to less than 28 days of life) did not suggest that infant mortality trends were substantially affected by changes in the distinction between fetal and neonatal deaths over the 20-year period. Reducing the number of low birth weight infants remains the greatest potential for future reductions in infant mortality.

DECLINES IN INFANT MORTALITY may reflect the birth of fewer infants of low birth weight, improved survival among infants in different birth weight groups, or both. Using information from individual States or groups of States, researchers have demonstrated that recent mortality reductions

in the United States have largely resulted from lower birth weight-specific mortality, that improvements in birth weight have been comparatively modest, and that improvements in birth weight have been greater among whites than blacks (*1–4*). Most of these studies have been focused on either perinatal or neonatal mortality, and most researchers have not considered trends in postneonatal mortality. In this paper, we compare infant mortality for the 1960 and 1980 U.S. birth cohorts—the 2 most recent years for which birth weight-specific infant mortality data are available for all States. The purpose is to describe the contribution of changes in birth weight distribution and birth weight-specific mortality to declines in both neonatal and postneonatal mortality. This comparison was done for infants in different race groups and in different regions of the country. Because shifts in the distinction between fetal deaths and very early neonatal deaths may have occurred between 1960 and 1980, we also considered changes in perinatal mortality risks.

Methods

For the 1980 birth cohort, we used data from the National Infant Mortality Surveillance (NIMS) project conducted by the Centers for Disease Control (CDC). For the 1960 cohort, we used data from a previous study conducted by the National Center for Health Statistics (NCHS) (*5*).

1980 birth cohort. The methods of the NIMS project, including data collection and evaluation, are described in detail elsewhere (*6–8*). In brief, 53 vital statistics reporting areas participated in the project: 50 States, New York City, the District of Columbia, and Puerto Rico. These national level tabulations do not include Puerto Rico. All 53 reporting areas (subsequently referred to as "States") linked 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. Birth and death certificate linkage is estimated to be approximately 95 percent complete (*7*). States provided the CDC with the number of infant deaths by birth weight, age at death, and other infant and maternal characteristics. CDC generated corresponding numbers of births from the computer tape of 1980 natality records produced by NCHS, with exceptions for Maine and New Mexico as previously described (*6*). For calculation of mortality risks, infants of unknown birth weight (0.2 percent of births and 3.3 percent of infant deaths) were assigned to birth weight categories according to the proportions of births and deaths with a known birth weight in each race group (*6*).

1960 cohort. For the 1960 birth cohort, NCHS linked birth and infant death certificates (*5*), and we used a computer tape of these records to generate numbers of infant deaths by birth weight, race of infant, type of delivery, and State of residence. Because this computer tape was limited to infants who died, we used another NCHS computer tape of 1960 natality records to generate corresponding numbers of births. Both computer tapes provided detailed information on birth weight and infant's race. Thus we were able to use the same birth weight categories in 1960 and 1980—less than 500 grams (g), 500–999 g, 1,000–1,499 g, 1,500–1,999 g, and so forth—and compare black infants in 1960 with black infants in 1980. Previous analyses of the 1960 data used slightly different birth weight categories (less than or equal to 1,000 g, 1,001–1,500 g, 1,501–2,000 g, and so forth) and a broader "nonwhite" race category. For information on hospital of delivery and on fetal deaths (described subsequently), we used published vital statistics that did not distinguish black infants from infants whose race was other than white (*9*). To be consistent with 1980 NIMS data (*6,7*), we assumed that all infants of less than 500 g birth weight died in the neonatal period. For these reasons, numbers of deaths and mortality risks may differ from previous reports for the 1960 cohort.

Definitions common to 1960 and 1980. State of residence was defined as mother's State of residence at time of birth, and States were grouped into four regions (Northeast, North Central, South, and West) according to categories used by NCHS (*9*). The infant's race was based on the race of both parents, using the NCHS algorithm (*10*). Three categories of the infant's race were used: white, black, and all races combined. Because these data are for birth cohorts rather than for births and deaths occurring in given years, 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) was defined as the number of postneonatal deaths (28 days to under 1 year) per 1,000 neonatal survivors; and the infant mortality risk IMR was defined as the number of infant deaths (less than 1 year) per 1,000 live births. Birth

weights were grouped into 10 levels: less than 500 g, 500-g categories between 500 and 4,499 g, and 4,500 g or more. All analyses were limited to infants from single deliveries. Multiple-delivery infants will be considered separately in a future analysis.

Racial differences in hospital versus out-of-hospital births. In 1960, 85.0 percent of reported live births for infants whose race was other than white (91.6 percent of such infants were black) and 98.8 percent of births of white infants occurred in hospitals. In 1980, 99.3 percent of black infants and 99.0 percent of white infants were born in hospitals (*11*). Because a large percentage of out-of-hospital births may be associated with underreporting of low birth weight, the greater proportionate increase in hospital births among blacks may obscure improvements in birth weight among blacks (*12*). Thus we repeated the 1960–80 comparison for 28 States where more than 95 percent of 1960 births among other than white infants occurred in-hospital. The 28 States were as follows:

California	Nebraska
Colorado	Nevada
Connecticut	New Hampshire
District of Columbia	New Jersey
Hawaii	New York
Idaho	North Dakota
Indiana	Ohio
Iowa	Oregon
Kansas	Pennsylvania
Maine	Rhode Island
Massachusetts	Vermont
Michigan	Washington
Minnesota	Wisconsin
Montana	Wyoming

These States represented 58 percent of single-delivery births in 1960 and 55 percent in 1980 (*9, 11*).

Perinatal deaths. For both 1960 and 1980, numbers of fetal deaths occurring at 20 weeks or more gestation were obtained from published vital statistics (*13,14*). Perinatal deaths were defined as deaths occurring from 20 weeks gestation to less than 28 days of life and the perinatal mortality risk (PeMR) was defined as perinatal deaths per 1,000 live births plus fetal deaths (NCHS perinatal death definition II [*15*]). Because more detailed information was not available for fetal deaths, the "other than white" race category was used for 1960 perinatal deaths; the lowest birth weight category was less than 1,000 g, and differences in birth weight groupings for fetal deaths (less than 1,000 g and so forth versus less than or equal to 1,000 g and so forth) were ignored. (In 1960, there were no live-born infants with exact birth weights of 999 g, 1,000 g, or 1,001 g, and so forth.)

There was a change in the percentage of infant deaths occurring in the neonatal and postneonatal periods. In 1980, compared with 1960, a greater percentage (33 percent versus 28 percent) of infant deaths occurred in the postneonatal period, and the percentage of both neonatal and postneonatal deaths represented by infants of less than 1,500 g birth weight increased.

Statistical methods. The change in infant mortality from 1960 to 1980 can be expressed as the summation over all birth weight categories of the following quantity calculated for each birth weight category (*16*):

$$[(P_{1960} + P_{1980}) \div 2] \times (R_{1980} - R_{1960}) + [(R_{1960} + R_{1980}) \div 2] \times (P_{1980} - P_{1960})$$

where P represents the proportion of infants in each birth weight category and R represents the birth weight-specific mortality risk for each category. The summation of the first half of this formula represents the change in mortality due to change in birth weight-specific mortality risks. For an individual birth weight category, this reflects both the magnitude of the shift in mortality and the average proportion of infants in that birth weight group. The summation of the second half represents the change in mortality resulting from a change in birth weight distribution.

Changes in mortality risks were calculated as the relative risk (RR) of death in 1980 compared with 1960, and 95 percent confidence intervals (CIs) were calculated, using the test-based method described by Rothman and Boice (*17*). The percent change in infant mortality and 95 percent CIs were calculated as (RR − 1) times 100, using the point estimate of the RR and the upper and lower bounds of the CI. Except where indicated, the 95 percent CI for RR estimates excluded 1.0, corresponding to $P < 0.05$ (for brevity, CIs will not be shown).

To determine what percentage of the decline in birth weight-specific IMR was due to lower birth

Table 1. Neonatal, postneonatal, and infant mortality risks, single-delivery infants, by birth weight and race, United States, 1960 and 1980 [1]

Race and year	Less than 500 g	500–999 g	1,000–1,499 g	1,500–1,999 g	2,000–2,499 g	2,500–2,999 g	3,000–3,499 g	3,500–3,999 g	4,000–4,499 g	4,500 g or more	Total
						Neonatal					
All races:											
1960	1,000.0	891.8	527.4	197.1	43.9	10.0	4.7	3.6	4.2	8.7	16.7
1980	1,000.0	647.6	186.5	53.9	16.0	4.0	1.9	1.4	1.5	3.5	7.3
Percent decline [2]	0.0	27.4	64.6	72.7	63.6	59.6	58.6	61.2	64.0	59.7	56.3
Whites:											
1960	1,000.0	908.6	562.2	218.7	48.2	10.2	4.4	3.3	3.6	7.7	15.4
1980	1,000.0	660.8	212.1	61.6	18.3	4.2	1.8	1.3	1.4	3.0	6.2
Percent decline [2]	0.0	27.3	62.3	71.8	62.1	59.0	58.2	61.4	62.0	60.2	59.4
Blacks:											
1960	1,000.0	853.4	434.1	134.5	30.7	9.3	6.5	6.8	10.4	16.2	24.7
1980	1,000.0	615.6	131.3	36.1	10.6	3.6	2.4	2.5	2.8	8.7	12.5
Percent decline [2]	0.0	27.9	69.8	73.1	65.7	61.9	62.5	63.5	73.3	46.0	49.3
						Postneonatal					
All races:											
1960		67.4	55.1	32.3	17.9	9.1	5.5	4.3	4.1	4.6	6.7
1980		135.2	45.8	20.7	10.2	4.9	2.9	2.0	1.9	2.2	3.7
Percent decline [2]		−100.7	16.8	36.0	42.8	45.7	47.1	52.9	54.2	51.3	44.8
Whites:											
1960		59.7	44.5	26.4	14.1	7.3	4.5	3.6	3.4	3.6	5.3
1980		115.0	43.7	18.9	9.4	4.4	2.5	1.8	1.7	2.0	3.1
Percent decline [2]		−92.5	1.8+	28.5	33.0	39.7	43.7	48.7	49.4	42.6	41.4
Blacks:											
1960		83.8	76.5	46.8	28.8	15.7	11.0	10.3	10.9	11.6	14.6
1980		157.1	49.8	24.2	11.6	6.5	4.4	3.2	3.3	4.1	6.5
Percent decline [2]		−87.4	34.8	48.4	59.6	58.7	60.2	68.6	69.7	64.4	55.9
						Infant					
All races:											
1960	1,000.0	899.1	553.4	223.0	61.0	19.0	10.1	8.0	8.3	13.3	23.3
1980	1,000.0	695.2	223.7	73.5	26.0	8.9	4.8	3.5	3.4	5.7	11.0
Percent decline [2]	0.0	22.7	59.6	67.1	57.3	52.9	52.3	56.6	59.1	56.8	52.9
Whites:											
1960	1,000.0	914.1	581.7	239.3	61.6	17.4	8.8	6.9	7.0	11.2	20.5
1980	1,000.0	699.8	246.5	79.3	27.5	8.5	4.3	3.1	3.1	5.1	9.3
Percent decline [2]	0.0	23.4	57.6	66.9	55.3	50.9	50.8	54.7	55.8	54.6	54.7
Blacks:											
1960	1,000.0	865.7	477.4	175.0	58.6	24.9	17.4	17.1	21.1	27.6	39.0
1980	1,000.0	676.0	174.6	59.4	22.1	10.0	6.8	5.7	6.1	12.8	18.9
Percent decline [2]	0.0	21.9	63.4	66.1	62.4	59.7	61.0	66.4	71.4	53.5	51.5

[1] Neonatal and infant mortality risks calculated per 1,000 live births. Postneonatal mortality risk calculated per 1,000 neonatal survivors.

[2] Percentage decline in mortality risk from 1960 to 1980, all $P < 0.05$ except for infants of <500 g birth weight and where noted by + (see text).

weight-specific NMR and lower birth weight-specific PNMR, we determined the difference between observed and expected neonatal and postneonatal deaths. We used NMRs and PNMRs for the 1960 cohort and numbers of live births for the 1980 cohort to calculate expected numbers of neonatal deaths, neonatal survivors, and postneonatal deaths in 1980.

Except for the redistribution of numbers of infants with unknown birth weight in 1980, all calculations were done with a microcomputer spreadsheet, and unrounded numbers were retained for calculations at each stage.

Results

The number of single-delivery live births was 4,171,168 in 1960 and 3,542,995 in 1980.

Infant mortality risks and birth weight distribution.

All races. Between these 2 years, the NMR for single-delivery infants declined from 16.7 to 7.3 deaths per 1,000 live births; the PNMR, from 6.7 to 3.7 deaths per 1,000 neonatal survivors; and the IMR, from 23.3 to 11.0 deaths per 1,000 live

Table 2. Birth weight distribution of live births and neonatal survivors, single-delivery infants, by race United States, 1960 and 1980 [1]

Race and year	Less than 500 g	500–999 g	1,000–1,499 g	1,500–1,999 g	2,000–2,499 g	2,500–2,999 g	3,000–3,499 g	3,500–3,999 g	4,000–4,499 g	4,500 g or more	Total [2]
	Live births										
All races:											
1960	0.10	0.38	0.55	1.19	4.60	18.26	38.47	27.25	7.61	1.58	100.0
1980	0.08	0.37	0.51	1.08	3.92	16.08	37.49	29.57	9.03	1.87	100.0
Whites:											
1960	0.08	0.32	0.47	1.03	4.05	16.99	38.59	28.69	8.14	1.64	100.0
1980	0.06	0.27	0.40	0.88	3.27	14.29	37.02	31.61	10.08	2.11	100.0
Blacks:											
1960	0.20	0.71	1.05	2.16	7.87	25.44	37.57	19.10	4.63	1.28	100.0
1980	0.20	0.84	1.06	2.11	7.08	24.20	39.06	20.26	4.38	0.82	100.0
	Neonatal survivors										
All races:											
1960		0.04	0.26	0.97	4.48	18.38	38.94	27.62	7.71	1.59	100.0
1980		0.13	0.42	1.03	3.88	16.14	37.69	29.74	9.08	1.88	100.0
Whites:											
1960		0.03	0.21	0.82	3.91	17.08	39.02	29.04	8.24	1.65	100.0
1980		0.09	0.32	0.83	3.23	14.32	37.18	31.77	10.13	2.12	100.0
Blacks:											
1960		0.11	0.61	1.91	7.82	25.85	38.27	19.45	4.70	1.29	100.0
1980		0.33	0.93	2.06	7.09	24.42	39.46	20.46	4.42	0.82	100.0

[1] There were 4,171,168 live births (3,531,364 white, 585,858 black) in 1960 and 3,542,995 live births (2,845,857 white, 575,306 black) in 1980.

[2] Percentages may not add to 100.0 due to rounding.

births (table 1). With one exception (PNMR for 500–999 g neonatal survivors), these risks declined for all birth weight groups of 500 g or more (table 1). The greatest percentage reduction (73 percent) in NMR occurred among infants of birth weights 1,500–1,999 g (197.1 to 53.9), in PNMR (54 percent) among infants of birth weights 4,000–4,499 g (4.1 to 1.9), and in IMR (67 percent) among infants of birth weights 1,500–1,999 g (223.0 to 73.5). Excluding infants of birth weights less than 500 g, infants with birth weights of 500–999 g had the smallest decline in IMR (23 percent, 899.1 to 695.2).

There was a small decrease in the proportion of infants of lower range birth weights and a corresponding increase in the proportion of heavier birth weight infants (table 2). Reflecting the decreases in birth weight-specific NMR, there was an increase in the proportion of neonatal survivors with birth weights 500–999 g, 1,000–1,499 g, and 1,500–1,999 g (table 2). When changes in mortality risks were partitioned into two components, 91 percent of the decline in NMR, 100 percent of the decline in PNMR, and 91 percent of the decline in IMR was due to lower birth weight-specific mortality risks and the remainder resulted from improvements in birth weight distribution (table 3). Lower mortality risks among infants of less than 2,500 g birth weight accounted for 65 percent of the reduction in the birth weight-specific NMR, for 14 percent of the reduction in the birth weight-specific PNMR, and 51 percent of the reduction in the IMR (table 4).

Seventy-six percent of the reduction in birth weight-specific IMR was due to lower NMR and 24 percent to lower PNMR.

Differences in NMR and PNMR declines resulted in a change in the percentage of infant deaths occurring in the neonatal and postneonatal periods. In 1980, compared with 1960, a greater percentage (33 percent versus 28 percent) of infant deaths occurred in the postneonatal period, and the percentage of both neonatal and postneonatal deaths represented by infants of less than 1,500 g birth weight increased (table 5). In both years most neonatal deaths occurred among infants of less than 2,500 g birth weight, whereas most postneonatal deaths occurred among infants of 2,500 g or more birth weight (table 5).

White and black infants. Because the percentage reductions in IMR were similar—55 percent for whites and 52 percent for blacks—the approximately twofold disparity in IMR between race groups persisted. However, reasons for the declines

Table 3. Partition decline in neonatal, postneonatal, and infant mortality risks into contribution of changes in birth weight distribution and changes in birth weight-specific mortality risks, single-delivery infants, by race, United States, 1960 and 1980

Race and age at death	Percentage of decline due to change in birth weight distribution and birth weight-specific mortality		
	Birth weight distribution	Birth weight-specific mortality	Total
All races:			
Neonatal mortality risk	9	91	100
Postneonatal mortality risk	0	100	100
Infant mortality risk	9	91	100
Whites:			
Neonatal mortality risk	16	84	100
Postneonatal mortality risk	3	97	100
Infant mortality risk	15	85	100
Blacks:			
Neonatal mortality risk	−6	106	100
Postneonatal mortality risk	−4	104	100
Infant mortality risk	−3	103	100

in IMR differed for whites and blacks (tables 1–4). NMR reduction was greater for whites than blacks (59 percent versus 49 percent), whereas PNMR reduction was greater for blacks than whites (56 percent versus 41 percent). For neonatal mortality and, to a greater extent, for postneonatal mortality, relative declines in mortality risks for individual birth weight categories were larger for blacks than whites (table 1). For both race groups, there was an increase in PNMR for neonatal survivors of 500–999 g birth weight (table 1). Among whites the birth weight distribution showed a small, favorable shift to heavier birth weights, whereas among blacks there was an increase in the percentage of infants of less than 1,500 g birth weight (table 2). Among both race groups, there was an increase in the percentage of neonatal survivors of less than 2,000 g birth weight (table 2). Among whites, 85 percent of the decline in IMR resulted from lower birth weight-specific mortality and 15 percent from improved birth weight distribution (table 3). In contrast, among blacks the increase in the percentage of infants of less than 1,500 g birth weight had a negative effect on IMR, and all of the improvement was due to lower birth weight-specific mortality (table 3). Reductions in mortality among infants of less than 2,500 g birth weight accounted for 51 percent of the decrease in birth weight-specific IMR for whites and 48 percent of the decrease for blacks (table 4).

Among whites, 79 percent of reduced birth weight-specific IMR was due to lower birth weight-specific NMR and 21 percent to lower birth weight-specific PNMR, whereas among blacks these percentages were 63 percent for NMR and 37 percent for PNMR.

In 1960, a smaller proportion of deaths of black infants occurred in the neonatal period—63 percent versus 75 percent for whites—but in 1980, 66 percent of black and 67 percent of white infant deaths were neonatal (table 5). In both years, a greater percentage of black than white neonatal and postneonatal deaths occurred among infants of less than 1,500 g birth weight.

Selected States. When the decline in infant mortality was examined for the 28 States where more than 95 percent of births among infants with race other than white occurred in a hospital in 1960, the findings were similar for whites compared with the decline for the nation, but it differed for blacks. In these States, the proportion of black newborns of less than 1,500 g birth weight decreased from 1960 to 1980 (2.28 percent to 2.15 percent) compared with the increase observed for the United States (1.96 percent to 2.10 percent). The percentage of black infants of 1,500–2,499 g birth weight was 10.58 percent in 1960 and 9.05 percent in 1980 (compared with 10.03 percent and 9.19 percent for the United States). In these States the NMR for blacks declined from 26.2 to 12.7, the PNMR from 10.0 to 6.4, and the IMR from 35.9 to 19.0. Ninety percent of IMR reduction resulted from lower birth weight-specific mortality risks and 10 percent from improved birth weight distribution. Eighty percent of the decline in black birth weight-specific infant mortality was due to lower birth weight-specific neonatal mortality. In 1960, 73 percent of deaths of black infants in these States were neonatal; 67 percent were neonatal in 1980.

The decline in the percentage of black newborns of less than 1,500 g birth weight in these 28 States actually resulted from declines in the percentage of such births in only 9 States (Colorado, Connecticut, Hawaii, Iowa, Montana, New Jersey, New York, Pennsylvania, Wyoming). Four of these were northeastern States (Connecticut, New Jersey, New York, Pennsylvania), where 95 percent of black births in that region were reported in 1960.

Regional declines in infant mortality. In all four regions, the percentage of white infants of less than 1,500 g birth weight declined. The percentage declines in IMR among whites were similar—approximately 55 percent—and approximately 85 percent of the decline resulted from lower birth weight-specific infant mortality (table 6).

Table 4. Percent of decline in birth weight-specific neonatal, postneonatal, and infant mortality attributable to change in mortality in 10 birth weight categories, single-delivery infants, by race, United States, 1960 and 1980

Race and age at death	Less than 500 g	500–999 g	1,000–1,499 g	1,500–1,999 g	2,000–2,499 g	2,500–2,999 g	3,000–3,499 g	3,500–3,999 g	4,000–4,499 g	4,500 g or more	Total [1]
All races:											
Neonatal mortality risk	0	11	21	19	14	12	12	7	3	1	100
Postneonatal mortality risk	0	−2	1	4	11	24	33	22	6	1	100
Infant mortality risk	0	7	16	15	13	15	18	11	4	1	100
Whites:											
Neonatal mortality risk	0	10	20	20	14	12	13	8	3	1	100
Postneonatal mortality risk	0	−2	0	3	8	22	35	25	7	1	100
Infant mortality risk	0	7	15	16	13	14	18	12	4	1	100
Blacks:											
Neonatal mortality risk	0	14	25	16	12	11	12	7	3	1	100
Postneonatal mortality risk	0	−2	2	5	15	27	30	17	4	1	100
Infant mortality risk	0	7	15	12	13	18	20	11	3	1	100

[1] Percentages may not add to 100 due to rounding.

Among blacks there was greater variation, with IMR reductions ranging from 55 percent in the South to 41 percent in the North Central Region (table 6). Changes in the percentage of black infants of less than 1,500 g birth weight were not uniform among regions. Except for the Northeast, the percentage of black infants of less than 1,500 g birth weight increased in all regions, and the entire decline in IMR was due to lower birth weight-specific mortality risks (table 6).

Perinatal mortality risks. For the 1960 and 1980 cohorts, the PeMR declined 50 percent (31.7 to 15.9) among all races combined, 51 percent (28.5 to 13.9) among whites, and 46 percent (48.9 to 26.3) among blacks. Except for the less than 1,000 g category, where PeMR reduction was only 13 percent (950.9 to 832.0), the percentage decline in PeMR ranged from 50 percent (646.9 to 321.3) for the 1,000–1,499 g group to 67 percent (34.5 to 11.4) for the 4,500 g or more group (table 7). Using the partitioning formula, 87 percent of the decline in PeMR resulted from lower birth weight-specific PeMRs and 13 percent from a shift in birth weight distribution. Of the change resulting from birth weight-specific mortality, lower PeMR among infants in the less than 1,500 g group accounted for 23 percent, in the 1,500–2,499 g group for 31 percent, in the 2,500–3,999 g group for 39 percent, and in the 4,000 g or more group for 7 percent. Lower birth weight-specific risks accounted for 80 percent of the reduction among whites and all of the reduction among blacks.

In 1960, 48.0 percent of perinatal deaths were fetal deaths, and in 1980, 54.5 percent were fetal deaths. The corresponding percentages for 1960 and 1980 were 46.9 percent and 55.2 percent among whites and 51.6 percent and 53.1 percent among blacks.

Table 5. Percentage distribution by birth weight of single-delivery infants who died, by race and age at death, 1960 and 1980

Age at death by race and year	Number of deaths	Less than 1,500 g	1,500–2,499 g	2,500–3,999 g	4,000 g or more	Total [1]
		Neonatal deaths				
All races:						
1960	69,815	43.6	26.1	27.5	2.7	100.0
1980	25,935	56.2	16.5	24.5	2.8	100.0
Whites:						
1960	54,268	41.6	27.4	28.3	2.7	100.0
1980	17,775	51.7	18.3	26.7	3.2	100.0
Blacks:						
1960	14,491	51.0	21.5	24.7	2.8	100.0
1980	7,215	68.0	12.0	18.5	1.5	100.0
		Postneonatal deaths				
All races:						
1960	27,356	2.6	16.7	74.8	5.9	100.0
1980	12,952	10.0	16.6	67.7	5.8	100.0
Whites:						
1960	18,262	2.1	14.6	76.8	6.5	100.0
1980	8,703	8.0	15.0	69.9	7.1	100.0
Blacks:						
1960	8,358	3.8	21.5	70.2	4.5	100.0
1980	3,665	15.2	20.5	61.6	2.8	100.0

[1] Percentages may not add to 100.0 due to rounding.

Maternal characteristics of single-delivery infants, 1960 and 1980. Among all races and among whites and blacks, the percentage of mothers under 20 years of age increased, and the percentage of mothers aged 30 years or older decreased, with a

Table 6. Frequency of very low birth weight (less than 1,500 g), single-delivery infants, infant mortality risk, and components of decline in infant mortality risk, by region and race, United States, 1960 and 1980

Region, race, and year	Births	Very low birth weight (percent)	Infant mortality risk	Infant mortality risk, percent decline [1]	Percent of decline in infant mortality risk		
					Due to birth weight distribution	Due to birth weight-specific mortality	Total
Northeast							
All races:							
1960	950,532	1.1	21.4				
1980	643,327	1.0	10.4	51.5	11	89	100
Whites:							
1960	854,384	0.9	19.6				
1980	529,765	0.8	8.8	55.1	15	85	100
Blacks:							
1960	92,516	2.6	38.4				
1980	97,860	2.2	19.0	50.5	20	80	100
North Central							
All races:							
1960	1,220,644	1.0	21.5				
1980	937,091	0.9	10.8	49.9	9	91	100
Whites:							
1960	1,103,724	0.9	20.0				
1980	799,471	0.7	9.2	53.9	15	85	100
Blacks:							
1960	110,524	2.1	35.3				
1980	119,649	2.3	20.7	41.4	−3	103	100
South							
All races:							
1960	1,326,072	1.1	26.9				
1980	1,208,121	1.1	12.1	54.9	5	95	100
Whites:							
1960	972,910	0.9	21.8				
1980	881,681	0.7	9.8	54.9	14	86	100
Blacks:							
1960	346,742	1.8	41.0				
1980	305,197	2.0	18.6	54.7	−8	108	100
West							
All races:							
1960	673,920	0.9	22.0				
1980	754,456	0.8	9.9	55.1	14	86	100
Whites:							
1960	600,346	0.8	20.8				
1980	634,940	0.7	9.1	56.2	17	83	100
Blacks:							
1960	36,076	1.7	32.3				
1980	52,600	1.9	16.5	48.8	−4	104	100

[1] Percentage decline in mortality risk from 1960 to 1980, all $P < 0.05$.

corresponding increase in the percentage with one or no previous live births and a decrease in the percentage with higher birth orders (table 8).

Discussion

From 1960 to 1980, the risk of infant death for single-delivery infants in the United States dropped by more than half, largely because of lower mortality risks within birth weight categories. Reductions in the percentage of low birth weight infants contributed to lower mortality to a much lesser extent. Previous investigations of perinatal or neonatal mortality trends have drawn similar conclusions by examining linked birth and death records from selected States or by inferring national trends from unlinked vital records (*1–4, 18, 19*). The NIMS project provides the first opportunity in two decades to examine directly birth weight-specific neonatal and postneonatal mortality risks at the national level.

There were important differences in the way changes in neonatal and postneonatal mortality contributed to the decline in IMR. For neonatal

Table 7. Perinatal mortality risks, single-delivery infants, by birth weight and race, United States, 1960 and 1980 [1]

Race and year	Less than 1,000	1,000–1,499 g	1,500–1,999 g	2,000–2,499 g	2,500–2,999 g	3,000–3,499 g	3,500–3,999 g	4,000–4,499 g	4,500 g or more	Total
All races:										
1960	950.9	646.9	303.5	84.0	20.9	9.9	8.1	10.7	34.5	31.7
1980	832.0	321.3	127.2	37.9	9.5	4.4	3.3	4.0	11.4	15.9
Percent decline [2]	12.5	50.3	58.1	54.9	54.8	56.1	59.1	63.1	66.9	49.7
Whites:										
1960	958.7	672.7	322.0	87.3	20.6	9.2	7.2	9.2	28.5	28.5
1980	842.9	351.4	139.3	42.0	9.8	4.2	3.1	3.5	9.7	13.9
Percent decline [2]	12.1	47.8	56.7	52.0	52.3	53.9	57.4	61.3	66.0	51.5
Blacks:[3]										
1960	930.4	581.0	253.2	74.4	22.0	14.1	15.7	25.5	75.5	48.9
1980	806.4	259.1	100.2	29.1	8.4	5.0	5.3	8.2	30.8	26.3
Percent decline [2]	13.3	55.4	60.4	60.9	61.8	64.4	66.4	67.8	59.2	46.2

[1] There were 4,235,635 live births plus fetal deaths (3,579,267 white, 656,368 other than white) in 1960 and 3,573,991 live births plus fetal deaths in 1980 (2,867,795 white, 583,460 black) in 1980.

[2] Percentage decline in mortality risk from 1960 to 1980, all $P < 0.05$.

[3] For 1960, includes all races other than white (see text).

mortality, the greatest decline occurred among infants in an intermediate low birth weight range—1,500–1,999 g—suggesting that this group has benefited most from advances in obstetric and newborn care. Moreover, two-thirds of the decline in birth weight-specific neonatal mortality resulted from improved survival of infants of less than 2,500 g birth weight. For postneonatal mortality, the greatest declines occurred among infants of 3,500 g or more birth weight, and 86 percent of the decline in birth weight-specific postneonatal mortality was due to better survival among infants of 2,500 g or more birth weight. The increase in the PNMR for infants of 500–999 g birth weight and the comparatively small decline in PNMR for infants of 1,000–1,499 g birth weight suggest that some deaths are postponed from the neonatal period to the postneonatal period. Infants in these birth weight ranges, however, represent a small proportion of all postneonatal deaths.

Differences were also observed in the way infant mortality has declined among blacks and whites, but these differences may partly reflect disparities in the reporting of neonatal deaths between blacks and whites. The percentage of infants with very low birth weight (less than 1,500 g) is a predominant determinant of neonatal and infant mortality risk (*20*). Among whites, this percentage declined, whereas among blacks, it increased. As a result, trends in birth weight distribution contributed to the decline in IMR among whites but had a negative effect among blacks. In trend analyses, David has shown that the worsening birth weight distribution among blacks may reflect underreporting of births for small black infants in past years

Table 8. Characteristics of mothers of single-delivery infants, by race of infant, United States, 1960 and 1980 [1]

Maternal characteristics	Percent of live births					
	All		White		Black	
	1960	1980	1960	1980	1960	1980
Maternal age (years):						
Under 15	0.2	0.3	0.1	0.1	0.7	1.0
15–19	13.9	15.4	12.8	13.5	20.7	25.7
20–24	33.6	34.0	34.0	34.0	31.9	35.6
25–29	25.6	30.6	26.1	32.1	22.2	22.9
30–34	16.0	15.2	16.2	15.8	14.5	10.8
35–39	8.4	3.9	8.5	3.9	7.7	3.3
40–44	2.1	0.6	2.2	0.6	2.0	0.7
45 or older	0.1	0.0	0.1	0.0	0.1	0.0
Unknown [2]	0.1	...	0.0	...	0.1	...
Previous live births:						
None	25.9	43.3	26.6	44.0	21.9	40.0
1	24.1	31.7	25.0	32.2	18.7	28.9
2	18.7	14.7	19.3	14.4	15.3	16.1
3	11.9	5.5	11.9	5.1	12.0	7.4
4	6.8	2.1	6.4	1.9	9.1	3.3
5 or more	9.7	2.0	7.6	1.7	22.1	3.3
Unknown	2.9	0.8	3.2	0.7	0.8	1.1

[1] Maternal educational achievement and measures of prenatal care (month of gestation that care begun, and number of visits) were available for the 1980 cohort but not for the 1960 cohort.

[2] In 1980, unknown maternal ages were assigned imputed values by the National Center for Health Statistics.

(*12*). In our study, the underreporting may be reflected by a higher percentage of out-of-hospital births among blacks in 1960 than occurred in 1980. If infants whose births are unreported are more likely to have low birth weights, as suggested by David's study, then these babies are also at increased risk of neonatal death. Thus, high proportions of out-of-hospital births are likely to be associated with underreporting of both births

'From 1960 to 1980, the risk of infant death for single-delivery infants in the United States dropped by more than half, largely because of lower mortality risks within birth weight categories. Reductions in the percentage of low birth weight infants contributed to lower mortality to a much lesser extent.'

and deaths. When we limited our 1960–80 comparison to States where nearly all black births occurred in hospitals in 1960, the percentage of black infants of less than 1,500 g birth weight decreased, and changes in birth weight distribution made a positive contribution to the decline in IMR.

In all four U.S. regions, the percentage of white infants of less than 1,500 g birth weight decreased, and relative declines in IMR were similar. In contrast, among blacks, birth weights of less than 1,500 g decreased in the Northeast, contributing to mortality declines, but they increased in the other three regions. In 1960, the proportions of infants with race other than white born in hospitals were 97.9 percent for the Northeast, 97.3 percent for the West, 96.5 percent in the North Central, and 73.8 in the South (*10*). Yet the frequency of birth weights under 1,500 g among black infants increased by 1980 in the North Central and West. These findings, and the observation that birth weights of less than 1,500 g declined among blacks in only 9 of the 28 States with more than 95 percent of other than white infants born in hospitals in 1960, suggest that underreporting of births in 1960 may not entirely explain the increase in birth weights of less than 1,500 g among blacks.

We considered trends in perinatal mortality because changes may have occurred from 1960 to 1980 in the distinction between fetal and early neonatal deaths. Although infants who die very shortly after birth should be classified as both live births and neonatal deaths, in some cases, particularly for very small infants, they may be reported as fetal deaths. If this practice decreased from 1960 to 1980, improvements in neonatal mortality would be underestimated. Our findings regarding this possibility are inconclusive. Perinatal mortality declined somewhat less than neonatal mortality (50 percent versus 56 percent), whereas the opposite would be expected if more neonatal deaths were inappropriately classified as fetal deaths in 1960. However, improvements in birth weight made a greater contribution to the reduction in perinatal compared with neonatal mortality, which is consistent with the hypothesis that more very small infants are being appropriately classified as live births in 1980. This comparison of perinatal and neonatal mortality is clouded by the possibility that underreporting is greater for fetal than for neonatal deaths and that improvements may have occurred in the reporting of fetal deaths. Infants of less than 500 g birth weight may be most affected by these reporting problems. We repeated our comparison of the 1960 and 1980 cohorts excluding infants in this weight category, but the conclusions were virtually unchanged regarding the contribution of changes in birth weight distribution and birth weight-specific mortality to NMR, PNMR, IMR, and PeMR reductions.

One difference between neonatal mortality and perinatal mortality is that the greatest reductions in perinatal mortality occurred among infants in the highest birth weight groups. This finding is consistent with perinatal mortality trends in California, which Williams and Chen attributed to increasing use of cesarean section (*2*).

There are a number of limitations to this study. As suggested by changes in birth weight and mortality among black infants, changes have occurred in the completeness of birth and death registration from 1960 to 1980, and the effect of these changes on the 1960–80 comparison cannot be fully determined. The 1960 and 1980 projects differed in methods used to link birth and infant death certificates. For the 1960 cohort, NCHS did these linkages at the national level. For the 1980 cohort, individual States performed record linkages, and CDC compiled State data tabulations into a national report. The advantage of national linkage, as done in 1960, is an opportunity to overcome problems associated with incomplete interstate exchange of vital records, that is, when birth or death occurs outside the State of residence. The percentage of death certificates linked to a birth certificate in the 1960 study (97.4 percent)—was greater than in the 1980 study (approximately 95 percent). One advantage of State linkage is that it can lead to an improvement in the quality of State vital records. Another advantage is that it promotes the capacity of States to use linked records to evaluate and target programs for improving infant health.

A more important limitation is that the results

of this study cannot explain why birth weight-specific mortality risks declined more than low birth weight. From 1960 to 1980, many disparate changes occurred that affect the health of pregnant women and infants at both the individual and population levels. The technologies of obstetric, newborn, and infant care have advanced dramatically, and in many areas the delivery of these services has been organized into regional systems. Programs to improve family planning, prenatal care, and nutrition services have been introduced and have evolved, yet unintended pregnancy and inadequate prenatal care persist as major problems. The demographic profile of childbearing women and attitudes toward health are changing. Infant safety measures, such as child-proof medicine containers and infant car seats, have been promoted. The number of pregnancies terminated by legal, induced abortion rose during the 1970s to more than 1 million in 1980. The relative frequency of intrauterine growth retardation among low birth weight newborns decreased compared with prematurity. Improved perinatal care is the most likely, predominant reason for the reductions in birth weight-specific neonatal mortality. Reasons for reduced birth weight-specific postneonatal mortality are undoubtedly more complex. Although improvements in birth weight have been modest, they have occurred among whites and, at least in some States, among blacks. Continued improvements in birth weight hold the greatest potential for future, large reductions in infant mortality.

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