Influence of Birth Weight, Sex, and Plurality on Neonatal Loss in the United States

SAM SHAPIRO, F.A.P.H.A.

Over the years an impressive body of literature has revealed the strong influence exercised by birth weight on the newborn's survival. In the main, the findings have been related to single communities or hospitals and have been directed toward mortality experience among the prematurely born. This report extends the information to offer help to programs inaugurated to reduce all losses in early infancy.

The data used in this study are based on the information reported on the 840,000 birth records for infants born during January, February, and March, 1950, throughout the country,* and on the death certificates for the members of the group who died within four weeks after birth. To consolidate the statistics appearing on both sets of forms, death records were matched against birth records.

No entirely new variables are considered—only some of the well established ones, e.g., birth weight, race, plurality, and sex—and period of gestation, about which perhaps too little has been said. However, in a number of respects the material presented here is relatively new, as it describes the situation existing in the country as a whole rather than in a selected area or institution. Then, again, the statistical sights in the report are raised beyond the group of prematurely born infants and birth weight gradations are introduced in the "mature" weights, over 2,500 gm., with interesting results.†

Because of the relatively large cohort of births involved, it is possible to consider the relationship between plurality, race, sex, and mortality during the neonatal period, taking into account a wide range of birth weights. Age at death statistics are introduced briefly to pursue a line of thought rather than to provide a comprehensive set of basic data.

The report continues the tradition of other investigations into mortality among the newborn by placing primary emphasis on the birth weight characteristic for differentiating levels of fetal development. In mass statistical operations, birth weight is still unquestionably a more objective and reliable measure for this purpose than gestation age which is also reported on the vital record. Poor as the gestation age data are, it would appear, however, that they can be used to throw some light on differentials delineated by the birth weight variable. They are introduced in the report as an auxiliary source of information to help sharpen a number of the issues and possibly to suggest courses of research that cannot be followed

* As indicated in the "Technical Notes," the data actually refer to the United States, excluding Massachusetts. The birth records in this state do not contain the items of birth weight and period of gestation.

† Births in the weight group "2,500 gm., or less," are classified as immature (premature) according to the definition recommended by the American Academy of Pediatrics in 1935 and adopted by the Sixth Revision of the International List of Diseases, Injuries, and Causes of Death (1948). The latter states further that "if weight is not specified, a live-born infant with a period of gestation of less than 37 weeks may be considered as the equivalent of an immature infant for purposes of classification."

Table 1—Birth Weight Distribution by Race, Sex and Plurality: United States, January-March, 1950

(Birth weight "not stated" distributed. Data for Massachusetts, which does not collect information on birth weight, excluded.)

Birth Weight (in Grams)	Percentage Distribution						
	Total	White	Nonwhite	Single	Plural	Male	Female
Total Live Births	837,786	717,133	120,653	820,618	17,168	429,506	408,280
1,000 or less	0.5	0.4	0.6	0.4	4.0	0.5	0.5
1,001–1,500	0.6	0.6	0.8	0.5	5.6	0.6	0.6
1,501–2,000	1.4	1.3	1.8	1.1	14.2	1.3	1.4
2,001–2,500	4.9	4.7	6.4	4.4	29.2	4.3	5.6
2,501–3,000	18.1	17.7	20.6	17.9	29.5	15.4	21.0
3,001–3,500	37.7	38.1	35.1	38.2	14.1	36.1	39.4
3,501–4,000	27.1	27.7	23.5	27.6	2.8	29.8	24.2
4,001–4,500	7.7	7.8	7.3	7.8	0.6	9.5	5.8
4,501 or more	2.1	1.8	3.8	2.1	0.1	2.6	1.5

through the exclusive use of the vital record.

Weight at Birth

The annual series of official vital statistics have made it clear for a long time that large differences exist between the races and between the sexes in the mortality risk during early infancy, with the white and female births having a decided advantage over the nonwhite and male groups, respectively. To this can be added the well known fact that mortality is considerably higher among the plural births than among the single. The comparative status of these groups is the resultant of differences in weight distribution at birth and differences in mortality experience over the entire range of weights.

Data appearing in Table 1 and Figure 1 tell the weight distribution story. Briefly, the highlights are:

1. A great majority of the births, 82.9 per cent, occurred at weights 2,501–4,000 gm., with about a third falling in the 500 gm. interval, 3,001–3,500 gm. Babies weighing 2,500 gm., or less, represented only 7.4 per cent of the total births, and two-thirds of this group were found at weights 2,001–2,500 gm. The numbers of births diminished with each successively lower weight group and the delivery of a live-born child weighing 1,000 gm., or less, was a relatively rare occurrence. At the other end of the weight scale there was also a rapid decline in the frequency of births. Only 2.1 per cent weighed over 4,500 gm., and it seems likely that the birth of a child over 5,000 gm. is almost as unusual as the birth of an infant of 1,000 gm., or less.

2. Average (median) weights at birth for white and nonwhite births differed only slightly, but the weight distributions for the two race groups varied in a number of crucial respects. Most important are the appreciably higher proportions of nonwhite births found at

Mr. Shapiro is chief, Natality Analysis Branch, National Office of Vital Statistics, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C.

This paper was presented before the Maternal and Child Health Section of the American Public Health Association at the Eighty-first Annual Meeting in New York, N. Y., November 12, 1953.

Figure 1

BIRTH WEIGHT DISTRIBUTIONS:
UNITED STATES, JANUARY-MARCH 1950

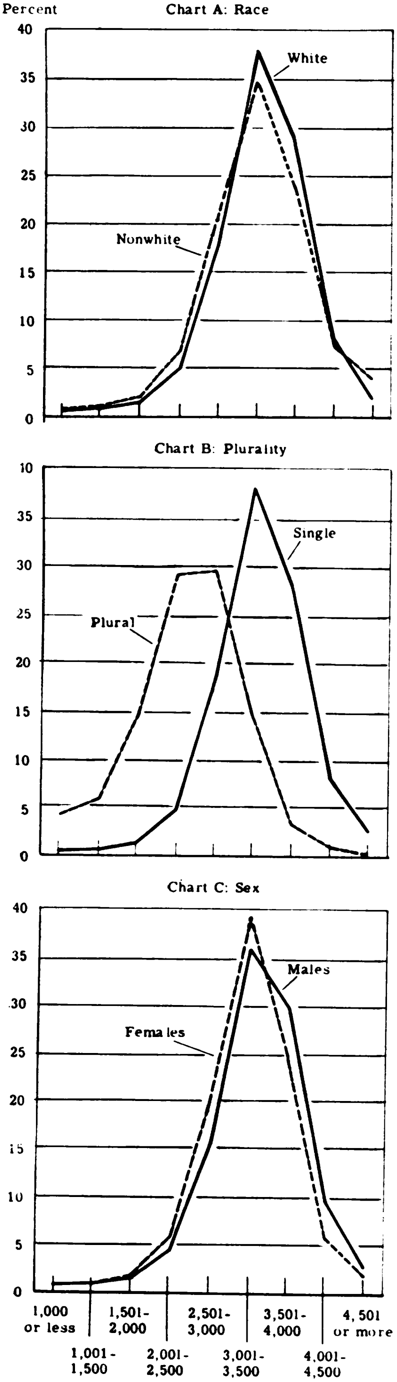
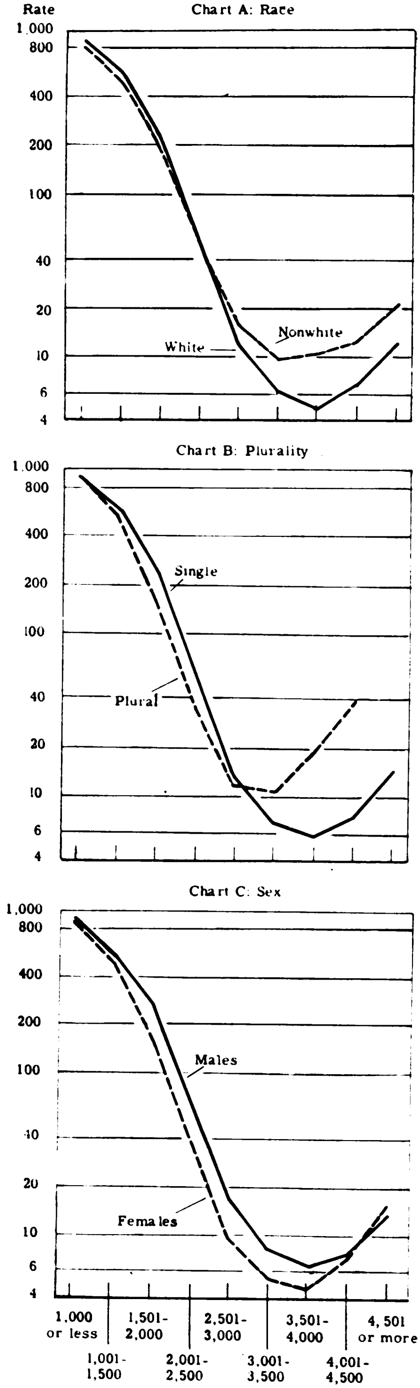


Figure 2

NEONATAL MORTALITY RATES BY BIRTH
WEIGHT: UNITED STATES, JAN.-MAR. 1950



Birth Weight Shown in Grams

both ends of the weight distribution where the major problems of obstetric and pediatric care are concentrated. Among nonwhite births, 9.7 per cent were born weighing 2,500 gm., or less, and 3.8 per cent were over 4,500 gm. In the white group, the comparable figures were 7.0 per cent and 2.1 per cent.

3. Individual members of plural sets had a completely different weight distribution at birth than did single births, weighing on the average about 870 gm., or almost two pounds less. Slightly over half of the plural births were 2,500 gm., or less, and not quite a fifth were over 3,000 gm.* A closer look at the data indicates that almost a tenth were in the very high risk group of 1,500 gm., or less. The distribution among single births was, of course, much nearer the situation among total births.

As a result of the heavy concentration of plural births in the lower weight groups, close to 15 per cent of all the infants 2,500 gm., or less, at birth came from this group, even though only 2 per cent of the 840,000 births in the study were members of plural sets.

4. Males generally weighed more than females at birth in both race groups. There was very little difference in the weight distributions for the two sexes until the 2,001–2,500 gm. interval was reached, where the distribution for female births turned up more sharply than for male. The modal weight group in both sexes was 3,001–3,500 gm. However, the distributions in the immediate vicinity of this weight interval differed considerably with a much higher proportion of births in the male group falling to the right of the interval than was the case for female births.

Of major significance in the interpretation of the statistics is the often considered question whether the variations between weight distributions reflect inherent differences in fetal development or are due to uterine or extrauterine environmental influences. Certainly, in the case of the marked dissimilarity between single and plural births, the physical limitation of the mother is a decisive factor. As it is, the combined weight of births in a plural set is undoubtedly much higher on the average than the weight of single births. Under the broad assumption that members of a multiple set weighed within 500 gm. of each other, the combined weight in about half of the cases in the study would be in excess of 5,000 gm.

An expression of the limitation imposed by plurality on fetal development, i.e., as measured by weight, can be found in the fairly crude gestation age data that are available. For example, the average weight of infants in multiple births at the gestation age interval "37 weeks, or more," was 2,640 gm., as compared with 3,360 for single births. Differences of this type are found at earlier gestation ages, but are on a somewhat smaller scale.

The reason and meaning of the variation between the sexes in weight at birth are not as straightforward. Differences in socioeconomic status, birth order, age of mother, and prenatal care can have little, if any, part in the matter. The influence of whatever factors are operating is probably felt at least as far back as the second trimester of pregnancy. This is suggested by the small but consistent differences in average weight in favor of male births (all races) given in Table 2. Intensive inquiry on this point would require distributions of weight by gestation age, based on more accurate data than are now available.

As indicated in many previous investigations, socioeconomic and other demographic factors probably play important roles in the race differentials. The effect of birth order and age of mother will be investigated at a future

* The term "plural births" throughout this report refers to the individual members of sets of twins and triplets.

Table 2—Median Birth Weights of Live Births at Selected Gestation Ages by Race, Sex, and Plurality: United States, January-March, 1950

(Birth weight and gestation age "not stated" distributed. Data for Massachusetts, which does not collect information on birth weight or gestation age, excluded. Median birth weights rounded to the nearest 10 gm.)

Gestation Ages	Total	White	Nonwhite	Single	Plural	Male	Female
Total *	3,320	3,330	3,280	3,330	2,460	3,390	3,260
Under 28 weeks	920	900	970	930	820	940	890
28–31 weeks	1,700	1,700	1,700	1,740	1,430	1,720	1,680
32–35 weeks	2,310	2,320	2,280	2,360	1,960	2,340	2,290
37 weeks or more	3,350	3,360	3,300	3,360	2,640	3,410	3,280

* Includes "36 weeks" gestation age, although this group is not shown separately.

time. However, data for other variables which may be more directly related to the issue are not available for the births in this series of studies. With respect to the gestation age information reported here, it will be noted that the race differences in birth weights do not follow a consistent pattern over the range of gestation groups in Table 2. The higher average weight for nonwhite births in the under 28-weeks group is in contrast to the situation at 32 weeks and above. Reporting errors and fetal loss differentials may have an important bearing on this reversal.

Mortality

The preceding issues become more real when related to the neonatal loss at specific birth weights. Table 3 and Figure 2 summarize the experience of

Table 3—Neonatal Mortality Rates by Birth Weight, Race, Sex, and Plurality: United States, January-March, 1950

(Rates per 1,000 live births. Birth weight "not stated" distributed. Data for Massachusetts, which does not collect information on birth weight, excluded.)

Birth Weight (in Grams)	Total	White	Nonwhite	Single	Plural	Male	Female
All Weights	20.0	18.9	26.7	18.3	98.6	22.7	17.1
1,000 or less	871.7	883.3	821.4	871.7	871.5	894.2	848.0
1,001–1,500	551.3	562.1	507.0	562.3	503.7	621.8	478.2
1,501–2,000	211.0	214.6	195.7	228.9	145.4	265.0	160.5
2,001–2,500	50.4	50.6	49.5	52.8	32.9	67.4	36.6
2,501–3,000	12.6	12.0	15.4	12.6	11.3	16.6	9.5
3,001–3,500	6.7	6.2	9.7	6.7	10.4	8.1	5.3
3,501–4,000	5.6	4.9	10.5	5.6	18.7*	6.4	4.6
4,001–4,500	7.5	6.7	12.5	7.4	38.1*	7.7	7.2
4,501 or more	14.2	12.0	20.2	14.2	..	13.7	15.1
2,500 or less	173.7	175.8	164.7	173.4	175.6	213.9	138.9
2,501 or more	7.8	7.1	11.9	7.7	11.8	9.1	6.4

* Based on less than 20 deaths.

Table 4—Mortality Rates by Birth Weight, Race, and Sex; at Specified Ages Under 28 Days: United States, January-March, 1950

(Rates per 1,000 infants alive at beginning of each age interval shown. Birth weight "not stated" distributed. Data for Massachusetts, which does not collect information on birth weight, excluded. Single and plural births are combined.)

Age at Death	All Weights *	1,001–1,500 gm.	1,501–2,000 gm.	2,001–2,500 gm.	2,501–3,000 gm.	3,001–4,500 gm.	4,501 gm. or more	2,500 gm. or less	2,501 gm. or more
All Races									
Under 1 day	9.7	304.7	99.1	19.0	4.2	2.2	4.9	97.9	2.7
1 day	3.0	127.9	43.4	8.8	1.8	0.9	2.6	29.2	1.1
2 days	2.0	72.1	28.8	6.7	1.5	0.7	1.3	18.2	0.9
3–6 days	2.6	109.1	27.5	8.3	2.2	1.1	2.2	21.0	1.4
7–13 days	1.4	67.5	17.8	4.0	1.2	0.7	1.9	10.3	0.8
14–27 days	1.5	40.0	13.1	4.6	1.7	0.9	1.3	8.1	1.0
White									
Under 1 day	9.3	314.3	103.6	19.1	4.1	2.1	3.6	100.3	2.5
1 day	2.9	133.0	45.8	9.5	1.8	0.8	2.1	30.4	1.0
2 days	2.0	74.2	31.8	7.4	1.6	0.6	1.3†	19.3	0.8
3–6 days	2.4	118.5	26.2	7.9	2.1	1.0	1.9	20.6	1.2
7–13 days	1.2	65.2	16.0	3.7	1.0	0.6	1.8	9.6	0.7
14–27 days	1.3	34.6	10.3	4.1	1.6	0.8	1.5†	6.9	0.9
Nonwhite									
Under 1 day	11.9	265.5	80.2	18.8	4.8	3.2	8.7	87.8	3.8
1 day	3.6	108.7	33.4	6.0	1.8	1.4	3.9†	24.2	1.6
2 days	2.3	64.0	17.0	3.7	1.4	1.2	1.5†	13.6	1.2
3–6 days	4.0	74.9	32.5	10.2	3.1	1.9	3.1†	23.0	2.2
7–13 days	2.4	75.7	24.9	5.1	2.0	1.2	2.2†	13.3	1.4
14–27 days	2.7	59.0	24.5	6.7	2.4	1.5	0.9†	13.1	1.7
Male									
Under 1 day	10.9	354.2	125.4	25.8	5.3	2.5	4.3	122.1	3.0
1 day	3.5	156.9	57.2	12.8	2.7	1.0	2.6	37.4	1.3
2 days	2.3	91.6	37.3	9.7	2.1	0.8	1.3†	23.6	1.1
3–6 days	3.0	137.6	37.6	10.9	2.9	1.3	2.2	26.9	1.6
7–13 days	1.5	77.1	21.9	4.2	1.5	0.7	2.0	11.6	0.9
14–27 days	1.7	39.3	16.5	5.9	2.2	1.0	1.3†	9.5	1.2
Female									
Under 1 day	8.3	253.3	74.6	13.6	3.3	1.9	6.1	77.1	2.3
1 day	2.5	102.0	31.2	5.7	1.1	0.7	2.6†	22.4	0.8
2 days	1.7	55.6	21.6	4.3	1.1	0.6	1.3†	13.8	0.7
3–6 days	2.2	86.1	19.0	6.2	1.7	0.9	2.2†	16.3	1.1
7–13 days	1.3	60.2	14.4	3.8	1.0	0.6	1.7†	9.3	0.7
14–27 days	1.3	40.5	10.2	3.5	1.3	0.7	1.3†	7.0	0.8

* Rates for 1,000 gm., or less, not shown separately. Two-thirds of these infants died in the first day after birth.
† Based on less than 20 deaths.

the infants in this study and indicate how rapidly the mortality rate is changing between weight groups. Also, the larger the gap between curves, the greater the relative difference in the mortality experience.

Considering what is known from general mortality statistics, it is not at all surprising to find that about two-thirds of the infants who died during the first four weeks after birth weighed 2,500 gm., or less.* Starting from the very

* Of the 16,741 infants who died, 10,706 were in this weight category.

high loss of seven out of eight live births 1,000 gm., or less, the neonatal mortality rate declined rapidly with additional weight to reach a low point among babies weighing 3,501–4,000 gm. (5.6 per 1,000 births). The modal weight group, 3,001–3,500 gm., was a close second. Appreciable increases in weight which brought the baby beyond 4,000 gm. at birth were a definite liability and above 4,500 gm. the rate was almost three times the low figure.

No sharp dividing point could be drawn between "immature" and "mature" from the data. The impression gained from statistical series that group together all weights above 2,500 gm. is that the drop in mortality after this point is far greater than the changes from one weight to the next among the prematurely born infants. However, subdivision of the data into 500 gm. intervals indicates clearly that a more orderly situation exists. Similar relative declines in the rate (about 75 per cent in 500 gm.) occur in the weight group just above 2,500 gm. and in the group just below. In part, this similarity reflects, of course, the special care extended by many hospitals to "immature" infants. Parenthetically, it might be noted that the rate of decline at these weights was the greatest over the entire 500 gm. weight range in both race groups and both sexes.

The mortality risk was most acute during the first day after birth regardless of the infant's weight (Table 4). With each additional day the loss in successive groups of survivors declined sharply. Ability to survive the hazardous first day was closely related to the infant's weight, but the advantage that went with additional weight at birth (until reaching the higher weights) was also felt long afterward. In the third and fourth weeks after birth a considerable margin still separated the mortality rates for adjacent birth weight groups, although in most instances the percentage difference was not as large as earlier. Another interesting feature of the data is that throughout the neonatal period, mortality was greater among the heavy babies, i.e., those over 4,500 gm., than in the group weighing 3,001–4,500 gm. The more difficult situations faced by the obstetrician in delivering large babies apparently had their counterpart in pediatric problems posed by the group.

Race—The substantial difference in the over-all neonatal mortality rates for white and nonwhite births (18.9 and 26.7, respectively) was due to far greater mortality among nonwhite infants weighing over 2,500 gm. and to the larger proportions of nonwhite births at the poor risk weights. The heavy contribution made by the latter factor can be seen from the neonatal mortality rates standardized for weight. These were 19.6 for the white group and 22.6 for the nonwhite.

At 2,000 gm., or less, the risk of loss was appreciably lower among nonwhite than white births. Although the data in Table 3 show that there was practically no difference between the two races in the next higher 500 gm. weight group (2,001–2,500 gm.), the following rates

Birth Weight	White	Nonwhite
1,001–1,250	668.1	614.4
1,251–1,500	489.5	430.9
1,501–1,750	315.4	203.1
1,751–2,000	191.6	125.5
2,001–2,250	84.2	67.4
2,251–2,500	36.0	32.4
2,501–2,750	16.6	13.8
2,751–3,000	8.3	9.5

indicate that among single births in hospitals the nonwhite definitely had a lower mortality here, too.* Also, the hospital birth data reveal that the survival advantage for the nonwhite group

* Note, these are the only figures in the report for hospital events. They give a later turning point than is indicated by the data for hospital and home births combined, page 1150. Figures for births occurring at home will be presented elsewhere.

did not end at 2,500 gm. Actually, the situation became relatively more favorable for the white births for the first time at 2,751–3,000 gm. This type of statistics may suffer from selectivity, but it is unquestionably more accurate than the figures that combine births in hospitals and at home, particularly for the nonwhite group.

In comparing these statistics with the findings reported in other studies, it should be borne in mind that they represent the composite experience of hospitals with an extremely broad range of services for handling prematurely born infants. Furthermore, the many types of hospitals are probably reflected differentially in the figures for the white and nonwhite births.

Differences of the type just discussed give the impression that white and nonwhite births do not reach the same level of development at the low weights. Equivalence between race groups is apparently also not found in the mortality experience at the gestation ages that follow for single births: *

Gestation Period	White	Nonwhite
Under 28 weeks	793.5	718.3
28–31 weeks	374.3	332.4
32–35 weeks	119.7	108.9
37 weeks or more	7.9	13.1

Returning to Table 3, it will be noted that the optimum rate for white births was considerably lower than for nonwhite. The advantage among nonwhites in the low weight groups resulted from their greater ability to survive the immediate period following parturition and the first few days afterward. With time, the environment factors exerted an increasingly greater influence on chances of survival and the situation changed. By the third and fourth weeks after birth, nonwhite mortality was well above the white.

* Data for 36 weeks gestation are omitted because of the special problems discussed in the "Technical Notes."

In the weights above 3,000 gm., white births had a marked advantage over the nonwhite from the very earliest period of life. The advantage generally reached its greatest proportions after the first few days. An exception to this was found above 4,500 gm. Here, the especially difficult problems faced in delivering very large nonwhite babies resulted in an even wider gap (relatively) between the rates in the first day than later in the neonatal period.

Plurality—Deaths among infants that were part of plural sets accounted for 10 per cent of the total neonatal loss. This was almost entirely because of the large concentration of multiple births at the low weights. Although weight was a decisive element in the mortality among these infants, the risk of loss was far below the experience among single births at weights 1,501–2,500 gm. The latter group had a marked advantage above 3,000 gm. The special meaning of "excessive" weight among plural births can be judged from the sharp increase in mortality after 3,500 gm.

Sex—Probably no characteristic has as interesting a set of differences in the mortality experience as sex. The loss among the males was about a third more than among the females during the entire neonatal period. Here the weight distribution was overridden by a more important factor, i.e., a markedly lower mortality rate among the females at almost all weights. In fact, the advantage became slightly greater when the rates were standardized for weight, 16.7 for the females and 23.6 for the males.

Over the broad weight range 1,001–4,000 gm., the rates among baby boys were between 30 and 84 per cent higher than those for girls. It was only above 4,500 gm. that males had a lower rate. It may well be that comparisons at the low weights are artificial in that female infants born at a certain weight may be more fully developed and ready to cope with the rigors of the birth process and the extrauterine environment than male babies of the same weight. This would appear to be supported by the following detailed weight data for single births, which indicate that at several points the rate for females was close to the rate for males in the next higher 250 gm. interval. Especially was this true for the white race where the male-female differentials in specific weight groups were generally larger than was the case for the nonwhite.

Birth Weight	White		Nonwhite	
	Male	Female	Male	Female
1,001–1,250	731.7	589.3	648.6	603.4
1,251–1,500	579.4	412.3	464.6	412.0
1,501–1,750	383.0	246.0	252.9	228.0
1,751–2,000	246.0	147.7	206.2	131.5
2,001–2,250	117.1	59.5	104.6	62.0
2,251–2,500	55.8	30.2	50.8	35.1
2,501–2,750	23.8	13.2	25.6	13.4
2,751–3,000	11.6	6.8	15.7	9.7

Not all of the sex differences in mortality can be explained by this method of equating weight groups. In Figure 2C, it will be observed that while the optimum weight level for both sexes was 3,501–4,000 gm., the mortality curves were still relatively far apart at this point. This strongly suggests that differences in development as measured by birth weight are not the entire explanation. Period of gestation also may not be the answer since about as large a percentage difference was found among births at or near full term as in the group occurring several weeks earlier. Mortality rates for single births (all races combined) follow:

Gestation Period	Male	Female
Under 28 weeks	805.0	749.0
28–31 weeks	406.0	319.2
32–35 weeks	137.9	96.7
37 weeks or more	9.9	7.3

That the differences between the sexes in the ability to survive goes beyond maturity at birth, as measured by either weight or gestation age, are indicated by the persistence of the advantage among females long after the hazardous first few days. Mortality differences toward the end of the neonatal period were comparatively large even at such favorable weights as 3,001–4,500 gm.

Fetal Deaths—Although this article is concerned with the mortality among the live-born, a word should be said about late fetal deaths (28 weeks or more gestation). To an increasing degree, it is being recognized that many of the problems posed by this group are similar to those found among early neonatal deaths. The following data for events

	Fetal Deaths (28 Weeks or More Gestation) per 1,000 Live Births	Deaths (Under 1 Week) per 1,000 Live Births
Total	15.4	17.2
White	13.6	16.4
Nonwhite	25.9	21.7
Single	14.9	15.7
Plural	39.1	89.1
Male	16.3	19.6
Female	14.5	14.6

that occurred in the first quarter of 1950 indicate that race, sex, and plurality differences are in the same direction for both groups. However, the magnitude of these differences is greater among the neonatal deaths for the sex and plurality characteristics. The reverse is true for the race variable.

These relationships will be examined more intensively at a later date, utilizing weight and gestation age information.

Technical Notes

Source of Data—The data presented in this report are based on information taken from (1) birth certificates for infants born in the first three months of 1950, and (2) death records for the group that died within 28 days after birth.* These two sets of records were matched to interrelate birth and death information for the same infants. Birth certificates were available for all but a small proportion of the deaths (2.4 per cent or 390 cases). This group included some foundlings. A birth record was created for each unmatched death record, utilizing data on the death certificate for certain personal particulars, e.g., race, and sex.

Seasonality—The proportion of children weighing 2,500 gm., or less, in the first three months of 1950 (7.4 per cent) was smaller than for the year as a whole (7.6 per cent). Although the differences between the weight distribution for the two time periods are statistically significant for all major characteristics, they are of a small enough order of magnitude not to disturb the comparisons made.

The neonatal mortality rate for the whole year of 1950 (20.5 per 1,000 live births) was slightly higher than the rate among the births in the study. However, this is in the direction indicated by the difference in weight distribution.

Distribution of "Unknown" Birth Weights and Limitations of Data—About 3 per cent of the birth records for the white and 7 per cent for the nonwhite did not have a statement on birth weight. Among the deaths, these percentages were 13 and 20 for the two race groups, respectively. It was apparent from the distributions of the data that birth weight reporting was less complete for infants born at early gestation ages than at a more advanced stage of pregnancy. To reduce this bias, gestation age information was used to distribute the groups that had no weight statements. This was accomplished by assuming that within each gestation age the "unknown" weights were distributed as the "known."

About 6 per cent of the total neonatal deaths and less than 2 per cent of all the births had no statement on both weight and gestation age. These were distributed proportionately as the known birth weights. Plurality, race, and sex were taken into account in making all of the distributions. Despite the fact that a reasonably sound basis existed for distributing the "unknowns," this group was fairly large and the reader is cautioned not to draw conclusions from relatively small differences. An exception to this would be a series of small differences which were all in the same direction.

Accuracy of Data—There is probably less of an error in the figures for white than nonwhite for reasons other than the "unknown" weight problem. In the latter race, about 45 per cent of the births were delivered at home and mainly by midwives. In the white race, the comparable figure was 8 per cent. Many of the midwives used scales graduated in quarter pound intervals and it is not known how carefully the weighing was done. To reduce the effect of this factor, most of the tabular material presented in this report is in 500 gm. intervals. Sex differentials within each race group should be influenced only slightly by errors of this type.

Although no measure of the problem

---

* Massachusetts births and deaths are excluded from the report since birth records in this state do not carry items on birth weight or gestation age. The effect of this exclusion was minor, as shown in the following over-all neonatal mortality rates for January–March, 1950: United States (including Massachusetts)—all races, 19.9; white, 18.8; nonwhite, 26.6. United States (excluding Massachusetts)—all races, 20.0; white, 18.9; nonwhite, 26.7.

is available, it is generally believed that there is slightly greater underreporting of infants who die immediately after birth than in the group that survives. Also, misreporting of some as fetal deaths does occur. Both of these types of errors lead to an understatement of the proportions of the births in the very low weights and of the mortality rates at these weights. This is, undoubtedly, a somewhat more important factor among nonwhite births than among the white and would affect the relationships discussed to some extent.

Classification—In most areas, birth weight was reported in pounds and ounces. The traditional gram groupings, however, are used to tabulate and present the data in order to facilitate comparison with other studies. Equivalents of these groupings in terms of pounds and ounces are as follows:

1,000 gm. or less	= 2 lbs. 3 oz. or less
1,001–1,250 gm.	= 2 lbs. 4 oz.–2 lbs. 12 oz.
1,251–1,500 "	= 2 " 13 "–3 " 4 "
1,501–1,750 "	= 3 " 5 "–3 " 13 "
1,751–2,000 "	= 3 " 14 "–4 " 6 "
2,001–2,250 "	= 4 " 7 "–4 " 15 "
2,251–2,500 "	= 5 " 0 "–5 " 8 "
2,501–2,750 "	= 5 " 9 "–6 " 1 "
2,751–3,000 "	= 6 " 2 "–6 " 9 "
3,001–3,500 "	= 6 " 10 "–7 " 11 "
3,501–4,000 "	= 7 " 12 "–8 " 13 "
4,001–4,500 "	= 8 " 14 "–9 " 14 "
4,501 gm. or more	= 9 lbs. 15 oz. or more

The 1950 birth records in all but a few of the states requested gestation age information in the following form: "length of pregnancy—weeks." In practice period of gestation is generally interpreted as referring to the number of completed weeks that have elapsed between the first day of the last menstrual period and the date of birth of the child. At the present time, important inaccuracies are evident in the data. These arise principally from errors or difficulties in computing "length of pregnancy" in weeks and are reflected in the statistics by extreme heaping at 36 and 40 weeks. The problem with "36 weeks" is believed to result from the practice among some attendants of converting nine calendar months (full-term gestation age) into weeks by multiplying by four. Heavy concentrations at 40 weeks are indicative in part of a failure to calculate period of gestation for the newborn infants who seem to be normally developed. This probably has its greatest effect on gestation ages close to term.

Summary

A nation-wide study of births that occurred during the first quarter of 1950 and deaths in the group within 28 days after birth was carried out on the basis of information on vital records. Birth and death records were matched to interrelate data appearing on them.

About 7.4 per cent of the infants weighed 2,500 gm., or less, at birth. Another 2.1 per cent were in the heavy weight group of 4,501 gm., or more. Nonwhite babies generally did not weigh as much as the white, and females weighed less than males. This resulted in larger proportions of the former groups weighing 2,500 gm., or less, than was the case for the white and male groups, respectively. A larger segment of nonwhite births than white was also found at the other end of the weight scale (over 4,500 gm.). Plural births were heavily concentrated in the lower weight groups, and close to 15 per cent of all the infants 2,500 gm., or less, at birth came from this group.

Relatively small increases in birth weight resulted in major reductions in neonatal mortality. The optimum weight was well past the 2,500 gm. upper level of immaturity. Appreciably heavier weights than the optimum were a definite liability and above 4,500 gm. the rate for all races combined was almost three times the low figure (5.6 per 1,000 births weighing 3,501–4,000 gm.).

The mortality risk was greatest during the first day after birth regardless of the infant's weight. Ability to survive this hazardous period was closely related to the infant's weight, but the advantage that went with additional weight at birth (until reaching the higher weights) was also felt at the end of the neonatal period.

At the low weights of 2,000 gm., or less, the risk of loss was substantially lower among the nonwhite than white births. The advantage among nonwhites at these weights resulted from their greater ability to survive the immediate period following parturition and the first few days afterward. In the weights above 3,000 gm., mortality among white births was far less than among the nonwhite from the earliest period of life.

Plural births had a lower neonatal mortality rate than single events at weights 1,501–2,500 gm. However, because of the weight distribution, infants in plural sets accounted for about a tenth of the total neonatal loss.

At almost every weight, mortality among males was higher than among females. There was evidence that in the low weights the mortality experience among females in one 250-gm. interval was close to the loss among males in the next higher weight group. However, not all of the sex differences in mortality could be explained in this way. The gap between the sexes in mortality risk was also relatively large at the optimum weight level and in favor of the female group. Differences between the sexes in the ability to survive persisted after the difficult first few days following birth.

BIBLIOGRAPHY

For a more detailed account of many of the variables reported in the preceding pages and of technical factors involved see the report by Sam Shapiro and Jeanne Unger, "Weight at Birth and Its Effect on Survival of the Newborn," Vital Statistics—Special Reports, Vol. 39, No. 1, Washington, D. C.: National Office of Vital Statistics. Data comparing births that occurred in hospitals and those delivered at home are also presented. Tables include frequencies used to compute percentage distributions, medians and rates.

The most complete set of references available today on studies related to birth weight and gestation age is found in Dr. Ethel C. Dunham's book, "Premature Infants" (2nd ed.). New York: Hoeber. (In press.) A selected group of references which are particularly relevant to a number of the statements made in this article follow:

McKeown, Thomas, and Gibson, J. R. Observations on All Births (23,970) in Birmingham, 1947; Brit. J. Social Med. Vol. 4:221–233 (Oct.), 1950; Vol. 5: 98–112 (Apr.), 1951; Vol. 5:177–183 (July), 1951; and also Brit. M. J. 2:513–517 (Sept.), 1951.

Taback, Matthew. Birth Weight and Length of Gestation with Relation to Prematurity. J.A.M.A. 146:897–901 (July 7), 1951.

Bundesen, Herman N., et al. Progress in the Prevention of Needless Neonatal Deaths. Annual Report of the Chicago Health Department, 1951.

Potter, Edith L., and Fuller, Harold. Multiple Pregnancies at the Chicago Lying-In Hospital, 1941 to 1947. Am. J. Obst. & Gynec. 58:139–146 (July), 1949.

Eastman, Nicholas J. Prematurity from the Viewpoint of the Obstetrician. Am. Pract. 1:343–352 (Mar.), 1947.

Anderson, Nina A.; Brown, Estelle W.; and Lyon, R. A. Causes of Prematurity. Am. J. Dis. Child. 65:523–534 (Apr.), 1943.

"Recommendations for Developing Comparable Statistics on Prematurely Born Infants and Neonatal Mortality," December, 1950, and "Suggested Tabulations of Statistics on Birth Weight and Related Characteristics for Live Births and Neonatal Deaths," February, 1952—joint statements of the Public Health Conference on Records and Statistics, the Association of Maternal and Child Health and Crippled Children Directors, Children's Bureau, and the National Office of Vital Statistics. Copies available at the National Office of Vital Statistics.