Navajo Infant Mortality, 1970

CHARLES BRENNER, MD, KEITH S. REISINGER, MD, MPH,
AND KENNETH D. ROGERS, MD, MPH

INFANT MORTALITY among nonwhites in the United States is much higher than that of whites (*1–3*). Unavailability of health services, low income, poor housing and sanitation, and large families have been found to be significant factors associated with high infant mortality (*1–3*). American Indians have many of these characteristics, but they are unique in that since 1955 their health care has been provided by the Indian Health Service of the Public Health Service.

The Navajos, the largest tribe of American Indians, live on a 25,000-square-mile reservation of barren, semi-arid land adjacent to portions of Arizona, New Mexico, and Utah. Living conditions are harsh for most Navajo families. Their unemployment rate is high, and many live in crowded one- or two-room houses without running water. Often, water must be hauled for many miles. Some Navajos rely on the traditional medicine man for their health care, and others receive care at several of the Indian Health Service facilities. Those who seek care often face major transportation problems. Under these circumstances, it is difficult to obtain accurate data on health care for the Navajos.

The present study was undertaken to establish the current mortality rate for Navajo infants as accurately as possible and to identify factors associated with infant deaths.

At the time of this study, Dr. Brenner was a third-year student in the Department of Community Medicine, University of Pittsburgh School of Medicine, and Dr. Reisinger was field health officer at the Fort Defiance Indian Hospital. Dr. Brenner is now an intern at the University of California (Irvine) Affiliated Hospitals. Dr. Reisinger is now a senior resident, Children's Hospital Medical Center, Boston. Dr. Rogers is professor and chairman of the Department of Community Medicine, University of Pittsburgh School of Medicine. *This project was supported by grant No. 5A07AH00144 from the Public Health Service.*

Tearsheet requests to Kenneth D. Rogers, MD, Department of Community Medicine, University of Pittsburgh School of Medicine, Pittsburgh, Pa. 15261.

Methods

A major source of data for the study was the Census Bureau maintained by the Navajo Tribe. Births and deaths are registered with the bureau from copies of birth and death certificates transmitted by Indian Health Service hospitals and by State health departments. Births of almost all Navajos residing in the reservation area take place in Indian Health Service hospitals. Although the Navajo population is quite mobile, most movement occurs within the reservation and the adjacent States. Thus, we believe that most infant deaths are made known to the Navajo Census Bureau by the present reporting system. (Followup of 276 infants born at Fort Defiance Indian Hospital in 1971–72 revealed that only 12 had been moved out of the reservation and the adjacent areas during their first year of life.)

In July 1972, birth certificates filed at the Navajo Census Bureau were reviewed to identify

live births to Navajos (at least one-half blood quantum recorded on the birth certificate) residing on or adjacent to the Navajo Reservation during 1970. Deaths during the first year of life among this cohort of 1970 births were identified from death certificates at the bureau (*4–6*). Records of Indian Health Service hospitals on and near the reservation were examined for details associated with deaths and to identify deaths among the 1970 cohort of births which might not have been recorded with the Navajo Census Bureau. Primary cause of death was established from hospital records because many death certificates showed that diagnoses were indefinite or nonspecific.

Each hospital chart in the infant death population (study group) was reviewed to determine age at death, cause of death, sex, birth weight, length of gestation, postnatal illness, and Apgar score (a numerical expression of the condition of a newborn infant at 60 seconds after birth, being the sum of points gained on assessment of the heart rate, respiratory effort, muscle tone, reflex irritability, and color). Information was obtained from the mother's hospital chart on birth order, maternal age, history of previous child loss, number of prenatal care visits, trimester of first prenatal care visit, and problems with pregnancy or delivery.

A comparison group was established by selecting the Navajo infant born next at each facility after a study group infant and who survived the first year of life. The same information was recorded for the comparison infants and their mothers as for the study infants and their mothers. The study group consisted of 108 infants who died and the comparison group, 106 infants. Records of two of the infants who died were not identified until after the field phase of data collection for the study had been completed. Additional comparison group infants were not selected; thus, the disparity in numbers of infants in the study and comparison groups.

Results

Mortality. A total of 3,424 Navajo infants were registered with the Navajo Census Bureau as born on or near the reservation in 1970; 84 deaths were registered with the bureau. Hospital records of death were found for 78 of the 84 dead infants, as well as 24 additional members of the 1970 birth cohort for whom there was no record of death at the bureau. Also, hospital records were found of deaths of two infants born in 1970 for whom Navajo Census Bureau birth certificates could not be found and whose place of birth was undetermined; these unlinked deaths were not included in the study. The infant mortality rate of the 1970 cohort was 31.5 per 1,000 live births. Of the 108 deaths, 51 or 47 percent (14.9 per 1,000) occurred during the neonatal period (first 28 days of life) and 57 or 53 percent (16.6 per 1,000) during the postneonatal period (remainder of the first year of life).

The primary causes of neonatal and postneonatal death are shown in table 1. Respiratory distress syndrome, prematurity, and congenital malformations accounted for 75 percent of the neonatal deaths. Infectious diseases accounted for 60

Table 1. Primary causes of infant deaths, Navajos, 1970

Cause	Neonatal		Postneonatal		Total	
	Number	Percent	Number	Percent	Number	Percent
Respiratory distress syndrome	19	37.3	0	0	19	17.6
Prematurity	13	25.5	0	0	13	12.0
Congenital malformation	6	11.8	10	17.5	16	14.8
Aspiration or anoxia	4	7.8	1	1.8	5	4.6
Infection	3	5.9	9	15.8	12	11.1
Pneumonia	2	3.9	3	5.3	5	4.6
Meningitis	1	2.0	6	10.5	7	6.5
Gastroenteritis	1	2.0	16	28.1	17	15.7
Sudden death syndrome	1	2.0	5	8.8	6	5.6
Accidents	0	0	1	1.8	1	0.9
Other	1	2.0	3	5.3	4	3.7
Unknown	0	0	3	5.3	3	2.8
Total deaths	51	...	57	...	108	...

Table 2. Abnormal conditions during neonatal period, Navajo infants, 1970

Conditions	Study group						Comparison group (N=106)	
	Neonatal deaths (N=51)		Postneonatal deaths (N=57)		Total deaths (N=108)			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Jaundice	4	7.8	9	15.8	13	12.0	17	16.0
Infection	5	9.8	11	19.3	16	14.8	4	3.8
Cardiac murmer	4	7.8	6	10.5	10	9.3	2	1.9
Congenital malfunction	9	17.6	11	19.3	20	18.5	1	0.9
Birth weight 2,500 grams or less	39	76.5	13	22.8	52	48.1	9	8.5
Cyanosis	17	33.3	3	5.3	20	18.5	5	4.7
Respiratory distress syndrome	26	51.0	3	5.3	29	26.9	0	0
Meconium stain	2	3.9	7	12.3	9	8.3	2	1.9
Flaccidity	5	9.8	0	0	5	4.6	1	.9
Rales	6	11.8	0	0	6	5.6	1	.9
Aspiration or anoxia	2	3.9	3	5.3	5	4.6	4	3.8
Heart rate <100 per minute	7	13.7	0	0	7	6.5	0	0
Apnea	5	9.8	0	0	5	4.6	2	1.9
Birth injury	4	7.8	1	1.8	5	4.6	0	0
Others	12	23.5	9	15.8	21	19.4	11	10.4
Total conditions	147	.....	76	.....	223	.....	59	.....

percent and congenital malformations for 18 percent of the postneonatal deaths.

Characteristics of infants. The Navajo infant deaths showed a male predominance of 1.21:1, with a neonatal ratio of 1.32:1 and a postneonatal ratio of 1.12:1. The male to female ratio of infants in the comparison group was 1.00:1.

Of the 108 dead infants, 54 (51 percent) had birth weights of 2,500 grams or less; 41 of these died in the neonatal period. Of the 106 comparison group infants, only 9 (8.5 percent) weighed 2,500 grams or less at birth.

Gestational age was estimated from information on birth certificates and on the hospital charts for mothers and infants. The study group infants had shorter gestational periods than the comparison infants. Almost all of this difference occurred among infants who died in the neonatal period. Almost half of the neonatal death infants (47 percent) had estimated gestational ages of 31 weeks or less. Only 4 percent of the postneonatal death infants and none of the comparison infants had such short estimated gestational ages. Comparable figures for estimated gestational ages of 35 weeks or less were 61 percent for the neonatal death group, 11 percent for the postneonatal death group, and 3 percent for the comparison group.

No difference was found in the birth order of study and comparison group infants, with the exception of those whose birth order was 10th or higher; there were 10 study and 5 comparison infants in this category.

A total of 78 of study and 37 of comparison group infants had one or more abnormal conditions which were identified in the neonatal period. A total of 60 of the study and 14 of the comparison infants had more than one condition. Both of these differences in frequency of neonatal period problems between study and comparison infants were statistically significant (X^2, 1 df, $P < 01$). Of the infants with abnormal conditions in the neonatal period, study infants averaged 2.9 and comparison infants averaged 1.5.

Infants dying in the neonatal period, infants dying in the postneonatal period, and comparison group infants differed in various ways with respect to abnormal conditions in the neonatal period (table 2). When the numbers of observations were sufficient, tests of statistical significance were performed for differences between groups (X^2, 1 df, $P < .05$). In almost all instances, the presence of problems in the neonatal period was strongly associated with death in the neonatal period and in many instances with death in the postneonatal period. Conditions in the neonatal period that were more frequent at a statistically significant level in neonatal death infants than in postneonatal death infants were low birth weight, cyanosis, and respiratory distress syndrome. Conditions more frequent at a statistically significant level in the

neonatal death group than in the comparison group were congenital malformation, low birth weight, cyanosis, and respiratory distress syndrome. Infection was significantly more frequent in infants subsequently dying in the postneonatal period than in those dying in the neonatal period. Finally, infection, congenital malformation, and low birth weight were more frequent at a statistically significant level in postneonatal death infants than in comparison group infants.

The mean of 5-minute Apgar scores for the study group was 6.4 compared with 8.6 for comparison group infants. This statistically significant difference (t test, $P < .01$) in Apgar scores was attributable entirely to the low mean score of the neonatal death group (3.7). There was no statistically significant difference in mean Apgar scores for the postneonatal death and the comparison groups.

Characteristics of mothers. Study and comparison group mothers were similar with respect to age and marital status. The mean age of the study group mothers was 26.2 years and of comparison group mothers, 26.3 years. There was no statistically significant difference between the mean age of mothers of infants dying in the neonatal or postneonatal periods. There were 30 unmarried mothers at the time of birth of infants in the study group (28 percent) and 28 in the comparison group (26 percent). A history of previous reproductive loss was given by 39 percent of the study group mothers and 21 percent of the comparison group mothers. The proportions of mothers with previous reproductive loss were 38 percent for the neonatal death group and 39 percent for the postneonatal death group. Reproductive loss included fetal death, stillbirth, abortion, neonatal death, or postneonatal death.

A total of 56 study group mothers (52 percent) and 39 comparison group mothers (37 percent) either had no prenatal care or only one visit for prenatal care. Thirty-four study group and 32 comparison group mothers had two to four prenatal care visits. Eighteen study group mothers (17 percent) and 35 comparison group mothers (33 percent) had five or more prenatal visits. These differences were statistically significant (X^2, 2 df, $P < .05 > .01$). No differences were observed in the trimester of first visit among study and comparison group mothers who had one or more prenatal visits or among mothers whose infants died in the neonatal or postneonatal periods.

Table 3. Problems during pregnancy, Navajos, 1970

Problems	Study group [1]				Comparison group [2] (N=106)	
	Neonatal deaths [3] (N=51)		Postneonatal deaths [4] (N=57)			
	Number	Percent	Numbet	Percent	Number	Percent
Edema	2	3.9	5	8.7	10	9.4
Hypertension [5]	1	2.0	5	8.7	6	5.7
Excess weight gain [6]	1	2.0	1	1.8	1	0.9
Preeclampsia [7]	2	3.9	11	19.2	8	7.5
Proteinuria	1	2.0	2	3.5	3	2.8
Urinary tract infection	3	5.9	4	7.0	4	3.8
Anemia [8]	11	21.6	6	10.5	7	6.6
Diabetes mellitus	1	2.0	0	0	1	.9
Other infections	4	7.8	1	1.8	11	10.4
Seizure disorder	1	2.0	1	1.8	1	.9
Varicose veins	0	0	2	3.5	2	1.9
Polyhydramnios	5	9.8	0	0	0	0
Other	7	13.7	4	7.0	4	3.8
Total problems	39	.....	42	.....	58	.....

[1] 45 study group mothers had 81 problems.
[2] 38 comparison group mothers had 58 problems.
[3] 24 mothers of neonatal death infants had 39 problems.
[4] 21 mothers of postneonatal death infants had 42 problems.
[5] Systolic>140 or diastolic>90, or both, at any time during pregnancy.
[6] More than 35 pounds for single birth.
[7] Diagnosis on chart or record of hypertension, edema, and proteinuria.
[8] Hematocrit less than 35 percent.

Table 4. Problems during delivery, Navajos, 1970

Problems	Study group [1]				Comparison group [2] (N=106)	
	Neonatal deaths [3] (N=51)		Postneonatal deaths [4] (N=57)			
	Number	Percent	Number	Percent	Number	Percent
Forceps [5]	3	5.9	1	1.8	3	2.8
Cesarean section	3	5.9	2	3.5	1	0.9
Breech	12	23.5	3	5.3	0	0
Premature rupture of membranes [6]	13	25.5	7	12.3	2	1.9
Prolonged labor	5	9.8	0	0	3	2.8
Endometritis	3	5.9	2	3.5	8	7.5
Cord prolapse	0	0	1	1.8	0	0
Abruptio placentae	4	7.8	1	1.8	0	0
Nuchal cord	0	0	3	5.3	3	2.8
Amnionitis	5	9.8	3	5.3	1	.9
Lacerations	0	0	4	7.0	7	6.6
Placenta praevia	2	3.9	0	0	0	0
Precipitous (unsterile)	3	5.9	1	1.8	4	3.8
Meconium stain	2	3.9	2	3.5	3	2.8
Others	1	2.0	4	7.0	4	3.8
Total problems	56	.....	34	.....	39	.....

[1] 59 study group mothers had 90 problems.
[2] 28 comparison group mothers had 39 problems.
[3] 38 mothers of neonatal death infants had 56 problems.
[4] 21 mothers of postneonatal death infants had 34 problems.
[5] Excluding low-outlet forceps.
[6] More than 24 hours before delivery.

Forty-five of 96 (47 percent) study group mothers and 38 of 103 (37 percent) comparison group mothers for whom information was available had one or more pregnancy problems that were identified in their hospital records. For 19 of the study group mothers and 13 of the comparison group mothers more than one problem of pregnancy was identified. These differences were not statistically significant (X^2, 2 *df*, $P > .05$). Of the mothers with problems, the study group averaged 1.8 and the comparison group averaged 1.5. Among study group mothers, there was no difference in the percentage of those with problems or the average number of problems during pregnancy between those whose infants died in the neonatal or postneonatal periods.

The frequencies of problems during pregnancy of mothers of infants dying in the neonatal period, infants dying in the postneonatal period, and infants surviving the first year of life are shown in table 3. Where the numbers of observations were sufficient, tests of the statistical significance of the differences between groups were performed (X^2, 1 *df*, $P < .05$). There was a statistically significant higher frequency of anemia in mothers of neonatal death infants than in those of postneonatal death and surviving infants. Mothers with hematocrit values of less than 35 percent were considered to be anemic. Usual hematocrit values of Navajos living at 5,000 to 7,000 feet elevation are 5 to 7 percent higher than values of persons living at sea level (7). There was a significantly higher frequency of preeclampsia in mothers of postneonatal death infants than in mothers of neonatal death infants and surviving infants.

Fifty-nine of 102 (58 percent) study group mothers and 28 of 106 (26 percent) comparison group mothers for whom information was available had one or more problems associated with delivery that were identified in their hospital records. Twenty-eight of the study group mothers and eight of the comparison group mothers had more than one problem of delivery. These differences were statistically significant (X^2, 2 *df*, $P < .01$). Of mothers with problems, study group members averaged 1.5 and the comparison group 1.4.

Table 4 shows the frequencies of problems during delivery of mothers of infants dying in the neonatal period, infants dying in the postneonatal period, and infants surviving the first year of life. Where the numbers of observations were sufficient, tests of statistical significance of the differences between groups were performed (X^2, 1 *df*, $P < .05$). There was a statistically significant higher frequency of breech presentation and premature rupture of membranes in mothers of neo-

natal death infants than in those of postneonatal death infants and surviving infants.

Both mothers of infants dying in the neonatal and in the postneonatal periods had higher frequencies of single and multiple problems associated with delivery than comparison group mothers. Mothers of neonatal death infants had higher frequencies of both single and multiple problems than did mothers of postneonatal death infants.

Discussion

The results of this study reaffirmed the low neonatal and high postneonatal mortality rates of Navajo infants and revealed some maternal and infant attributes associated with neonatal and postneonatal death. Three questions about this study seem appropriate to discuss:

1. Did the study method using Navajo Census Bureau data produce different mortality rates from those of the Indian Health Service?
2. What explanations can be offered for the observed neonatal and postneonatal mortality rates and associated circumstances?
3. What are the program implications of these findings?

The neonatal rate of 14.9 per 1,000 live births and the postneonatal mortality rate of 16.6 per 1,000 live births determined in this study were similar to those reported (15.3 and 16.9) for all American Indians in 1967 (*2*) and for Navajos (13.6 and 15.5) in 1970 (*8*). The 1970 report of the Indian Health Service used the Tribal Census Bureau to identify births and the bureau plus Indian Health Service records to identify deaths. Despite the seeming similarity of methods used in compiling the Indian Health Service report and the one presented here, the numbers of observations differed markedly, even though the mortality rates were almost the same. The Indian Health Service identified 770 more Navajo births and 14 more infant deaths than did the linked-record study.

The comparison of the Indian Health Service findings with those of the present study for 1970 does not indicate that the additional labor of linking birth and death records resulted in appreciably different estimates of the mortality rate. However, the results obtained by using these two methods will have to be compared for other years before there is sufficient evidence to indicate that the similarity in 1970 findings resulted from equivalency of methods rather than fortuitous circumstances. The use of the hospital record rather than the death certificate as the source document for describing infant deaths resulted in different classifications of the cause of death by the Indian Health Service and the present study. In our opinion, the deduced causes of death from hospital records were more accurate. There were numerous instances in which the primary cause of death listed on the death certificate was grossly inconsistent with hospital chart observations.

The Navajo neonatal mortality rate of 14.9 in this study was only slightly greater than the 1970 U.S. rate of 13.5 for whites and much lower than the neonatal mortality rate of 21.6 for nonwhites (*9*). This favorable neonatal rate may in part be related to hospital delivery (estimated at 98 to 99 percent of Navajo births) and postnatal maternal and infant care by specialists. The rate also may reflect the rate of low birth weights among Navajos (only 7 to 8 percent), which is lower than rates among blacks and which limits the number of Navajo infants at risk of dying in the neonatal period from causes associated with this condition. The high Navajo postneonatal mortality rate, compared with white and black populations in the United States, is likely related to poor sanitation and nutrition and limited use of health services. The predominance of infectious disease as the cause of death in this period supports this observation.

The associations identified in this study were not unexpected. The highest levels of association were of neonatal death with maternal problems during delivery and abnormal conditions in infants during the neonatal period. Thus, mothers with breech deliveries, prolonged labor, faulty placentation, and intrauterine infection were more likely to have infants who died early. Infants who exhibited cyanosis, flaccidity, rales, bradycardia, apnea, respiratory distress syndrome, birth injury, low birth weight, and congenital malformations were more likely than other infants to die during the first month. Women with poor reproductive histories, preeclampsia, and poor use of prenatal care had higher infant mortality than other women, but it was not determined that these associations were directly causal or whether they occurred indirectly as manifestations of a common single factor or general lifestyle.

The infant mortality rates observed were lower than had been nticipated. In terms of program implications, these lower rates suggest, at least,

that present maternal and child health programs of the Indian Health Service be maintained. The aspects of these programs which have been strengthened in recent years and which appear to be directly related to problems associated with infant mortality are prenatal care, infant nutrition, sanitation, and health education. Additionally, there has been steady improvement in the living standards and educational levels of Navajos.

It seems that programs aimed at preventing or mitigating infectious diseases in infants should have high priority, since these disorders account for almost two-thirds of the postneonatal death rates. It is a matter of speculation whether increased amounts of prenatal care or changes in hospital obstetrical care can reduce the frequency or mitigate the outcome of some of the problems of pregnancy and delivery which are associated with neonatal death. Labeling and special followup of high-risk infants and their families might aid in reduction of postneonatal deaths, although the effectiveness of this device alone could be expected to be limited since many deaths occurred also in non-high-risk infants. It is possible that postneonatal deaths from infectious disease might be decreased by general improvement in sanitation and sanitary education, better nutrition to increase host resistance, and increased accessibility to health care and education in its use.

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A total of 3,424 Navajo Indian infants born on or near the Navajo Reservation in 1970 were identified from records of the Tribal Census Bureau. During their first year of life, 108 of these infants died, according to records of the bureau and of Indian Health Service hospitals. The hospital chart of each infant who had died was reviewed to ascertain circumstances associated with the death, and information was also obtained from the mother's chart concerning characteristics of pregnancy and delivery. The same observations were recorded for a comparison group of infants and mothers established by selecting the Navajo infant who was born next after a study infant and who survived the first year of life.

The neonatal mortality rate was 14.9 and the postneonatal mortality rate was 16.6 per 1,000 live births. Infants who died compared with those who survived the first year of life had lower birth weights, shorter gestational ages at birth, more problems in the immediate postnatal period, and a higher incidence of congenital malformations. Their mothers were more likely to have had a previous reproductive loss, to have received lesser amounts of prenatal care, and to have had more problems associated with pregnancy and delivery than mothers of infants who survived the first year of life.

The mortality rates observed were lower than anticipated and may reflect effective maternal and child health programs as well as improvement in general living standards. Deaths in the postneonatal period due to infectious disease appear to be a high priority problem and one likely to be improved by health education and increased accessibility to health care.