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IDENTIFICATION OF HIGH RISK NAVAJO CHILDREN AT BIRTH

CHAPTER I

INTRODUCTION

Extensive progress has been made in virtually every branch of medicine and its related fields during the present century. This progress has made it possible to reduce or eradicate some diseases, and to reduce suffering. Despite the progress, there are still many persistent problems.

In the United States maternal deaths decreased from 14,836 in 1930 to a low of 987 in 1967. The maternal death rate per 100,000 live births declined from 376.0 in 1940 to 28.0 in 1967. Maternal deaths due to hemorrhage declined by 113.7 percent from 1956 to 1967. During the same period maternal deaths declined by 58.3 percent for toxemia, 46.8 percent for ectopic pregnancy and 28 percent each for abortions and infection. Also maternal deaths from all other causes declined by 25 percent during the same period. This decline may be largely attributed to progress in the practice of obstetrics and its related fields.

Much progress has also been made in reducing infant mortality in the United States. Infant mortality declined from 85.8 per 1,000 live births in 1920 to a low of 22.4 per 1,000 live births in 1967. During this period neonatal mortality declined from 41.5 to 16.5, and post neonatal mortality declined from 44.3 to 5.9.

Infant mortality declined steadily from 1915 through 1956 (Table 1). In 1957 and 1958 the rate increased slightly and from then on declined slowly. In spite of this decline, comparison with other nations shows that the United States ranks 13th. Sweden ranked first with a rate of 13.3 per 1,000 live births (neonatal rate 10.6 per 1,000 live births, 1965). The neonatal mortality rate (16.5) of the U.S. is higher than the infant mortality rate of Sweden.

In recent years, the high neonatal mortality rate in the United States population has received much attention from research workers. The emphasis in almost all studies has been on the identification of high risk mothers. Mothers were classified as high risk if the pregnancy was considered likely, at the initial examination of the mother, to terminate in a high risk baby, that is, a baby who is at higher risk of becoming ill and/or dying. In most studies, maternal factors (maternal age, parity, nutrition, gestational age) and child factors (birth weight, length of baby, sex and Apgar score) have been evaluated as possible predictors of perinatal and neonatal mortality. All studies stress early prenatal care for identification of the high risk group of mothers.

By providing early prenatal care, it is possible to identify those mothers who may give birth to a premature child with a high risk of neonatal death. Also, complications of pregnancies can be identified during the first trimester, and many can be prevented through medical supervision. Most researchers emphasize the importance of early prenatal care to prevent perinatal and neonatal deaths.

Despite the importance of early prenatal care, many expectant

TABLE 1

INFANT, NEONATAL AND POST NEONATAL MORTALITY RATES
PER 1,000 LIVE BIRTHS, BY COLOR,
UNITED STATES, 1915-1967[a]

Year	Infant Mortality Rates				Neonatal Mortality Rates				Post Neonatal Mortality Rates			
	Total	White	Non White[b]	Indian	Total	White	Non White[b]	Indian	Total	White	Non White[b]	Indian
1915	99.9	98.6	181.2	-	44.4	-	-	-	55.5	-	-	-
1920	85.8	82.1	131.7	-	41.5	40.4	55.0	-	44.3	41.7	76.7	-
1925	71.7	68.3	110.8	-	37.8	36.8	49.5	-	33.9	31.5	61.3	-
1930	64.6	60.1	99.9	-	35.7	34.2	47.4	-	28.9	25.9	52.5	-
1935	55.7	51.9	83.2	-	32.4	31.0	42.7	-	23.3	20.9	40.6	-
1940	47.0	43.2	73.8	-	28.8	27.2	39.7	-	18.3	16.0	34.1	-
1945	38.3	35.6	57.0	-	24.3	23.3	32.6	-	13.9	12.3	25.0	-
1950	29.2	26.8	44.5	-	20.5	19.4	27.5	-	8.7	7.4	16.9	-
1955	26.4	23.6	42.8	61.2	19.1	17.7	27.2	22.2	7.3	5.9	15.6	39.0
1956	26.0	23.2	42.1	56.1	18.9	17.5	27.0	22.2	7.1	5.7	15.0	33.9
1957	26.3	23.3	43.9	58.2	19.1	17.5	27.8	22.4	7.3	5.8	15.9	35.9
1958	27.1	23.9	45.7	56.7	19.5	17.8	29.0	22.4	7.6	6.0	16.7	34.3
1959	26.4	23.2	43.7	46.7	19.0	17.5	27.5	20.4	7.3	5.7	16.2	26.4
1960	26.0	23.2	43.7	47.6	18.7	17.2	26.9	18.1	7.3	5.7	16.3	29.5
1961	25.3	22.4	40.7	42.3	18.4	16.9	26.2	19.1	6.9	5.5	14.5	23.1
1962	25.3	22.3	41.6	41.8	18.3	16.9	26.1	15.9	7.0	5.5	15.3	25.9
1963	25.2	22.2	41.5	42.9	18.2	16.7	26.1	18.0	7.0	5.5	15.4	24.9
1964	24.8	21.6	41.4	35.9	17.9	16.2	26.5	16.5	6.9	5.4	14.6	19.4
1965	24.7	21.5	40.3	36.4	17.7	16.1	25.4	15.2	7.0	5.4	14.9	21.1
1966	23.7	20.6	38.8	37.7	17.2	15.6	24.8	16.8	6.5	5.0	14.0	20.9
1967	22.4	19.7	35.9	30.1	16.5	15.0	23.8	14.2	5.9	4.7	12.1	15.9

[a]Reference (23) and (31).

[b]Includes Indian.

mothers do not receive prenatal care, or receive it too late in the pregnancy. This is especially true among mothers who have given birth previously. Some reasons for not receiving prenatal care are lack of knowledge, lack of service, the high cost of care, long distance to clinics and mere negligence. Thus it is not possible to identify all high risk mothers.

An alternative to identifying high risk mothers is to identify high risk infants at birth. Identification of high risk infants at birth has many advantages. About 95 percent of deliveries occur in a hospital where newborns may be screened routinely. A list of all high risk children could be maintained for follow-up and for special services. Special services could be provided by health personnel both in the community and at the health facility itself. Parents of high risk children could be educated to seek early medical care at the first symptom.

The purpose of this study was to evaluate and to improve an instrument for identifying high risk infants at birth. The instrument tested was the Denver scale. The Denver scale consists of several maternal and child factors. Each factor receives a score and the total score, obtained by adding the scores of each factor, is an indicator of the probability of getting sick during the first year of life. An infant with a high score has a high probability of illness during his first year of life.

The population used to test the Denver scale was Navajo infants born in Public Health Service (PHS) Indian Hospital, Gallup, New Mexico, during a two year period from July 1, 1965 through June 30, 1967.

The Navajo Indians receive medical services from PHS Indian hospitals located on and around the Navajo reservation. These hospitals are virtually the only source of in-patient care. Information about hospitalization and follow-up are fairly complete in these hospitals, as is information on the delivery of babies born there.

The Indian population will benefit greatly from the identification of high risk babies. The Indian infant mortality rate is about one and one-half times higher than the U.S. white rate. In 1967, the infant mortality rate for Indians was 30.1 per 1,000 live births, as compared with 19.7 for whites. The neonatal mortality rates of these two populations are almost the same (14.2 for Indians, 15.0 for whites in 1967), whereas the post neonatal rate for Indians is 3-4 times higher than that of whites (15.9 for Indians, 4.7 for whites in 1967).

The two major causes of death among Indian infants are enteric and respiratory diseases. These are mainly associated with the socio-economic and environmental conditions in which the baby lives. Most Navajo Indians live on the reservation, widely scattered in their traditional "hogans" (one room houses). The size of the family is large, with an average of 5-6 children per family; many families have 8-10 children. The average annual income is very low ($300-$1,500). Infectious diseases are still a problem of great importance in this population.

Indian mothers seldom receive prenatal care. They do not attach importance to prenatal care, primarily because of lack of knowledge. The long distances to the hospitals and the lack of transportation are contributory factors.

Prenatal care is offered both at the PHS hospitals and on the reservation through field health clinics. However, the prenatal care provided through the field health clinics and by home visits is limited. Prenatal services could be greatly increased if a current list of expectant mothers were available. Many mothers receive no prenatal care because no such list is in existence.

Identification of high risk children at birth will provide a list of children who need specialized services. Special services could be provided easily and efficiently to this group of children through field health clinics and by home visits by the Public Health staff.

The accuracy of the Denver scale in identifying high risk children at birth was tested on Navajo children from July 1, 1965 through June 30, 1967 at the PHS Indian Hospital, Gallup, New Mexico. Children were assigned to risk groups using the Denver scale. The probability of illness according to the Denver scale was compared with the actual morbidity and mortality experience of the children, during their first year of life. To identify the factors which better discriminate the high risk and the low risk children, discriminant analysis was performed on the factors in the Denver scale along with other factors considered as beneficial in the discriminant procedure.

A classification criterion based on the discriminant analysis was used to classify a newborn in one of two risk groups. The discriminant criterion was modified in order to reduce the number of false negatives.

CHAPTER II

REVIEW OF THE LITERATURE

The Concept of High Risk Pregnancy

Clifford (11), in discussing high risk pregnancy, concludes that "perinatal mortality can be reduced by application of available knowledge to high rate areas". Rossi (38) comments that "high risk babies have high risk mothers", and the condition of the mother determines the outcome of the pregnancy.

The American Medical Association Committee on Maternal and Child Care also expressed the opinion that perinatal mortality could be reduced by concentrating on proven techniques in the care of high risk cases (3). Providing special care for high risk mothers is not new. It has been a long tradition among obstetricians to provide adequate supervision and special care to those identified as at risk. This is part of their continuing effort to have every pregnancy result in a healthy mother and a healthy child. In order to receive special care, it is necessary that the high risk mothers be identified early in the pregnancy.

Gold (17) defines high risk to mean a "very serious chance of morbidity and mortality-to mother, fetus or infant". The President's Panel on Mental Retardation defines high risk pregnant women as those "...who have or are likely to have conditions associated with child bearing which increase the hazard to the mothers or their infants (including those which may cause physical or mental defects in the infants), and/or in which the prospective mother comes from a low income family" (43). The American Medical Association Committee on Maternal and Child Care (3) recommends early identification of high risk mothers and all high risk newborn as a possible preventive measure to reduce infant mortality. Anderson et al. (4) believes that the present level of perinatal mortality may be significantly lowered through the identification of high risk pregnancies for special care.

In order to identify high risk mothers and high risk infants, it is necessary to know the factors which contribute to high risk. Some of the maternal factors which influence the outcome of pregnancy are maternal age, parity, prenatal care, number of previous abortions, complications during pregnancy. Most of these factors are interrelated. Wiener and Milton (46) indicated that parity, mother's age, socioeconomic status and legitimacy are significantly related to birth weight of the child. Mother's age is related to parity. The higher the maternal age, in general, the higher will be the parity. Further, a healthy mother most often produces a healthy child without any complications.

The infant factors which point to high risk are also interrelated. Some of the factors are birth weight, length of the baby, gestational age, and Apgar score. A low birth weight child usually has a low gestational age and a low Apgar score. Apgar score has a positive association with birth weight of the child. The latter is also correlated with perinatal mortality.

Thus both maternal and infant factors are considered in the identification of the high risk child. These factors are considered individually in the following section.

Maternal Factors

Age of Mother

Age of mother is routinely collected and its association with perinatal mortality has been widely studied. Using information about 51,000 deliveries, in Finland, Timonen et al. (42) found higher perinatal mortality and malformation among children of mothers above 25 years of age. A positive correlation was also found between the frequency of malformation and maternal age.

Israel and Deutschburger (24) found that children born to very young (under 16 years) teenagers and to mothers 40 years of age and over were at high risk. Prematurity rates were higher among the very young mothers. Perinatal mortality was higher among the older primigravidas (first pregnancy). Also they found that children born to mothers age 40 years and older were at higher risk of having congenital malformations and neurological abnormalities. They concluded that the best age for child bearing is between 18 and 25 years.

On the other hand a North Carolina study suggested that maternal age was not itself a major factor but a precursor to other complications. Greenberg and Wells (18) applied linear discriminant analysis to data on 138 perinatal deaths and a sample of 287 infants who survived the neonatal period. Thirty factors, including maternal age, were used to discriminate between infants who died and those who survived. Maternal age did not contribute significantly to the discrimination, but was found to be a precursor to the medical complications which did make a significant contribution.

Parity

Information on parity is also collected routinely by the hospital for every pregnancy. Parity is associated with maternal age. In general, the higher the parity, the higher is the maternal age. Kane (25) shows that "progressive increase in the number of pregnancies is associated with increase in the mortality of the newborn". The results of Montgomery et al. (30) were in agreement with those of Kane (25). They reported that mothers with high parity had a higher incidence of perinatal mortality.

Parity is also associated with birth weight. Using information on 13,730 infants and mothers, Karen and Penrose (26) found that both parity and maternal age influence the mean birth weight. Birth weight increases with parity and decreases slightly with mother's age. They concluded that parity and maternal age have independent effects on birth weight. The influence of parity is greater than the influence of mother's age.

Selvin and Janerich (39) found a different relationship between birth weight, parity and mother's age. They analyzed more than 1.5 million births (1959-1967) in New York state excluding New York City. They found that mean birth weight increased with both maternal age and parity. The difference between their findings and those of Karen and Penrose may be due to the larger sample in New York state. Also in New York there was a large number of young mothers with high parity.

Abortions

Hunt (21) indicates that about 10 percent of all pregnancies terminate before the end of twenty weeks of gestation. The number of previous abortions has a significant effect on the outcome of pregnancy. He shows that the incidence of abortion in mothers who had one previous abortion is 13.2 percent and in mothers who had two previous abortions is 36.9 percent. The incidence in mothers who had three previous abortions is 83.6 percent.

Other Maternal Factors

Timonen _et al_. (42) reported a higher frequency of malformation among babies born to mothers with toxemia than to mothers without toxemia. Complications during pregnancy such as toxemia, premature rupture of membranes, use of anesthesia during pregnancy, hemorrhage, infection and their relationship to prematurity have been reported (14, 34).

Räihä (36) discusses the implications of maternal nutrition, smoking habits, heart volume, socioeconomic status and other maternal characteristics on the outcome of pregnancy.

Infant Factors

Birth Weight

Birth weight is routinely recorded for all infants born in a hospital. Birth weight is associated with perinatal mortality. The higher the birth weight, the lower the perinatal mortality. Among low birth weight children the perinatal mortality is very high. Birth weight is also associated with mother's age, gestational age, parity, socioeconomic condition, multiple births, Apgar score and sex of the infant.

The World Health Organization (48) defines prematurity in terms of birth weight: a premature baby is a live-born infant with a birth weight of 2500 gms. or less. This definition of prematurity, though convenient for selecting newborns for premature care, has certain drawbacks. Average birth weight varies by country and by race. For example, the Navajo Indian male weighs 3555 gms. at birth, on the average and the Choctaw Indian male weighs 3838 gms. (2). These weights are much higher than the average weight of the Negro (about 3100) and white (about 3300) babies.

A large proportion of perinatal and neonatal deaths are due to prematurity. Children whose birth weight was 2500 gms. or less at birth, had a neonatal mortality rate of 174 per 1,000 live births as compared to 7.8 per 1,000 for other infants in 1964 (40).

Classification of premature infants by both birth weight and gestational age is found to be better than the classification by either one alone.

Gestational Age

Several authorities have proposed that prematurity should be defined in terms of gestational age as well as birth weight. Battaglia and Lubchenco (9) suggested the classification of the newborn into nine groups. Three groups are defined by gestational age - preterm (37 weeks and under), term (38-42 weeks), and post-term (above 42 weeks). Each gestational group is further subdivided into three groups by birth weight. The three birth weight groups are: infants above the 90th percentile in weight, between the 10th and the 90th percentile, and below the 10th percentile.

Yerushalmy (49) suggested five categories. Group I consisted of all children with a birth weight of 1500 gms. or less. Children with a birth weight of 1501-2500 gms. were classified in group II if their gestational age was less than 37 weeks, otherwise in group III. Children with a birth weight of more than 2500 gms. but with a gestational age of less than 37 weeks were classified as group IV; all others in group V.

These classifications were applied by Yerushalmy (49) to children born in New York City, 1957-1959. He found a high neonatal mortality rate (707.8 per 1,000 live births) in group I as compared with 4.7 in group V. The neonatal mortality rates for groups II, III, and IV were, respectively, 104.7, 32.0 and 13.7.

Gosh and Dage (16), in a study of 2,273 births found lower mortality among children with long gestational age within each birth weight group. They concluded that weight alone is not satisfactory for premature classification, and that weight with gestational age is better.

Length of Baby at Birth

Birth weight, gestational age and length of baby at birth are reported on vital records of California. Montgomery et al. (30) analyzed this information, using birth certificates and death certificates of 369,304 infants born in 1959. Among these there were 10,555 children who weighed 2500 gms. or less, whose gestational age was under 37 weeks and whose length was 18 1/2 inches or less. Of the 10,555, 13.9 percent were fetal deaths and 24.6 percent died within a month. They found lower mortality among children who were classified using only one or two criteria instead of all three. They concluded that the three factors combined constituted a better index of prematurity.

Abernathy _et al_. (1) investigated the influence of 28 factors on perinatal mortality. The analysis was first done using all 28 factors. It was repeated with 3 factors only, birth weight, gestational age and length; the remaining 25 factors were analyzed separately. The analysis based on 3 factors agreed with the analysis based on all 28 factors, whereas the analysis based on the 25 factors did not. Further investigation indicated that birth weight, gestational age and length of baby, in that order, were the most significant factors in perinatal mortality.

Sex

Male babies are slightly heavier at birth than female babies. Nevertheless, mortality among males is slightly higher than among females, even when birth weight is held constant (40).

Apgar Score

In 1953 Apgar (5) developed a scoring system of five items in an attempt to evaluate changes which occur during the first few minutes of life. The five items are: heart rate, respiratory effort, muscle tone, reflex irritability, and color. These five items were scored by the physician one minute after delivery and again at five minutes. A score of 10 is considered a perfect score.

Apgar and James (7), using information on 27,715 infants during the period 1952-1960, found that among children under 1000 gms. irrespective of the score, neonatal mortality was high. Conversely, mortality was low among full term children receiving low scores (0-3). Their study also showed a strong association between Apgar score and neonatal mortality in other weight groups.

Among 17,221 infants, Drage and Berendes (12), found that 57.2 percent of the children weighing 1500 gms. or less had a one-minute score of 0-3 as compared to 5.3 percent of the children weighing 3001-3500 gms. Further, 3.9 percent of the children weighing 1500 gms. or less received a score of 9-10 as compared to 51.9 percent for children weighing 3001-3500 gms. Similar observations were made using five-minute scores. They found a six-fold difference in neurologic abnormality between the birth weight groups weighing 1001-2000 gms. at birth and those weighing above 2500 gms. They concluded that both one-minute and five-minute scores have a strong association with birth weight, with low birth weight associated with low scores. Also, the five-minute scores are strongly associated with infant morbidity even when birth weight is controlled.

Apgar (6) reported that the five-minute score correlated better than the one-minute score with mortality and neurologic damage. Nevertheless, she suggested that the one-minute score should be retained.

High Risk Pregnancy

Gold's (17) criteria for high risk pregnancies consisted of maternal characteristics (age, weight), the obstetric and medical history, and the patient's habits. These criteria were used to classify patients at the New York Medical College in December, 1965. The objectives were to provide total maternity care to high risk mothers and to identify factors in prenatal care which affect the outcome of the pregnancy. Those identified as high risk received total maternal care (antipartum, intrapartum and postpartum care), family planning and child health services from a multidisciplinary team. The result was a reduction of 29 percent in prematurity incidence among the case load, from 21.9 percent in 1966 to 15.5 percent in 1967. The neonatal death rate was reduced by 45 percent from 54.1 in 1966 to 29.5 in 1967.

Nesbitt and Aubry (35) suggested a maternal child health care index based on eight factors: maternal age, race and marital status, parity, past obstetric history, medical disorders and nutrition, genetic disorders, emotional conditions and socioeconomic status. The index was arrived at by levying penalties for all presumed adverse factors. The sum of all such penalties was subtracted from a perfect score of 100 to obtain the index score. An index score of less than 70 was classified as high risk; a score of 70-84 as moderate risk; and a score of 85 or more as low risk.

These scores were used to assign 1,001 consecutive patients (at their first visit to the prenatal clinic) into the three risk groups. The incidence of premature births and low birth weight infants in the high risk group was about double that in the low risk group (19.59 percent vs 10.00 percent). The incidence in the moderate risk group was slightly higher than the low risk group (11.28 percent). More than 50 percent of all maternal complications and 50 percent of all maternal deaths occurred in the high risk group. In a later paper the authors (8) indicated that the scoring system appears to be a significant adjunct to clinical judgement in the selection of high risk patients. They summarized the need for such a scoring system as follows:

> ...adoption of a quick, simple, inexpensive, relatively sensitive index for routine use has considerable merit in screening prenatal patients and in estimating the degree of vulnerability according to a semiobjective scoring system. This device identifies those individuals who deserve workup, intensive supervision, and specialized care on a personalized basis, and focuses attention upon a broadened obstetric perspective which favorably influences the education of professional health workers, students, and the laity.

It encourages the aggregation of patients at special risk for purposes of teaching and research, and this concentration of effort and resources offers the best hope of achieving optimal clinical results and of making further inroads in the search for the millennium. Index scores might serve as a common denominator for statistical analyses of maternal and perinatal outcome, tending to neutralize the problems of making valid comparisons among diverse heterogenous groups of patients. Finally, it might be a useful device in establishing a roster of high-risk patients in each area which is the first important step in mobilizing the total health resources within the community. A roster of this type would assist the various health and welfare agencies in providing preventive and curative health services and in demonstrating the need for financial support of these programs.

Anderson et al. (4) suggested the identification of high risk geographical areas using available statistics on infant mortality, perinatal mortality and prematurity. A geographical area was considered high risk if mortality (infant and perinatal) and/or prematurity rate were high. They also proposed to give special care to the high risk people who live in the high risk geographical areas.

The success of these criteria depends on the expectant mother submitting to care early in the pregnancy. As indicated previously, mothers often neglect or postpone prenatal services. Hence the identification of high risk mothers, though proven successful in reducing perinatal mortality, is not feasible as a routine measure.

In Denver, Colorado, Dr. Lubchenco devised an index which would identify high risk babies instead of high risk mothers. The factors considered are maternal factors and infant factors. Maternal factors include age, complications during pregnancy, and previous health status. Infant factors include birth weight, gestational age, condition at birth (Apgar score) and sex of the child. The method is to levy a penalty for each factor (15 factors in all). The total score is used to estimate the probability of illness during the neonatal period, based on the experience of a previous cohort of babies. Since most deliveries occur in a hospital, and since it does not require the mother's cooperation in obtaining prenatal care, this method would be more satisfactory for identifying the high risk children.

Discriminant Analysis

Fisher, in 1936 (15), developed the discriminant function[1] for comparing linear compounds made up of several variables. He considered the problem of getting a linear combination of p variables which would, better than any other linear combination, discriminate between two chosen groups. By better discrimination he meant, specifically, that the ratio of the between group sum of squares of this linear combination to its within groups sum of squares would have a larger value than that for any other linear function of the same variables. Fisher proposed the discriminant function as a solution to the problem of using information to classify an unclassified object into one of two groups to which it must belong.

Mahalanobis (29) developed the statistic D^2, which is a measure of the distance between two groups. The relationship of the discriminant function to the generalized distance D^2 enables us to use discriminant function in studies of distances between two group centroids. A test of significance on discriminant function can be made using D^2 statistics (37).

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[1]For mathematical derivations see P. G. Hoel (29).

CHAPTER III

GENERAL CHARACTERISTICS

Geography

The Navajo Indian Reservation, the largest in the United States, lies in three states: northeastern Arizona, northwestern New Mexico and the southern part of Utah. The reservation is a vast area of 24,000 square miles, about equal in size to the state of West Virginia. The Navajo country consists of semi-arid desert, mesa, and canyon; it is located on a mountainous plateau with elevations ranging from 3,000 to 10,000 feet. The climate is temperate in summer and cold in winter, with a wide diurnal variation in temperature (10).

Population

The population was estimated by the Indian Health Service to be about 96,000 in 1967 (33). Most Navajo families live several miles from their nearest neighbor in small cabins or in traditional hogans, one-room windowless huts of mud and wood. Larger settlements can be found near missions, Government facilities, tribal headquarters, and in communities adjoining the reservation. The population is very young, only 3.5 percent of the population being over 65 years of age. Although the sex ratio is almost unity there are more females in the younger age groups (27,870 males, 28,980 females under 20 years of age), and more males in the age group 65 years and over (1,950 males, 1,590 females). The age and sex distribution of this population is presented in Table 2.

Socioeconomic and Educational Status

In recent years, the pick-up truck has replaced the horse-drawn wagon on the Navajo Reservation. Improved roads have opened new avenues to the outside. In spite of this, outside influence has not appreciably affected Navajo tradition.

The Navajos, to a large extent, have retained their traditional culture and language. Many adults do not speak English, and many more cannot read English.

The educational level is very low. In 1960, the Bureau of Indian Affairs reported that 41.3 percent had no schooling at all; and 14.9 percent had four years of schooling or less. According to the 1960 census, the median number of school years completed was 3-5 years.

Most Navajo Indians live on the reservation. They derive their income from sheep herding and rug weaving. The tribe receives some income from oil leases and, recently, by promoting tourism. Many Indians who live off the reservation hold jobs in State and Federal Agencies.

According to the 1960 census, median family income is under $1,800. This is less than half the median family income of the rural farm population living in the states[1] in which the Navajo Reservation is located.

Navajo families are often isolated. Their one-room huts are

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[1] The median family income of the general population living in rural farm areas of Arizona and New Mexico is $3,384 and $3,780 respectively.

TABLE 2

ESTIMATED NAVAJO POPULATION BY AGE GROUP
AND SEX, FISCAL YEAR 1969

	Estimated Population			Percent Distributions		
Age	Total	Male	Female	Total	Male	Female
<1	4,360	2,170	2,190	4.5	4.6	4.5
01 - 04	15,400	8,000	7,400	16.0	16.9	15.1
05 - 09	15,120	6,900	8,220	15.7	14.5	16.8
10 - 14	12,500	6,250	6,250	13.0	13.2	12.7
15 - 19	9,470	4,550	4,920	9.8	9.6	10.0
20 - 24	7,270	3,430	3,840	7.5	7.2	7.8
25 - 29	6,090	2,820	3,270	6.3	5.9	6.7
30 - 34	5,240	2,490	2,750	5.4	5.2	5.6
35 - 39	4,610	2,220	2,390	4.8	4.7	4.9
40 - 44	3,560	1,800	1,760	3.7	3.8	3.6
45 - 49	3,170	1,580	1,590	3.3	3.3	3.2
50 - 54	2,360	1,260	1,100	2.4	2.6	2.2
55 - 59	2,340	1,230	1,110	2.4	2.6	2.3
60 - 64	1,470	810	660	1.5	1.7	1.3
65 - 69	1,380	770	610	1.4	1.6	1.2
70 - 74	810	450	360	0.8	0.9	0.7
75 - 79	610	340	270	0.6	0.7	0.6
80 - 84	330	180	150	0.3	0.4	0.3
85+	410	210	200	0.4	0.4	0.4
TOTAL	96,500	47,460	49,040	100.0	99.8	99.9

Source: Program Analysis and Statistics Branch, Division of Indian Health, Silver Spring, Maryland.

crowded. Average family size is estimated to be 5-6 persons (32). The majority of families live in substandard houses, and only about 19 percent of their homes have inside plumbing and water.

Navajos have accepted modern medicine for the immediate treatment of disease, but for the cure of underlying causes of disease they look to the medicine man. Frequently, the medicine man refers his patient to the hospital for treatment.

Health Services

Before July 1955, the Bureau of Indian Affairs was responsible for providing administrative, educational, and health services to the Indians. Public Law 568 of the 83rd Congress, effective July, 1955, charged the Public Health Service (PHS) with the responsibility for providing to the recognized Indians and Alaska Natives residing on or near Federal Reservations and Alaska Native villages, the health and medical services required to raise their health status to a level comparable with that of the nation as a whole (22). The Indian Health Service (formerly the Division of Indian Health) administers the delivery of health services to Indians and Alaska Natives through eight Indian Health Area Offices.

The Navajo Indian Health Area Office is located at Window Rock, Arizona. The Navajo area is divided into eight service areas called Service Units. Five of the eight Service Units have PHS Indian Hospitals and two Units have outpatient Health Centers. Gallup Service Unit, the 8th Unit, has a hospital and two health centers. The location of PHS medical facilities and the number of beds in each hospital are shown in Table 3 (also see map, Figure 1). Table 4 shows the age distribution of

TABLE 3

NAVAJO INDIAN HEALTH FACILITIES

Facilities	
Hospitals	Number of Beds
1. U.S. PHS Indian Hospital Gallup Service Unit Gallup, New Mexico	200
2. U.S. PHS Indian Hospital Ft. Defiance Service Unit Ft. Defiance, Arizona	110
3. U.S. PHS Indian Hospital Shiprock Service Unit Shiprock, New Mexico	75
4. U.S. PHS Indian Hospital Tuba City Service Unit Tuba City, Arizona	75
5. U.S. PHS Indian Hospital Crownpoint Service Unit Crownpoint, New Mexico	56
6. U.S. PHS Indian Hospital Winslow Service Unit Winslow, Arizona	50
Health Centers	
1. U.S. PHS Indian Health Center Chinle Service Unit Chinle, Arizona	
2. U.S. PHS Indian Health Center Kayenta Service Unit Kayenta, Arizona	
3. U.S. PHS Indian Health Center Gallup Service Unit Tohatchi, New Mexico	
4. U.S. PHS Indian Health Center Gallup Service Unit Ft. Wingate, New Mexico	

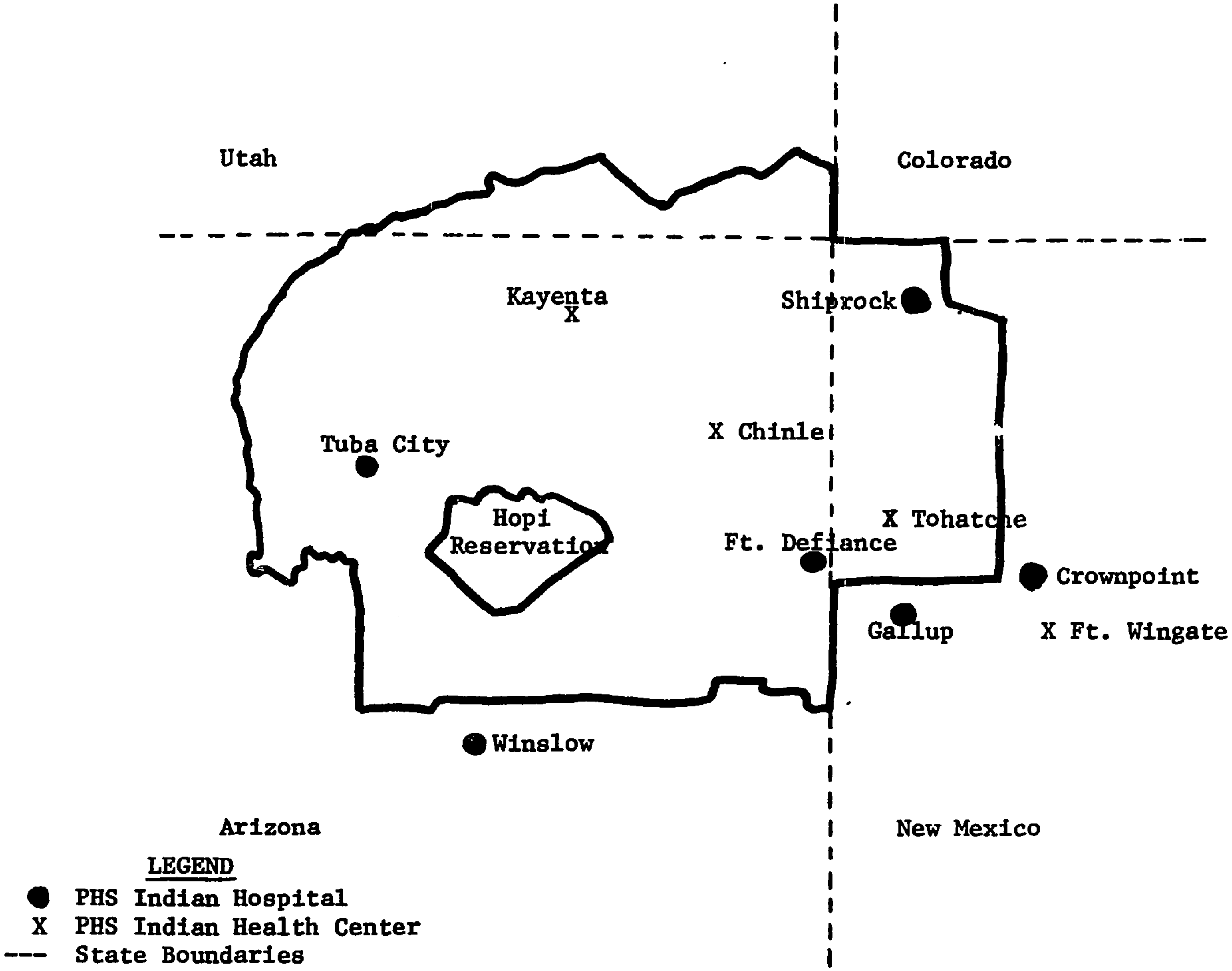

Figure 1--Navajo Indian Reservation: Location of Indian Health facilities.

TABLE 4

ESTIMATED NAVAJO POPULATION BY SERVICE UNIT
AND AGE GROUP, FISCAL YEAR 1969

Age Group	Chinle	Crownpoint	Fort Defiance	Gallup - Tohatchi	Kayenta	Shiprock	Tuba City	Winslow
<1	580	370	600	730	310	880	470	400
01 - 04	2,070	1,310	2,130	2,590	1,100	3,110	1,660	1,430
05 - 09	2,030	1,290	2,100	2,540	1,080	3,060	1,630	1,410
10 - 14	1,680	1,060	1,730	2,100	890	2,530	1,350	1,160
15 - 19	1,270	800	1,310	1,590	680	1,910	1,020	880
20 - 24	980	620	1,010	1,220	520	1,470	780	680
25 - 29	820	520	840	1,020	440	1,230	660	570
30 - 34	700	450	720	880	380	1,060	560	490
35 - 39	620	390	640	770	330	930	500	430
40 - 44	480	300	490	600	250	720	360	330
45 - 49	430	270	440	530	230	640	340	300
50 - 54	320	200	330	400	170	480	250	220
55 - 59	310	200	320	390	170	470	250	220
60 - 64	200	120	200	250	100	300	160	140
65 - 69	180	120	190	230	100	280	150	130
70 - 74	110	70	110	140	60	160	90	80
75 - 79	80	50	80	100	40	120	70	60
80 - 84	40	30	50	50	20	70	40	30
85+	50	30	60	70	30	80	40	40
ALL AGES	12,950	8,200	13,350	16,200	6,900	19,500	10,400	9,000

the Navajo population in each of the Service Units. Health services are also available in numerous field health centers and school health centers. Some services are obtained from private and public facilities by contract or by informal agreement.

Health Problems

In the early 1950's tuberculosis, pneumonia and diarrheal diseases were at a peak among the Navajos, and their health level was almost two generations behind that of the general population (22). In 1955, the tuberculosis death rate was 64 per 100,000 population; by 1963, the rate had decreased to 20-30 per 100,000 population. This decline is attributed to early casefinding, new methods of treatment, increased awareness of health needs among the people, improved transportation and easier accessibility of health services.

Another health problem of importance for the Navajos is infant mortality and morbidity. The infant mortality rate has been declining in recent years, from a rate of 87.8 per 1,000 live births in 1955 to 52.3 in 1966 (23). However, this rate is still double that of the general population. The U.S. general population experiences a high proportion of its infant loss in the neonatal period. The Navajos experience a higher proportion of infant loss in the postneonatal period. The rate in the postneonatal period among Navajo infants (33.0) is 5-6 times higher than the rate of the U.S. general population (6.5), although the two neonatal rates are about the same.

Most of the deaths among infants are from respiratory diseases, and diseases of the enteric tract. In 1967 there were 1,300 new cases of pneumonia, 1,922 new cases of gastroenteritis and 1,196 new cases of upper respiratory infection among Navajo infants. These conditions are associated with the home environment: crowding, poor sanitary conditions, lack of safe water, and poor nutrition.

The reduction of infant mortality in recent years has influenced the life expectancy of Indians. The expectation of life at birth for Indians is estimated to be about 64 years as compared to 70 years for the general population in 1964 (22).

Hospital utilization by Navajos differs by age group. Utilization is highest, and length of stay longest, for infants, followed by the age group 65 years and over. Infants have the highest discharge rate (398 per 1,000 persons), the longest average length of stay (18.5 days) and, on the average, occupied more beds daily: 2,020 beds per day per 100,000 persons (19). Thus hospital utilization by the Navajo deviates markedly from patterns in the nation at large. The National Health Survey for 1965, reported an average length of stay 7.8 days in short-stay hospitals. The longest average length of stay, the highest discharge rate per 1,000 persons, and the highest average daily bed occupancy for the U.S. general populations was in the age group 75 years and over. The average length of stay for infants was only 8.5 days in U.S. short-stay hospitals, as compared with 18.5 days for infants in Navajo Indian Hospitals (22).

Reduction in infant mortality is possible through early prenatal care. In Fiscal Year 1967, there were 3,495 discharges for deliveries and complication of pregnancies. About 33 percent of the expectant mothers had received no prenatal care and many others received it too late in the pregnancy for adequate recognition and management of certain complications of pregnancy.

The incidence of congenital malformation among Navajo Indians is not known. An investigation of 2,500 births at the Indian hospital, Shiprock, New Mexico revealed that the incidence of congenital hip dislocation is high. The study conducted by the Navajo-Cornell research station in 1960 found a prevalence of 10.9 per 1,000 population as compared with a frequency of 1.3 per 1,000 live births in New York City. The malformation occurred predominantly in females, in a 4 to 1 ratio to the males.

About 95 percent of the mothers delivered in the hospital. Of the 3,088 delivered in Fiscal Year 1967, the health records indicate that 336 were anemic and 1,361 had other complications. Maternal mortality among Navajo has been almost eliminated.

Neonatal mortality, although it is slightly lower than in the general population, still needs further reduction. Postneonatal deaths could be reduced by better sanitary facilities, improved housing, and other environmental changes with a bearing on infectious and respiratory diseases. Navajos who live in a one-room hogan with an average family of 7-8 are highly susceptible to infectious diseases.

Hospitals are centrally located to provide accessible care, but poor road conditions and the lack of vehicles cause delay in seeking care when an infant shows early symptoms of sickness.

The PHS hospitals provide the great majority of hospital services to Navajo Indians. Thus, information on patients hospitalized is readily available. Since at least 90 percent of the deliveries occur in the hospital, information on these deliveries is also available. The

Navajo population is an almost ideal population for study.

The identification of high risk babies at birth will facilitate early care for high risk children. Follow-up of these children through field health staff and by public health personnel will be easy since a ready list of high risk children is available. Special care for these children might influence their health status substantially, reducing morbidity and mortality.

CHAPTER IV

DESCRIPTION OF THE PRESENT STUDY

Background

The high rate of infant mortality among the Navajo Indians led to the formation of a Maternal Child Health Committee at the PHS hospital, Gallup, New Mexico. In April 1967, a special study was initiated at this facility to investigate Navajo infant problems, to find ways to reduce mortality among Indian infants to the level of the U. S. general population and to develop a scale for the early detection of high risk infants.

The study was based on a scoring system developed by Dr. Lubchenco, University of Colorado Medical Center, Denver, Colorado. This system consists of 15 maternal and infant factors (Figure 2) which are considered to be the most influential in predicting hospital stay at birth. The scoring system was based upon the experience of the Denver population, predominantly white. The scoring system was designed in such a way that the higher the total score (the sum of the scores of the 15 factors), the higher will be the probability of illness, leading to continued hospitalization at birth. The Committee on Maternal and Child Health felt that these 15 factors were good predictors of infant morbidity and mortality during the first year of life. A pilot investigation of these factors was initiated in April 1967.

PHS Indian Hospital, Gallup, New Mexico	Date:
MORBIDITY MODEL:	Ward:
	Name:
Pilot study based on Morbidity Model, University of Colorado Medical Center, Newborn and Premature Inf. Center.	Hosp. No.:
	Address:

Encircle the scores which apply and add to get morbidity score.

Variable		Score
Constant		-30
Birth weight	1500 grams or less	617
	1501 - 2000	550
	2001 - 2500	158
	2501 - 3500	43
	3501 or more	50
Gestational age	27 weeks or less	216
	28 - 31	184
	32 - 33	150
	34 - 35	90
	36 - 37	38
	38 weeks or more	11
	Unknown	27
Mother's age	Less than 15 yrs.	74
	15 - 19	19
	20 - 34	0
	35 yrs. or more	39
Condition at birth (5-minute Apgar scores)	Good (Apgar 8 - 10)	0
	Fair (Apgar 5 - 7)	31
	Poor (Apgar 0 - 4)	110
Toxemia		45
Diabetes		347
Fetal distress		42
Saddle, Spinal, Caudal anesthesia		24
Labor complications		41
PROM (24 hrs. or more before delivery)		63
Abnormal delivery		53
Endotrachial aspiration or positive pressure resuscitation		64
Stimulants in delivery room		118
Habitual aborter		104
If male baby		41

Figure 2--Pilot study data form (Form I).

The pilot study was to be conducted in two stages. During the first stage, data was collected on 15 factors using Form I (Figure 2) on 1,000 consecutive babies born at Gallup Indian hospital. The second stage was to follow the babies through their first year of life, to collect information on morbidity and mortality experience. However, the second stage of the pilot study was not completed.

Study Population

The present study was restricted to Navajo infants born at the PHS Hospital, Gallup, New Mexico, and residing in the Gallup Service Unit. The PHS Indian Hospital, Gallup is a 200 bed hospital, which serves as a referral hospital for the other seven Service Units.

The Gallup Service Unit population was estimated to be 22,000 in 1967. The number of newborns, the number of adult and pediatric admissions, and the average daily patient load for the years 1965-1969 are shown in Table 5.

Data Retrieval Forms

After the pilot investigation, a new information retrieval form was developed. The new form (shown in Figure 3) includes information on length of the infant, parity and number of abortions. Also a follow-up form was developed to retrieve information on morbidity and mortality experience of the child during the first year of life. This form is presented in Figure 4.

Data Collection

Information required for this study was retrieved by Dr. Hurtado[1]

[1]Deputy Director, Indian Health Area Office, formerly Chief, Pediatric Department.

TABLE 5

NUMBER OF NEWBORN, ADULT AND PEDIATRIC ADMISSIONS, AND AVERAGE DAILY PATIENT LOAD, PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1965-69

Fiscal Year	Number of Newborn Admissions	Number of Adult and Pediatric Admissions	Hospital Days	Average Daily Patient Load
1965	753	4,192	63,209	173.2
1966	653	4,367	66,341	181.8
1967	650	4,209	63,064	172.8
1968	643	4,510	61,822	168.9
1969	742	4,638	58,614	160.6

$$\text{Average Daily Patient Load} = \frac{\text{Hospital days}}{\text{Number of days in the year.}}$$

Source: Hospital admission records, PHS Indian Hospital, Gallup, New Mexico.

Name: Date of birth: Hosp. No.: Address:

No.	Variable	Score	No.	Variable	Score
1.	Length of baby		6.	Toxemia	45
	Less than 18 inches	50	7.	Fetal distress	42
	18	10	8.	Anesthesia (Saddle, spinal, caudal)	24
	19 - 20	0	9.	Labor complications[a]	41
	21	5	10.	PROM (24 hrs. or more before del.)	63
	More than 21 inches	10	11.	Abnormal delivery	53
2.	Birth weight		12.	If male baby	41
	1500 grams or less	617	13.	Parity	
	1501 - 2000	550		4 or less	0
	2001 - 2500	185		5 - 6	50
	2501 - 3500	43		7 - 8	100
	3501 or more	50		9 - 10	200
3.	Gestational age			11 or more	300
	27 weeks or less	216	14.	Number of abortions	
	28 - 31	184		None	0
	32 - 33	150		1	10
	34 - 35	90		2	50
	36 - 37	38		3 or more	200
	38 weeks or more	11			
	Unknown	27			
4.	Mother's age				
	Less than 15 years	74			
	15 - 19	19			
	20 - 34	0			
	35 years or more	39			
5.	Condition at birth (5-minute Apgar Score)				
	Good (Apgar 8 - 10)	0			
	Fair (Apgar 5 - 7)	31			
	Poor (Apgar 0 - 4)	110			

[a]Includes induction, pit stimulation, uterine inertia, prolapsed cord, contracted pelvis, transverse arrest, antepartum hemorrhage, other.

Figure 3--Revised data collection form (Form II).

DOB	Sex	Days	Weight	EPI
Primary Diagnosis		P.	T.	Yes No PHN Referral

Secondary Diagnosis
None
R.D.S.
Sepsis
Erythroblastosis

Congenital
Cardiovasc.
Cleft lip or palate
Orthopedic
Other

Others

Date of Death	Age	Yes No Autopsy	Cause of Death	ICD Code

IMMUNIZATIONS

None	PPD Pos	DPT 1	OPV 1
BCG	PPD Neg	DPT 2	OPV 2
Sm. Pox	Tine Pos	DPT 3	
Measles	Tine Neg	DPT B	

MORBIDITY (Minor)				MORBIDITY (Major)			
Date	Age	Diagnosis	Code	Date	Age	Diagnosis	Code

#WBC Visits	Yes No N/A Ref. to CCS	Yes No Ref. to Soc. Svc.	Yes No Ref. to PHN	Yes No Answered	Weight at 6 wk 3 mo 6 mos 12 mos
Hgb	Age at Hgb	Feeding Breast Bottle Both	Serial #		

Figure 4--Data collection form for follow-up study (Form III).

from the health records of mother and child. Information about the predictor variables was recorded on Form II (Figure 3) and the follow-up information on Form III (Figure 4) for each child included in the study.

Information was collected on all babies born between July 1, 1965 and June 30, 1969, at PHS Indian Hospital, Gallup, New Mexico. Navajo babies born at the hospital but residing outside the Gallup Service Unit, and non-Indian babies born at the hospital, were excluded from the study, due to difficulties encountered in the follow-up of these babies. The number of babies born at the hospital and those included and excluded from the study is shown in Table 6.

Method of Analysis

The analysis was conducted in two phases. In the first phase of the analysis, Navajo children born during July 1, 1965 through June 30, 1967 were given scores for 15 factors using the Denver scale (Form I, Figure 2). The total score for each child and the expected probability of illness (Table 7) associated with the total score was obtained. The children were then assigned to eight groups according to the total score to obtain the expected probability of illness suggested in the Denver model. The actual hospitalization and mortality experience were compared with the expected probability of illness. The Chi-square test was used to test the association between the actual morbidity experience and expected probability of illness.

The second phase of the analysis was in two stages. In the first stage, the children born during the first two years of the study (July 1, 1965 through June 30, 1967), were assigned into two groups, hospitalized and non-hospitalized. The hospitalized group included all

TABLE 6

NUMBER OF CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, PERCENT INCLUDED IN THE STUDY, FISCAL YEARS 1966-69.

Fiscal Year	No. of Births	No. Included	No. Excluded (Lived Outside Gallup Service Area)	Missing Information	Percent Included	Percent Missing Information
1966	653	554	88	11[a]	84.84	1.68
1967	650	567	80	3[a]	87.23	0.46
1968	643	533	110	0	82.89	0.00
1969	742	553	189	0	74.53	0.00

[a]Length of baby on 8 and parity on 6.

TABLE 7

ESTIMATED PROBABILITY OF ILLNESS BY DENVER SCORE

Score	Estimated Probability of Illness (EPI)
Under - 50	0.05
50 - 100	0.08
100 - 150	0.11
150 - 250	0.17
250 - 400	0.35
400 - 600	0.54
600 - 800	0.80
Over - 800	0.90

[a]Based on, Morbidity Model, Newborn and Premature Information Center. University of Colorado Medical Center, Denver, Colorado.

children who were hospitalized and/or died during the first year of life, and also those who stayed more than 14 days at birth. All others were included in the non-hospitalized group.

Discriminant analysis was performed on these two groups and the linear combination of 14 factors[1] which best discriminated the two groups was identified. Using the discriminant criteria the children were assigned to the two risk groups which were then compared with the actual morbidity groups. Finally, the discriminant criteria were modified to identify children in the hospitalized group more often than the non-hospitalized.

During the second stage, the children born during the last two years of the study (July 1, 1967 to June 30, 1969) were classified, using the discriminant function criteria developed in the first phase of the analysis. This classification was compared with the actual experience of these children, in order to test the reproducibility of the discriminant function criteria.

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[1]Length of baby, birth weight, gestational age, mother's age, Apgar score, toxemia, fetal distress, anesthesia, labor complications, PROM, abnormal delivery, sex, parity and number of abortions.

CHAPTER V

ANALYSIS

Denver Scoring System

The 1,135 Indian children born at PHS Indian Hospital during fiscal years 1966-67, and living in the Gallup Service area, received scores on the 15 factors according to the Denver system. The children were then assigned to eight groups, the same eight groups suggested by the Denver model, according to their total score. The frequency distribution of the children by total score and by number of hospitalizations and/or death is shown in Table 8. Of the 1,135 children, 909 children were not hospitalized during their first year of life. There were 36 deaths and the remaining 190 children had one or more hospitalization during their first year of life.

The children were assigned to two morbidity groups, hospitalized and non-hospitalized, according to their hospitalization and mortality experience during the first year of life. The hospitalized group consisted of all children who had one or more hospitalizations or died during the first year; the remaining children fell in the non-hospitalized group. Table 9 shows the distribution of children within each morbidity group and by score. Percent distribution of children within each score is also shown in Table 9. Of the children receiving a score of 250 or less, only 16 to 20 percent fell in the hospitalized group. The

TABLE 8

NUMBER OF HOSPITALIZATIONS AND DEATHS DURING FIRST YEAR OF LIFE, BY DENVER SCORE. NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Denver Score	Number of Hospitalizations				Deaths	Total
	0	1	2	3 and 4		
Under 50	201	26	12	6	4	249
50 - 100	307	40	14	5	1	367
100 - 150	218	33	7	1	4	263
150 - 250	136	20	5	1	7	169
250 - 400	26	8	2	0	4	40
400 - 600	5	2	0	0	1	8
600 - 800	13	3	1	0	2	19
Over 800	3	1	3	0	13	20
Total	909	133	44	13	36	1,135

TABLE 9

NUMBER AND PERCENT DISTRIBUTION BY DENVER SCORE AND BY MORBIDITY GROUP. NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Denver Score	Non-Hospitalized		Hospitalized		Total	
	Number	Percent	Number	Percent	Number	Percent
Under 50	201	80.7	48	19.3	249	100.0
50 - 100	307	83.7	60	16.3	367	100.0
100 - 150	218	82.9	45	17.1	263	100.0
150 - 250	136	80.5	33	19.5	169	100.0
250 - 400	26	65.0	14	35.0	40	100.0
400 - 600	5	62.5	3	37.5	8	100.0
600 - 800	13	68.4	6	31.6	19	100.0
Over 800	3	15.0	17	85.0	20	100.0
Total	909	80.1	226	19.9	1,135	100.0

percentage increased (31-38 percent) for those receiving a higher score, 250-800; and of the children with scores above 800, 85 percent were hospitalized.

Table 10 shows the observed and expected number of children by score in the two morbidity groups. The expected frequencies for the hospitalized group were obtained by multiplying the expected probability of illness (EPI) by the total number of children in a given score. There were 48 children in the hospitalized group with a score of 50 or less compared to an expected frequency of 12.45. The χ^2 test was used to test the association between the expected and the observed number of children within a total score. The results are shown in Table 10. The χ^2 was highly significant for the three groups of children with low scores: less than 50, 50-100, 100-150. This indicates that the actual morbidity of the children was not in agreement with the predicted. For the next three groups, children with scores of 150-250, 250-400, 400-600, the χ^2 test was not statistically significant. There was good agreement between expected and observed morbidity. Children receiving a score of 600-800 showed no agreement, but children receiving a score of above 800 showed strong agreement between observed and expected morbidity experience.

Among the 226 children who were hospitalized or died (hospitalized group), 153 received a score of 150 or less and 50 had a score between 150-600. The number of children who died or were hospitalized was much larger than the number predicted by the Denver Scale. Since a large proportion of Navajo children (879 out of 1,135) received a score of 150 or less, the expected probability of illness derived from the Denver population is not satisfactory for predicting morbidity among the

TABLE 10

COMPARISON OF OBSERVED AND EXPECTED MORBIDITY FREQUENCIES WITHIN A DENVER SCORE. NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Denver Score	Hospitalized		Non-hospitalized		Total	EPI[a] (Percent)	Chi Square	P
	Observed	Expected (Total x EPI)	Observed	Expected [Total x (100-EPI)]				
Under 50	48	12.45	201	236.55	249	5.0	106.85	**[b]
50 - 100	60	29.36	307	337.64	367	8.0	34.76	**[b]
100 - 150	45	28.93	218	234.07	263	11.0	10.03	**[b]
150 - 250	33	28.73	136	140.27	169	17.0	0.77	NS
250 - 400	14	14.00	26	26.00	40	35.0	0.00	NS
400 - 600	3	4.32	5	3.68	8	54.0	0.88	NS
600 - 800	6	15.20	13	3.80	19	80.0	27.84	**[b]
Above 800	17	18.00	3	2.00	20	90.0	0.56	NS

[a]Expected probability of illness (Table 7).

[b]Significant at .01 level.

NS = Not significant at .05 level.

Navajo. Further, the estimated probability of illness gives only the probability of illness associated with a particular score. It does not correctly classify the infant in risk groups. Hence, the Denver method is not satisfactory for the routine identification of high risk Navajo children, without modifications.

Factors Considered in the Discriminant Analysis

Information about length of baby and parity was added to the Denver factors in the hope of improving our predictions. The number of abortions was recorded instead of "habitual abortion". Three factors in the Denver model were excluded because very few Navajo deliveries had these characteristics: maternal diabetes, endotrachial aspiration or positive pressure resuscitation for the infant, and administration of stimulants in the delivery room.

Of the 1,135 children who met the criteria for inclusion in the study, there was complete information on 1,121 children. Of the 14 children with missing information, eight had no record of length at birth, and six were parity unknown.

The 1,121 children were classified into two groups; a hospitalized group and a non-hospitalized group. The criteria used for classifying a child into one of these two groups were as follows. Children who had one or more hospitalizations and/or died during the first year of life, or who stayed in the hospital more than 14 days after birth, were classified in the hospitalized group. All other children were classified in the non-hospitalized group. There were 282 children in the hospitalized group and 839 children in the non-hospitalized group.

Discriminant analysis was performed on the 14 factors listed in

Table 11. When the factors are considered individually, most of them sharply differentiated the two groups of children, the hospitalized and non-hospitalized.

Sex Ratio

Of the 1,121 children, 51 percent (572) were male and 49 percent (549) were female. There were 140 male and 142 female children in the hospitalized group and 432 male and 407 female children in the non-hospitalized group. The sex distribution by morbidity groups is shown in Table 12.

Length of Baby

The average length at birth of a child in the hospitalized group was 19.07 inches as compared to 19.84 inches among the non-hospitalized group. The "t" test showed this difference to be statistically significant.

The number and percent distribution by length at birth, sex and morbidity group is shown in Table 13. Among the hospitalized children, 26.3 percent were less than 19 inches in length at birth as compared to 5 percent of the non-hospitalized group. On the other hand, only 9.9 percent of the hospitalized group children were 21 inches long or more, as compared with 23.4 percent for the non-hospitalized group.

Birth Weight

The average birth weight of Navajo children born at PHS Indian Hospital, Gallup, was 3100 gms. In the hospitalized group, the average birth weight was 2797 gms., and in the non-hospitalized group it was 3215 gms. The "t" test indicated that the mean difference in birth

TABLE 11

VARIABLES INCLUDED IN THE DISCRIMINANT ANALYSIS

Number	Variable
1	Length of baby
2	Birth weight
3	Gestational age
4	Mother's age
5	Apgar score
6	Toxemia
7	Fetal distress
8	Anesthesia
9	Labor complication
10	Premature rupture of the membrane
11	Abnormal delivery
12	Sex
13	Parity
14	Number of abortions

TABLE 12

NUMBER AND PERCENT DISTRIBUTION BY SEX AND BY MORBIDITY GROUP, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

	Morbidity Group					
	Hospitalized		Non-hospitalized		Total	
Sex	Number	Percent	Number	Percent	Number	Percent
Male	140	12.5	432	38.5	572	51.0
Female	142	12.7	407	36.3	549	49.0
Total	282	25.2	839	74.8	1,121	100.0

TABLE 13

NUMBER AND PERCENT DISTRIBUTION BY LENGTH AT BIRTH, SEX, AND MORBIDITY GROUP. NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Length (inches)	Score	Total			Male			Female		
		Total	Hospital-ized	Non-Hospital-ized	Total	Hospital-ized	Non-Hospital-ized	Total	Hospital-ized	Non-Hospital-ized
17	50	29	29	0	10	10	0	19	19	0
18	10	87	45	42	40	24	16	47	21	26
19-20	0	781	180	601	380	87	293	401	93	308
21	5	202	25	177	125	16	109	77	9	68
Over 21	10	22	3	19	17	3	14	5	0	5
Total		1,121	282	839	572	140	432	549	142	407
				Percent Distribution						
17	50	2.6	10.3	0.0	1.7	7.1	0.0	3.5	13.4	0.0
18	10	7.7	16.0	5.0	7.0	17.2	6.4	8.6	14.8	6.4
19-20	0	69.7	63.8	71.6	66.4	62.2	67.8	73.0	65.5	75.7
21	5	18.0	8.9	21.1	21.9	11.4	25.2	14.0	6.3	16.7
Over 21	10	2.0	1.0	2.3	3.0	2.1	3.3	0.9	0.0	1.2
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

weight was significant. The number and percent distribution by birth weight, sex and morbidity group is shown in Table 14.

Among the hospitalized children, 29.4 percent were under 2501 gms. as compared to 3.8 percent of the non-hospitalized group. Further, only 59.2 percent of the hospitalized group had a birth weight of 2501 to 3500 gms. as compared to 72.5 percent among the non-hospitalized group.

Apgar Score

The hospitalized group had an Apgar score of 8.5 on the average as compared to 9.1 in the non-hospitalized group. The "t" test showed the difference between the two mean Apgar scores was significant. The number and percent distribution by Apgar score, sex and morbidity group is shown in Table 15.

A score of 8-10 was achieved in only 79.1 percent of the hospitalized group as compared to 92.5 percent of the non-hospitalized group. Conversely, 14.5 percent of the hospitalized group and only 6.4 percent of the non-hospitalized group received a score of 5 to 7.

Age of Mother

Mothers in the non-hospitalized group, on the average, were 1.3 years younger than those in the hospitalized group. The average age of mothers in the non-hospitalized group was 25.7 years and in the hospitalized group was 27.0 years. The average age difference between the two groups was significant.

The number and percent distribution by age of mother, sex and morbidity group is shown in Table 16. In the hospitalized group 17.4 percent of the mothers were 35 years and above as compared to 10.6

TABLE 14

NUMBER AND PERCENT DISTRIBUTION BY BIRTH WEIGHT, SEX AND MORBIDITY GROUP, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Birth weight (in grams)	Denver Score	Total			Male			Female		
		Total	Hospital-ized	Non-Hospital-ized	Total	Hospital-ized	Non-Hospital-ized	Total	Hospital-ized	Non-Hospital-ized
<1500	617	11	11	0	3	3	0	8	8	0
1501-2000	550	26	26	0	13	13	0	13	13	0
2001-2500	185	78	46	32	35	21	14	43	25	18
2501-3500	43	775	167	608	385	80	305	390	87	303
>3500	50	231	32	199	136	23	113	95	9	86
Total		1,121	282	839	572	140	432	549	142	407
					Percent Distribution					
<1500	617	1.0	3.9	0.0	0.5	2.1	0.0	1.5	5.6	0.0
1501-2000	550	2.3	9.2	0.0	2.3	9.3	0.0	2.4	9.2	0.0
2001-2500	185	7.0	16.3	3.8	6.1	15.0	3.2	7.8	17.6	4.4
2501-3500	43	69.1	59.2	72.5	67.3	57.2	70.6	71.0	61.3	74.5
>3500	50	20.6	11.4	23.7	23.8	16.4	26.2	17.3	6.3	21.1
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 15

NUMBER AND PERCENT DISTRIBUTION BY APGAR SCORE, SEX, AND MORBIDITY GROUP, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

		Total			Male			Female		
Apgar Score	Denver Score	Total	Hospital-ized	Non-Hospital-ized	Total	Hospital-ized	Non-Hospital-ized	Total	Hospital-ized	Non-Hospital-ized
8-10	0	999	223	776	507	111	396	492	112	380
5- 7	31	95	41	54	51	22	29	44	19	25
0- 4	110	27	18	9	14	7	7	13	11	2
Total		1,121	282	839	572	140	432	549	142	407
					Percent Distribution					
8-10	0	89.1	79.1	92.5	88.6	79.3	91.7	89.6	78.9	93.4
5- 7	31	8.5	14.5	6.4	8.9	15.7	6.7	8.0	13.4	6.1
0- 4	110	2.4	6.4	1.1	2.5	5.0	1.6	2.4	7.7	0.5
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 16

NUMBER AND PERCENT DISTRIBUTION BY AGE OF MOTHER, SEX AND MORBIDITY GROUP, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Age of Mother (in years)	Denver Score	Total: Total	Total: Hospital-ized	Total: Non-Hospital-ized	Male: Total	Male: Hospital-ized	Male: Non-Hospital-ized	Female: Total	Female: Hospital-ized	Female: Non-Hospital-ized
< 15	74	4	2	2	1	0	1	3	2	1
15-19	19	157	39	118	79	20	59	78	19	59
20-34	0	822	192	630	414	93	321	408	99	309
> 34	39	138	49	89	78	27	51	60	22	38
Total		1,121	282	839	572	140	432	549	142	407
Percent Distribution										
< 15	74	0.4	0.7	0.2	0.2	0.0	0.2	0.6	1.4	0.3
15-19	19	14.0	13.8	14.1	13.8	14.3	13.7	14.2	13.4	14.5
20-34	0	73.3	68.1	75.1	72.4	66.4	74.3	74.3	69.7	75.9
> 34	39	12.3	17.4	10.6	13.6	19.3	11.8	10.9	15.5	9.3
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

percent in the non-hospitalized group.

Gestational Age

The gestational age of hospitalized children was 1.2 weeks shorter on the average than that of the non-hospitalized children. The average gestational age for the hospitalized group was 38.3 weeks as compared with 39.6 weeks for the non-hospitalized group. The mean difference was significant.

The number and percent distribution by gestational age, sex, and morbidity group is shown in Table 17. The hospitalized group had 12.7 percent of deliveries before 36 weeks as compared to 1.2 percent in the non-hospitalized group. Also, 71.3 percent of the hospitalized and 90.2 percent of the non-hospitalized deliveries occurred after 37 weeks.

Parity

Mothers of the hospitalized group had an average parity of 3.5 as compared to 2.8 for the non-hospitalized group. The difference was significant. The number and percent distribution by parity, sex, and morbidity group are shown in Table 18. In the hospitalized group, 66 percent had a parity of 4 or less as compared to 77.3 percent in the non-hospitalized group. Also 10.3 percent of the hospitalized group and 5.0 percent of the non-hospitalized group had a parity of 9 or more.

Table 19 shows the number and percent distribution by parity and birth weight of the child. Among nullipara's (mothers delivering for the first time), low birth weight (2500 gms. or less) children accounted for 13.87 percent. The percent distribution of low birth weight children decreased as the parity increased, reaching a low of 5.8 percent among the

TABLE 17

NUMBER AND PERCENT DISTRIBUTION BY GESTATIONAL AGE, SEX AND MORBIDITY GROUP, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Gestational Age (in weeks)	Denver Score	Total			Male			Female		
		Total	Hospitalized	Non-Hospitalized	Total	Hospitalized	Non-Hospitalized	Total	Hospitalized	Non-Hospitalized
27	216	4	4	0	2	2	0	2	2	0
28-31	184	7	7	0	3	3	0	4	4	0
32-33	150	12	8	4	5	3	2	7	5	2
34-35	90	23	17	6	8	6	2	15	11	4
36-37	38	92	37	55	50	21	29	42	16	26
38 and above	11	958	201	757	493	103	390	465	98	367
Not Specified	27	25	8	17	11	2	9	14	6	8
Total		1,121	282	839	572	140	432	549	142	407
					Percent Distribution					
27	216	0.4	1.4	0.0	0.3	1.4	0.0	0.4	1.4	0.0
28-31	184	0.6	2.5	0.0	0.5	2.1	0.0	0.7	2.8	0.0
32-33	150	1.1	2.8	0.5	0.9	2.1	0.5	1.3	3.5	0.5
34-35	90	2.1	6.0	0.7	1.4	4.3	0.5	2.7	7.8	1.0
36-37	38	8.2	13.1	6.6	8.7	15.0	6.7	7.7	11.3	6.4
38 and above	11	85.4	71.3	90.2	86.3	73.7	90.3	84.7	69.0	90.2
Not Specified	27	2.2	2.9	2.0	1.9	1.4	2.0	2.5	4.2	1.9
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 18

NUMBER AND PERCENT DISTRIBUTION BY PARITY, SEX AND MORBIDITY GROUP, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Parity	Score	Total: Total	Total: Hospital-ized	Total: Non-Hospital-ized	Male: Total	Male: Hospital-ized	Male: Non-Hospital-ized	Female: Total	Female: Hospital-ized	Female: Non-Hospital-ized
Under 5	0	835	186	649	427	91	336	408	95	313
5- 6	50	121	35	86	61	17	44	60	18	42
7- 8	100	94	32	62	50	19	31	44	13	31
9-10	200	39	13	26	16	4	12	23	9	14
Above 10	300	32	16	16	18	9	9	14	7	7
Total		1,121	282	839	572	140	432	549	142	407
					Percent Distribution					
Under 5	0	74.5	66.0	77.3	74.7	65.0	77.8	74.3	66.9	76.9
5- 6	50	10.8	12.4	10.3	10.7	12.1	10.2	10.9	12.7	10.3
7- 8	100	8.4	11.3	7.4	8.7	13.6	7.2	8.0	9.2	7.6
9-10	200	3.5	4.6	3.1	2.8	2.9	2.8	4.2	6.3	3.5
Above 10	300	2.8	5.7	1.9	3.1	6.4	2.0	2.6	4.9	1.7
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 19

NUMBER AND PERCENT DISTRIBUTION BY PARITY AND BIRTH WEIGHT,
NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL,
GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Birth Weight	Parity										
	0	1	2	3	4	5-6	7-8	9-10	11+	Unknown	Total
2500 gms or less	38	18	15	9	5	16	11	5	4	0	121[a]
Above 2500 gms.	236	184	143	110	81	107	85	34	28	6	1,014[b]
Total	274	202	158	119	86	123	96	39	32	6	1,135
					Percent Distribution						
2500 gms or less	13.87	8.91	9.49	7.56	5.81	13.01	11.46	12.82	12.50	0.00	10.66
Above 2500 gms.	86.13	91.09	90.51	92.44	94.19	86.99	88.54	87.18	87.50	100.00	89.34
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a]Includes 19 deaths.

[b]Includes 17 deaths.

mothers with a parity of 4; then it increased to 13 percent among mothers with parity 5 to 6. Mothers with parity 5 or more had at least 11 percent low birth weight children.

Abortions

The hospitalized group had 32 mothers (11.4 percent) with one or more previous abortions as compared with 86 mothers (10.2 percent) among the non-hospitalized group, and the difference was not significant. The number and percent distribution by number of previous abortions, sex and morbidity group is shown in Table 20.

Maternal and Perinatal Complications

The frequency and percent distribution, by morbidity group, of mothers having toxemia, fetal distress, anesthesia, labor complications, premature rupture of membrane, and abnormal delivery is shown in Table 21. In the hospitalized group, toxemia, fetal distress and premature rupture of the membrane were more common than in the non-hospitalized group. However, anesthesia was more frequent in the non-hospitalized group and the proportions with labor complications and abnormal delivery were almost the same for both morbidity groups.

Hospital Stay at Birth

The average length of stay at birth for all hospitalized children was 15.7 days. Of the 282 children in the hospitalized group, 64 (22.7 percent) stayed more than 14 days at birth, but were hospitalized again during the first year of life. If the 64 children are excluded, the average length of stay was 8.9 days. The average stay at birth for non-hospitalized children was 4.4 days, which is significantly different

TABLE 20

NUMBER AND PERCENT DISTRIBUTION BY NUMBER OF PREVIOUS ABORTIONS, SEX AND MORBIDITY GROUP, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

No. of Abortions	Score	Total			Male			Female		
		Total	Hospital-ized	Non-Hospital-ized	Total	Hospital-ized	Non-Hospital-ized	Total	Hospital-ized	Non-Hospital-ized
0	0	1,003	250	753	519	120	399	484	130	354
1	10	91	25	66	42	16	26	49	9	40
2	50	22	4	18	9	3	6	13	1	12
3 or more	200	5	3	2	2	1	1	3	2	1
Total		1,121	282	839	572	140	432	549	142	407
					Percent Distribution					
0	0	89.5	88.6	89.8	90.7	85.7	92.4	88.2	91.6	87.0
1	10	8.1	8.9	7.9	7.3	11.4	6.0	8.9	6.3	9.8
2	50	2.0	1.4	2.1	1.6	2.2	1.4	2.4	0.7	2.9
3 or more	200	0.4	1.1	0.2	0.4	0.7	0.2	0.5	0.7	0.3
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 21

NUMBER AND PERCENT DISTRIBUTION BY MATERNAL AND PERINATAL COMPLICATIONS AND MORBIDITY GROUP, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Maternal and Perinatal Complications		Denver Score	Total		Hospitalized		Non-Hospitalized	
			Number	Percent	Number	Percent	Number	Percent
Toxemia	Present	45	94	8.4	29	10.3	65	7.7
	Absent	0	1,027	91.6	253	89.7	774	92.3
Fetal Distress	Present	42	18	1.6	9	3.2	9	1.1
	Absent	0	1,103	98.4	273	96.8	830	98.9
Anesthesia	Used	24	227	20.2	46	16.3	181	21.6
	Not Used	0	894	79.8	236	83.7	658	78.4
Labor Complications	Present	41	46	4.1	12	4.3	34	4.1
	Absent	0	1,075	95.9	270	95.7	805	95.9
Premature Rupture of Membrane	Present	63	44	3.9	22	7.8	22	2.6
	Absent	0	1,077	96.1	260	92.2	817	97.4
Abnormal Delivery	Present	53	333	29.7	84	29.8	249	29.7
	Absent	0	788	70.3	198	70.2	590	70.3

from the hospitalized group.

The number and percent distribution by hospital stay at birth, sex and morbidity group is shown in Table 22. In the hospitalized group, 62.4 percent of the children stayed 7 days or less, as compared with 94.9 percent among the not hospitalized group. Also, 32.3 percent of the hospitalized children stayed more than 14 days at birth; 9.6 percent returning to the hospital or dying; 22.7 percent without further difficulties.

Results of the Discriminant Analyses

A total of 12 different discriminant analyses were performed, using the 14 factors and subsets of these 14 factors. The factors considered in each analysis are shown in Table 23. All 14 factors were used in analysis 1, whereas only 3 factors (birth weight, gestational age and parity) were used in analysis 12. The mean scores, covariance matrix for the 14 variables and the coefficient λ's are given in the Appendix, Tables 38 through 43.

The generalized distance, Mahalanobis' D^2, between the hospitalized and the not hospitalized group for the 12 discriminant analyses were tested (for test statistic, see Rao p. 37) and found significantly different from zero (Table 24). The Mahalanobis D^2 for the subset of 14 factors (analyses 2-12) were compared with the Mahalanobis D^2 of 14 factors (analysis 1) and found nonsignificant (Table 24).

In analysis number 12, the Mahalanobis D^2 (0.9625) for the three variables (birth weight, gestational age, and parity) was not significant when compared to the Mahalanobis D^2 (1.0182) based on 14 variables. This indicates that the discriminant function based on the three variables was sufficient to discriminate the two groups.

TABLE 22

NUMBER AND PERCENT DISTRIBUTION BY HOSPITAL STAY AT BIRTH, SEX AND MORBIDITY GROUP, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Hospital Stay at Birth (in days)	Total			Male			Female		
	Total	Hospital-ized	Non-Hospital-ized	Total	Hospital-ized	Non-Hospital-ized	Total	Hospital-ized	Non-Hospital-ized
< 8 days	972	176	796	503	94	409	469	82	387
8-14 days	58	15	43	30	7	23	28	8	20
>14 days	91	91	0	39	39	0	52	52	0
Total	1,121	282	839	572	140	432	549	142	407
				Percent Distribution					
< 8 days	86.7	62.4	94.9	87.9	67.1	94.7	85.4	57.8	95.1
8-14 days	5.2	5.3	5.1	5.3	5.0	5.3	5.1	5.6	4.9
>14 days	8.1	32.3	0.0	6.8	27.9	0.0	9.5	36.6	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 23

FACTORS CONSIDERED IN DISCRIMINANT FUNCTION ANALYSES

Number	Variable	Analysis Number											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Length of baby	x	x	x	x	x	x					x	
2	Birth weight	x	x	x	x	x	x	x	x	x	x	x	x
3	Gestational age	x	x	x	x	x	x	x	x	x	x	x	x
4	Mother's age	x	x		x	x	x	x	x			x	
5	Apgar score	x	x	x	x	x	x	x	x	x	x	x	
6	Toxemia	x	x		x								
7	Fetal distress	x			x	x	x						
8	Anesthesia	x											
9	Labor complications	x											
10	Premature rupture of membrane	x	x	x	x	x							
11	Abnormal delivery	x											
12	Sex of child	x											
13	Parity	x	x	x	x	x	x	x		x	x		x
14	Number of abortions	x	x	x	x	x				x			

TABLE 24

NUMBER OF PARAMETERS USED IN THE DISCRIMINANT FUNCTION, MAHALANOBIS D^2 AND TEST OF SIGNIFICANCE

Analysis Number	No. of Parameters Used	Mahalanobis D^2	F	Significance	F*	Significance
1	14	1.0182	15.17	**	-	-
2	9	0.9985	23.25	**	0.69	NS
3	7	0.9907	29.71	**	0.69	NS
4	10	0.9987	20.91	**	0.85	NS
5	9	0.9962	23.19	**	0.77	NS
6	8	0.9947	26.08	**	0.69	NS
7	5	0.9937	41.80	**	0.48	NS
8	4	0.9527	50.14	**	1.16	NS
9	5	0.9900	41.64	**	0.55	NS
10	4	0.9883	52.01	**	0.53	NS
11	5	0.9528	40.07	**	1.28	NS
12	3	0.9625	67.59	**	0.89	NS

n = 282 and m = 839

** significant at .01 level

NS = not significant at .10 level

F test used to test the distance is zero

F* test used to test whether the variables left out contribute additional information in the discrimination.

In analysis number 8, four variables were used; birth weight, gestational age, mother's age and Apgar score. In analysis number 11, the same variables were used, plus length of baby. In analysis number 12, only three variables were used; birth weight, gestational age and parity. However, the Mahalanobis D^2 of analysis number 12 was higher than for either analysis number 8 or number 11. This shows that parity contributed more information to the discrimination than length of baby, mother's age and Apgar score.

Assignment of Newborn Children to Risk Groups

Discriminant functions were calculated for the purpose of assigning a newborn to one of the two risk groups - high and low. The following criteria were used in the classification.

The newborn was classified in risk group I (high risk group) if $\sum_{i=1}^{b} \lambda_i X_i > C$ and in risk group II (low risk group) if $\sum_{i=1}^{b} \lambda_i X_i \leq C$ where X_i, i=1, b are the scores of the i^{th} variable received at birth, λ's are the associated discriminant constants (weights) and C an arbitrarily chosen number. By selecting $C = \sum_{i=1}^{b} \lambda_i(\bar{X}_{1i} + \bar{X}_{2i})/2$, the error of misclassification associated with any group is minimized, where $\bar{X}_{1i}$ and $\bar{X}_{2i}$ are the mean scores of the i^{th} variable in the hospitalized and the non-hospitalized group respectively.

None of the discriminant functions based on subsets of the 14-variables were significantly different from that of the 14-variables. Any one of the discriminant function criteria was adequate to classify the 1,121 children in risk groups. However, four discriminant functions, the 14-variables and three other discriminant functions (7-variables, 5-variables and 3-variables) were chosen for further analysis. The latter three were selected to determine the amount of discrimination gained by including additional variables. The frequency distributions of the

$\sum_{i=1}^{b} \lambda_i X_i$ for these four cases are shown in Tables 44, 45, 46 and 47 in the Appendix.

Classification Criterion I (Based on 14-variables)

The 1,121 children were assigned according to the 14-variable discriminant criterion to two risk groups. A child was classified as high risk if $\sum_{i=1}^{14} \lambda_i X_i$ was greater than C = 1.1449, otherwise as low risk. Table 25 shows the two groups and their actual subsequent experience of hospitalization and/or deaths.

The criterion correctly classified 39.6 percent of the hospitalized and 90.35 percent of the non-hospitalized children. A large proportion (60.6 percent) of the hospitalized children were classified incorrectly as low risk (false negatives). Thus the criterion tended to be quite specific, but not adequately sensitive.

Among the 192 children classified in the high risk group, 81 were not hospitalized, a large proportion (42.2 percent). Also, among the 929 children in the low risk group, 171 (18.4 percent) were hospitalized.

An ideal criterion for identifying high risk children would be both highly sensitive and highly specific. The discriminant criterion proved to be moderately specific, but it was unsatisfactory because of

TABLE 25

CLASSIFICATION BY 14-VARIABLE DISCRIMINANT CRITERION OF 1,121 NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

	Discriminant Criterion			Percent Distribution		
	High Risk	Low Risk	Total	High Risk	Low Risk	Total
Hospitalized or died[a]	111	171	282	39.36	60.64	100.0
Not hospitalized	81	758	839	9.65	90.35	100.0
Total	192	929	1,121	17.13	82.87	100.0

[a]Includes children who stayed more than 14 days at birth.

its very low sensitivity and its high false negative rate. It was possible to modify the discriminant criterion so as to increase its sensitivity, but only by reducing its specificity and increasing the false positive rate. However, low specificity is a less serious disadvantage than low sensitivity. It is of paramount importance to identify as many as possible of the children who need special services. If some children receive services who do not need them, this is unfortunate, but not a critical defect.

Consequently the discriminant criterion was modified by shifting the value of C to a lower value (0.545) in the expectation that false negatives would be reduced. A child was considered high risk if $\sum_{i=1}^{14} \lambda_i X_i$ was greater than 0.545, otherwise low risk. The risk groups according to the modified criterion results are shown in Table 26. This criterion had a sensitivity of 64.89 percent and a specificity of 56.02 percent. The false negatives were reduced from 60.64 percent to 35.11 percent, and the false positives were increased from 9.6 percent to 43.98 percent. The criterion classified 552 (49.24 percent) of the 1,121 children as high risk and the remainder of 569 (50.76 percent) as low risk. Of the 552 high risk children 182 (33.0 percent) were hospitalized (includes deaths). Of the 569 low risk children 470 (82.6 percent) had no hospitalization during the first year of life. Further increase in the sensitivity of this criterion was not possible without a large increase in the false positives.

Classification Criterion II (Based on 7-Variables)

When the 7-variable criterion was used to assign the 1,121

TABLE 26

CLASSIFICATION BY MODIFIED 14-VARIABLE DISCRIMINANT CRITERION
OF 1,121 NAVAJO CHILDREN BORN AT PHS INDIAN
HOSPITAL, GALLUP, NEW MEXICO,
FISCAL YEARS 1966-67

	Modified Discriminant Criterion			Percent Distribution		
	High Risk	Low Risk	Total	High Risk	Low Risk	Total
Hospitalized or died[a]	183	99	282	64.89	35.11	100.0
Not hospitalized	369	470	839	43.98	56.02	100.0
Total	552	569	1,121	49.24	50.76	100.0

[a]Includes children who stayed in the hospital more than 14 days at birth.

children to risk groups, the results were similar to those of the 14-variable criterion. The 7-variable criterion classified a child as high risk if $\sum_{i=1}^{7} \lambda_i X_i$ was greater than 1.1333, otherwise low risk. There were 195 children in the high risk group and 926 in the low risk group according to this criterion. Children in the high risk and low risk groups were compared with their hospitalization experience (Table 27).

The sensitivity of this criterion was 39.72 percent, the specificity 90.11 percent. The false negatives and false positives were 60.28 percent and 9.89 percent respectively. The sensitivity of this criterion was not different from that of the 14-variable criterion, and for the same reason was not satisfactory for identifying high risk children.

Again, the criterion was modified. According to the modified criterion, a child was high risk if $\sum_{i=1}^{7} \lambda_i X_i$ was greater than 0.4833, otherwise low risk. The results of the classification are shown with subsequent hospitalization experience in Table 28. The sensitivity of the modified criterion was 64.89 percent, specificity 55.07 percent. The false negatives and false positives were 35.11 percent and 44.93 percent respectively. The criterion classified 560 (50.0 percent) of the 1,121 children in the high risk group and the remaining 561 (50.0 percent) in the low risk group. Of the 560 high risk children, 183 (32.7 percent) were hospitalized, 462 (82.4 percent) of the 561 low risk children did not have any hospitalization during their first year of life.

Classification Criterion III (Based on 5-Variables)

The results of the 5-variable criterion were similar to the

TABLE 27

CLASSIFICATION BY 7-VARIABLE DISCRIMINANT CRITERION OF 1,121 NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

	Discriminant Criterion			Percent Distribution		
	High Risk	Low Risk	Total	High Risk	Low Risk	Total
Hospitalized and deaths[a]	112	170	282	39.72	60.28	100.0
Not hospitalized	83	756	839	9.89	90.11	100.0
Total	195	926	1,121	17.40	82.60	100.0

TABLE 28

CLASSIFICATION BY MODIFIED 7-VARIABLE DISCRIMINANT CRITERION OF 1,121 NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

	Modified Discriminant Criterion			Percent Distribution		
	High Risk	Low Risk	Total	High Risk	Low Risk	Total
Hospitalized and deaths[a]	183	99	282	64.89	35.11	100.0
Not hospitalized	377	462	839	44.93	55.07	100.0
Total	560	561	1,121	49.96	50.04	100.0

[a]Includes children who stayed in the hospital more than 14 days at birth.

other two criteria. Sensitivity was low and specificity high. The 5-variable criterion consists of birth weight; gestational age; mother's age; Apgar score and parity. A child was classified in the high risk group if $\sum_{i=1}^{5} \lambda_i X_i$ was greater than 1.52997, otherwise in the low risk group. According to this criterion, 188 (16.8 percent) children were high risk; 933 (83.2 percent) were low risk (Table 29). Sensitivity was 38.3 percent, specificity 90.46 percent. The false negatives and false positives were 61.70 percent and 9.54 percent respectively.

Again, the criterion was modified by shifting the value of C to 0.502997. The new criterion classified 591 (52.7 percent) of the 1,121 children as high risk and the remaining 530 (47.3 percent) as low risk (Table 30). Sensitivity was increased to 69.50 percent; specificity was reduced to 52.92 percent. Accordingly false negatives decreased to 30.50 percent and false positives increased to 47.08 percent.

Classification Criterion IV (Based on 3-Variables)

The results of the 3-variable discriminant criterion were again similar to the previous three criteria. Sensitivity was low and specificity was high. A child was classified as high risk if $\sum_{i=1}^{3} \lambda_i X_i > 1.12$, otherwise as low risk. This criterion classified 180 (16.06 percent) of the 1,121 children as high risk and 941 (83.9 percent) as low risk.

Sensitivity of this criterion was 37.2 percent and specificity was 91.1 percent (Table 31). Also, false negatives (62.8 percent) were high and false positives were low (8.9 percent). Consequently, this criterion also was not satisfactory without modification.

The modified discriminant criterion classified 585 (52.2 percent)

TABLE 29

CLASSIFICATION BY 5-VARIABLE DISCRIMINANT CRITERION OF 1,121 NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

	Discriminant Criterion			Percent Distribution		
	High Risk	Low Risk	Total	High Risk	Low Risk	Total
Hospitalized and deaths[a]	108	174	282	38.30	61.70	100.0
Not hospitalized	80	759	839	9.54	90.46	100.0
Total	188	933	1,121	16.77	83.23	100.0

TABLE 30

CLASSIFICATION BY MODIFIED 5-VARIABLE DISCRIMINANT CRITERION OF 1,121 NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

	Modified Discriminant Criterion			Percent Distribution		
	High Risk	Low Risk	Total	High Risk	Low Risk	Total
Hospitalized and deaths[a]	196	86	282	69.50	30.50	100.0
Not Hospitalized	395	444	839	47.08	52.92	100.0
Total	591	530	1,121	52.72	47.28	100.0

[a]Includes children who stayed in the hospital more than 14 days at birth.

TABLE 31

CLASSIFICATION BY 3-VARIABLE DISCRIMINANT CRITERION OF 1,121
NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL,
GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

	Discriminant Criterion			Percent Distribution		
	High Risk	Low Risk	Total	High Risk	Low Risk	Total
Hospitalized and Deaths[a]	105	177	282	37.23	62.77	100.00
Not Hospitalized	75	764	839	8.94	91.06	100.00
Total	180	941	1,121	16.06	83.94	100.00

[a]Includes children who stayed in the hospital more than 14 days at birth.

of 1,121 children as high risk and the remaining as low risk (Table 32). Sensitivity was increased to 62.4 percent and specificity was reduced to 51.3 percent. Accordingly, the false negatives were reduced to 37.6 percent while the false positives increased to 48.8 percent (Table 32).

Regardless of the number of variables used, the results of the four discriminant criteria were almost identical. Sensitivity was the same for the 14-variable and 7-variable criterion and decreased as the number of variables decreased. Specificity remained about the same. The results of the modified discriminant criterion, again, were similar except for the 5-variable modified discriminant criterion, whose sensitivity was slightly higher and specificity slightly lower than the other three criteria.

Test of Modified Discriminant Criteria for Reproducibility

The modified discriminant criteria (14, 7, 5 and 3 variables) were applied to a new set of data in order to test their reproducibility. Data on 1,086 children born during fiscal years 1968-69, at PHS Indian Hospital, Gallup, New Mexico were used. The results are shown in Table 33. Of the 1,086 children, the 14-variable criterion (Criterion I) classified 50.19 percent (545) as high risk. The other three criteria (Criterion II, Criterion III and Criterion IV) classified 52.67 percent, 56.17 percent and 48.34 percent respectively. The hospitalization experience of the children in each risk group is shown in Tables 34, 35, 36 and 37.

Table 34 shows the results using the 14-variable discriminant criterion. The sensitivity and specificity, when Criterion I was applied to the 1968-69 data was 63.81 percent and 54.28 percent respectively, as

TABLE 32

CLASSIFICATION BY MODIFIED 3-VARIABLE DISCRIMINANT CRITERION OF 1,121 NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

	Modified Discriminant Criterion			Percent Distribution		
	High Risk	Low Risk	Total	High Risk	Low Risk	Total
Hospitalized and Deaths[a]	176	106	282	62.41	37.59	100.00
Not Hospitalized	409	430	839	48.75	51.25	100.00
Total	585	536	1,121	52.19	47.81	100.00

[a]Includes children who stayed in the hospital more than 14 days at birth.

TABLE 33

CLASSIFICATION BY MODIFIED DISCRIMINANT CRITERIA OF 1,086
NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL,
GALLUP, NEW MEXICO, FISCAL YEARS 1968-69

Discriminant Criteria	Risk Groups				Total	
	High Risk		Low Risk			
	Number	Percent	Number	Percent	Number	Percent
Criterion I (14 variables)	545	50.19	541	49.81	1,086	100.0
Criterion II (7 variables)	572	52.67	514	47.33	1,086	100.0
Criterion III (5 variables)	610	56.17	476	43.83	1,086	100.0
Criterion IV (3 variables)	525	48.34	561	51.66	1,086	100.0

TABLE 34

CLASSIFICATION BY MODIFIED 14-VARIABLE DISCRIMINANT CRITERION, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67 AND FISCAL YEARS 1968-69

Observed	Modified Discriminant Criterion			Percent Distribution		
	High Risk	Low Risk	Total	High Risk	Low Risk	Total
			Fiscal Years 1968-69			
Hospitalized and deaths[a]	171	97	268	63.81	36.19	100.0
Not hospitalized	374	444	818	45.72	54.28	100.0
Total	545	541	1,086	50.19	49.81	100.0
			Fiscal Years 1966-67			
Hospitalized and deaths[a]	183	99	282	64.89	35.11	100.0
Not hospitalized	369	470	839	43.98	56.02	100.0
Total	552	569	1,121	49.24	50.76	100.0

[a]Includes children who stayed in the hospital more than 14 days at birth.

TABLE 35

CLASSIFICATION BY MODIFIED 7-VARIABLE DISCRIMINANT CRITERION,
NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL,
GALLUP, NEW MEXICO, FISCAL YEARS 1966-67
AND FISCAL YEARS 1968-69

Observed	Modified Discriminant Criterion			Percent Distribution		
	High Risk	Low Risk	Total	High Risk	Low Risk	Total
			Fiscal Years 1968-69			
Hospitalized and deaths[a]	181	87	268	67.54	32.46	100.0
Not hospitalized	391	427	818	47.80	52.20	100.0
Total	572	514	1,086	52.67	47.33	100.0
			Fiscal Years 1966-67			
Hospitalized and deaths[a]	183	99	282	64.89	35.11	100.0
Not hospitalized	377	462	839	44.93	55.07	100.0
Total	560	561	1,121	49.96	50.04	100.0

[a]Includes children who stayed in the hospital more than 14 days at birth.

TABLE 36

CLASSIFICATION BY MODIFIED 5-VARIABLE DISCRIMINANT CRITERION, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67 AND FISCAL YEARS 1968-69

Observed	Modified Discriminant Criterion			Percent Distribution		
	High Risk	Low Risk	Total	High Risk	Low Risk	Total
			Fiscal Years 1968-69			
Hospitalized and deaths[a]	179	89	268	66.79	33.21	100.0
Not hospitalized	431	387	818	52.69	47.31	100.0
Total	610	476	1,086	56.17	43.83	100.0
			Fiscal Years 1966-67			
Hospitalized and deaths[a]	196	86	282	69.51	30.49	100.0
Not hospitalized	395	444	839	47.08	52.92	100.0
Total	591	530	1,121	52.72	47.28	100.0

[a]Includes children who stayed in the hospital more than 14 days at birth.

TABLE 37

CLASSIFICATION BY MODIFIED 3-VARIABLE DISCRIMINANT CRITERION, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67 AND FISCAL YEARS 1968-69

Observed	Modified Discriminant Criterion			Percent Distribution		
	High Risk	Low Risk	Total	High Risk	Low Risk	Total
			Fiscal Years 1968-69			
Hospitalized and Deaths[a]	174	94	268	64.93	35.07	100.0
Not Hospitalized	351	467	818	42.91	57.09	100.0
Total	525	561	1,086	48.34	51.66	100.0
			Fiscal Years 1966-67			
Hospitalized and Deaths[a]	176	106	282	62.41	37.59	100.0
Not Hospitalized	409	430	839	48.75	51.25	100.0
Total	585	536	1,121	52.19	47.81	100.0

[a]Includes children who stayed in the hospital more than 14 days at birth.

compared with 64.89 percent and 56.02 percent respectively for 1966-67 data. The false negatives and false positives were 36.19 percent and 45.72 percent respectively for 1968-69 as compared to 35.11 percent and 43.98 percent for the 1966-67 data. Thus, the discriminant Criterion I reproduced itself quite well.

Table 35 shows the results of the 7-variable discriminant criterion (Criterion II). The sensitivity of this criterion when applied to the 1968-69 data was 67.54 percent. This was slightly higher than the sensitivity for 1966-67 data. However, the specificity (52.20 percent) was lower than the specificity for 1966-67 data. Hence, the false negatives were lower and the false positives higher than in the 1966-67 data. Sensitivity was slightly higher, specificity slightly lower. However, Criterion II did not reproduce as well as did Criterion I.

The application of the 5-variable criterion (Criterion III) to 1968-69 babies is shown in Table 36. Sensitivity is 66.79 percent lower than the sensitivity observed in 1966-67 data. Specificity is also lower. Hence, false negatives and false positives are slightly higher for 1968-69 data than for 1966-67 data.

Criterion III gave results different from either of the other two criteria. The results of Criterion III did not reproduce, and it seems the results are not stable when applied to different sets of data.

The results obtained with the 3-variable criterion are shown in Table 37. Sensitivity is 64.9 percent, slightly higher than the sensitivity for the 1966-67 data. Specificity is 57.1 percent, also somewhat higher than the specificity of the 1966-67 data. Hence, false negatives and false positives are slightly lower for 1968-69 data than for 1966-67 data.

The test shows that the results of the 14-variable criterion reproduced better than the results of the other three criteria. The 1968-69 results of the 3-variable discriminant criterion were better than the results of the other three criteria. However, the 14-variable criterion is recommended because of its greater reproducibility.

If the cost of obtaining information on all fourteen variables prohibits the use of this criterion, the 3-variable criterion could be used in the identification of high risk children with considerable confidence. Its sensitivity is comparable with Criterion I (14-variables); and the difference in reproducibility is slight.

CHAPTER VI

DISCUSSION

It is well established that infant mortality and morbidity vary greatly amongst different subgroups of the population. Infants born prematurely, or to very young or very old mothers, or to mothers with toxemia or other complications during pregnancy or delivery, generally experience higher morbidity and mortality than infants who do not have this type of history. In addition to these variables, factors such as race, socio-economic status, prenatal care, and others, affect infant morbidity and mortality. The American Indian is one subgroup which has experienced high infant morbidity and mortality.

The present study was concerned with developing a "model" which will identify high risk children at birth so that adequate follow-up care may be provided. If such a group can be identified, it will be possible to reduce infant morbidity and mortality by applying preventive measures.

Several methods have been suggested for the identification of high risk mothers and high risk children. Among these, the methods suggested by Nesbitt and Aubry (33), Gold (17), Anderson et al. (4) and Lubchenco's Denver Model, are of importance. Nesbitt and Aubry (33) and Gold (17) recommend early prenatal care for expectant mothers in order to screen high risk pregnancies. High risk mothers are identified at the first prenatal visit by evaluating certain socio-economic and biological factors. The two methods are similar, and both have been successful in reducing perinatal mortality. The main drawback of these methods is that early prenatal care is essential for their success. Many mothers do not receive prenatal care; those who do receive prenatal care do so too late to prevent the sequalae of high risk pregnancy.

The usefulness of these methods for the Navajo Indian population is very limited for two reasons: first, because most Navajo mothers do not seek prenatal care even when it is available; and second, because Navajo infant mortality, by contrast to white, is higher in the post-neonatal than the neonatal period.

Anderson et al. (4) method focuses on geographical areas with high infant morbidity and mortality. Follow-up services are provided to those at greater risk in these high risk areas. This method is well suited for urban areas where small pockets of high risk people are present; but it is not suitable for Navajo areas. According to this method the entire Navajo population would be considered a target.

The Denver model differs from the above in that it attempts to identify high risk children instead of high risk mothers. The method is to evaluate every child when it is born, obtaining a composite score which is used as an indicator of risk. The scores are devised in such a way that the higher the score, the greater the probability of being hospitalized during the neonatal period. The scale may be used to rank risk groups from "low" to "high".

A distinct advantage of the Denver model is that it does not rely on the prenatal care of expectant mothers. Since most deliveries in the U.S. occur in hospitals, it is feasible to screen children at birth. A list of high risk children may be used to provide follow-up services. The information required by this model is routinely collected as part of the health record and is easily accessible. In general, this method is both economical and convenient. Hence, this model was selected to test its ability to predict hospitalization during the first year of life among Navajo Indians.

In recent years, about 90 percent of Navajo children have been born in hospitals. The Indian Health Service provides follow-up care through field health clinics and, more important, through home visits by the public health personnel, such as public health nurses, public health nutritionists, social workers, and sanitarians. Navajo babies could easily be screened, since the information required in the Denver Model is routinely collected as part of the health record. Follow-up services could be provided to high risk children with relative ease if they could be identified at birth.

The present study was restricted to Navajo children born at the Public Health Service (PHS) Indian Hospital, Gallup, New Mexico and residing in the Gallup Service Area. This restriction was essential for several reasons. Many high risk Navajo mothers belonging to other service areas deliver at Gallup hospital and return to their service hospitals for follow-up care. Also, some non-Indian babies are delivered at the hospital and the follow-up information required for this study is not available on these children.

Information on the 15 factors (Figure 2, CHAPTER IV) was retrieved from the records for all Navajo children born at the PHS Indian Hospital, Gallup, New Mexico for the study period July 1965-June 1967.

Certain types of information, such as length of baby, gestational age, and Apgar score, are not as accurate as one would like, measuring the baby's length at birth is not always carried out with accuracy. Calculation of gestational age requires information on last menstrual period, which is obtained from memory. Apgar scores are based on subjective evaluation and are probably not consistent from hospital to hospital. However, within a single hospital, it is possible to standardize the procedures. Also, the effect of these errors on the final scores is minimized, since the scores are based on groupings, and deviation within groups will not affect the score.

About 78 percent of the Navajo children received a composite score of 150 or less on the Denver scale, -- which was considered a low risk score. Among these, 17.4 percent were hospitalized and/or died during the first year of life, although the model predicted only about 9 percent hospitalization and/or death for this group. Among children who received a score of 600-800 (1.67 percent), the model also predicted too low a rate of hospitalization and/or death. However, among children receiving a score of 150-600 (19.1 percent) and a score of above 800 (1.76 percent) the predicted hospitalization and/or death was closer to the observed. In general, the Denver model is not adequate to predict hospitalization and/or death during the first year of life among Navajo children. The inadequacy of the Denver model may be due to several factors.

1. The Denver model was formulated to predict hospitalization during the neonatal period only and hence is not suitable for predicting hospitalization during the first year of life as

desired in this study.

2. The Indian population experiences higher mortality in the post-neonatal period, whereas the Denver population, which is predominantly white, is higher in the neonatal period.
3. Indian children, on the average, have higher birth weight, maternal age and parity than the general white population. This peculiarity of the Indian population tends to reduce the number of children who are classified as high risk.

In order to develop a screening device more appropriate for Navajo infants, selected maternal and infant variables, some from the Denver model along with other variables, were employed to develop scores upon which discriminant analyses were performed. In all, 14 maternal and infant factors were considered. Several of these factors, when analysed individually, differed significantly between the two groups, those hospitalized and those non-hospitalized. Children in the hospitalized group were, on the average, shorter and lighter at birth; had lower Apgar scores, lower gestational age, and higher maternal age and parity. Also, they stayed in the hospital for a longer period of time at birth.

Twelve different models were investigated, employing the 14 variables and various subsets of these 14 variables (different each time). In one model, all 14 variables were used, whereas in another, only 3 variables (birth weight, gestational age and parity) were considered. In other, between 3 and 14 variables were considered in different combinations (Table 23, CHAPTER V). Birth weight and gestational age were common to all the 12 discriminant analyses, whereas parity was excluded in analysis 8 and analysis 11. The Apgar score was used in all except analysis 12.

To measure the distance between mean vectors of the two groups, the Mahalanobis D^2 statistic was computed in each of the 12 discriminant analyses. In all 12 cases, the test based on the D^2 statistic showed that the distance between the two groups was significantly different from zero. Each of the D^2s computed, using the subsets of the 14 variables, was tested against the 14-variable D^2, and each time it was not significant. This finding shows that the results of any of the 12 discriminant analyses could be used to assign children to risk groups. Furthermore, these findings suggest that the 3 variables, birth weight, gestational age and parity[1], are sufficient for discrimination. Thus the remaining 11 variables - length of baby, mother's age, Apgar score, toxemia, fetal distress, anesthesia, labor complications, premature rupture of the membrane, abnormal delivery, sex of the child and number of abortions, do not provide additional discrimination.

In performing the discriminant analysis, the usual assumption is that the variables in the risk groups follow a multivariate normal distribution with the same variance. Violation of the normality assumption is not considered serious, since the discriminant analysis could be made on scores or dichotomous variables. However, the results in these cases are crude (27). There appears to be a large variation among the scores of the hospitalized children than among those of the non-hospitalized children. This is largely due to the fact that most children

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[1]In analyses 8 and 11, the Mahalanobis D^2 statistic was smaller than the D^2 statistic of analysis 7. This shows that parity, which was excluded in analyses 8 and 11, does contribute additional discrimination.

in the hospitalized group exhibit one or more unfavorable characteristics and hence received a wide variety of scores. Therefore, the assumption of homogeneity of variances between the hospitalized and the non-hospitalized group is not met. In spite of this, the discriminant analyses were performed on the scores of these two groups, and the results of the analyses, however crude, may be useful in the identification of high risk children if in practice they provide criteria which are reasonably sensitive and specific.

Sensitivity in this study is defined as the ability of the discriminant criterion to identify correctly the children who were hospitalized and/or died; specificity is the ability of the discriminant criterion to identify correctly the non-hospitalized children. Any criterion used as a screening device is considered accurate if it approaches 100 percent sensitivity and specificity; that is, it produces few or no false negatives and few or no false positives. It is hard to devise such an accurate criterion with data obtained from sampling. A more realistic goal is a criterion with high sensitivity and high specificity. It is always possible to increase the sensitivity by reducing the specificity, or, conversely, to increase the specificity by reducing the sensitivity.

In order to assign a newborn to a high or low risk group, twelve discriminant criteria or models were devised, based on the results of the discriminant analyses. Navajo children born during fiscal years 1966-67 at the PHS Indian Hospital, Gallup, New Mexico were assigned to risk groups using each of the 12 discriminant criteria. In all cases, the probability of misclassification was about 30 percent. Unfortunately, when classification was compared with outcome, sensitivity was affected more than specificity. The false negative rate was 60 percent; the false positive rate, only 10 percent. In other words, sensitivity was far too low (only 40 percent). Thus the twelve discriminant criteria would not be suitable for routine use in the identification of high risk children, unless their sensitivity could be improved.

Of the twelve discriminant models, four were chosen for improvement in sensitivity: those using 14, 7, 5, and 3 variables. These criteria were modified by adjusting the constant which separates the two risk groups. Navajo children were reclassified according to these modified criteria. Sensitivity was increased from about 40 percent to 65 percent for the criteria using 14 and 7 variables; to 69.5 percent for the 5-variable criterion, and to 62.4 percent for the 3-variable criterion. Specificity decreased as the number of variables in the criteria decreased. The decrease was from 90 percent to 56.0 for 14 variables; to 55.1 percent for the 7 variables; to 52.9 percent for the 5 variables and to 51.2 percent for the 3 variables. Further improvement in sensitivity could only be achieved with large sacrifices in specificity.

Thus, improvement in sensitivity required a substantial increase in false positives. This would not be acceptable if special services were expensive or inconvenient for the patient's family. However, in this case, the Indian Health Service provides follow-up care free of charge. Hence the number of false positives is not a serious disadvantage. The increase in sensitivity will ensure the identification of most children with the greatest need for care.

In order to select one of these four models or criteria for routine use in the PHS Indian Hospitals, the four criteria were tested for reproducibility upon a later cohort of children: those born at the PHS Indian Hospital, Gallup, New Mexico, during the fiscal years 1968-69. Here, reproducibility is defined as the ability of the criterion or model to maintain the same sensitivity and specificity when applied to different sets of data. The results of the 14-variable criterion were closer to the results of the previous years data than the other three criteria. The 14-variable criterion correctly identified 64 percent of the hospitalized children and about 54 percent of the non-hospitalized children. However, the other three criteria reproduced almost as well.

The 14-variable criteria should be used if information on all 14 variables is available without additional cost. If not, fewer variables may be employed. The 3-variable criterion would be the most economical. It is important to note here that the 3-variable criterion when applied to the new set of data gave <u>better</u> results than previously. Thus, although it was not wholly reproducible, sensitivity and specificity were both improved. Further tests may be desirable to determine which results are more representative.

In addition the results of the present study could have been improved by considering nullipara-mothers (mothers without previous pregnancy), separately in the analysis. Also, it is suggested that parity should be grouped in smaller intervals.

Eleven of the fourteen maternal and infant factors considered in the present study did not contribute much to the discrimination. Most of the contribution for the discrimination was due to birth weight, gestational age and parity. However, these three factors could identify only about 90 percent of the non-hospitalized and about 40 percent of the hospitalized children. Even after the criteria were modified, sensitivity improved only up to 65 percent. This suggests that important variables may have been left out of the model. Environmental factors and nutrition may contribute heavily to the high post-neonatal mortality of the Navajo. Most Navajo live on the reservation in substandard houses, and their education and income level are much lower than those of the general U.S. population.

Other important factors are related to the accessibility of needed care. The criteria might have been more accurate if they had included distance to the hospital and availability of transportation. Although the pick-up truck has almost replaced the horse-drawn wagon on the reservation, it remains difficult to reach hospitals and health centers on poor roads. Many families may not seek care because they have no means of transportation.

Thus, in future attempts to develop a model suitable for reservation Indians, environmental factors and relative accessibility of care should be considered.

The three variables, birth weight, gestational age, and parity contributed more towards the discrimination between the two groups than all the other 11 variables. Hence, these three should be included in future studies attempting to develop a more accurate screening device or model to identify high risk children in any population.

In conclusion, the present study proposes a model or a criterion to identify high risk children at birth in order to provide follow-up care. By this method of classification, each child born in a hospital may be ranked according to the probability of being at high or low risk.

The procedure is simple and economical, and may serve to improve the health of reservation Indians until a more accurate model can be developed.

CHAPTER VII

SUMMARY

The purpose of this study was to develop a method for identifying high risk Navajo children at birth. Morbidity and mortality may be reduced by providing special follow-up care to high risk children.

The adequacy of the Denver scoring system in the identification of high risk children was tested, using Navajo children born at PHS Indian Hospital, Gallup, during fiscal years 1966-67. It was found that the Denver model was not satisfactory for routine use in the identification of high risk Navajo children.

A modified model was developed using 14 factors, and subjected to discriminant analysis. A total of 12 discriminant functions were obtained using these 14 factors and subsets of these 14 factors (different each time). All the analyses gave significant results, indicating that the high risk group children could be separated from the low risk group. A discriminant criterion for classifying a newborn in one of the two risk groups was developed. The criterion correctly identified 39 percent of the high risk children. A modified criterion increased those correctly identified to 65 percent of the high risk group.

The discriminant criterion was tested for reproducibility, using information about Navajo children born in a different period (fiscal years 1968-69). Similar results were obtained.

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APPENDIX

TABLE 38

MEAN SCORES OF VARIABLES CONSIDERED IN THE DISCRIMINANT ANALYSIS BY MORBIDITY GROUP, NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL, GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Variable	Mean Scores	
	Hospitalized	Non-hospitalized
Length of baby	7.2872	1.7819
Birth weight	136.0922	50.0763
Gestational age	30.9043	14.3218
Mother's age	9.9291	6.9857
Apgar score	11.5284	3.1752
Toxemia	4.6277	3.4863
Fetal distress	1.3404	0.4505
Anesthesia	3.9149	5.1776
Labor complications	1.7447	1.6615
Premature rupture of membrane	4.9149	1.6520
Abnormal delivery	15.7872	15.7294
Sex	20.3546	21.1108
Parity	43.7943	24.5530
Number of abortions	3.7234	2.2408

TABLE 39

VARIANCE-COVARIANCE MATRIX OF THE 14 VARIABLES
USED IN DISCRIMINANT ANALYSIS

Variable No.[1]	1 8	2 9	3 10	4 11	5 12	6 13	7 14
1	63.2804	520.0994	120.3178	-0.0785	38.5677	-1.8962	3.5048
	-3.8120	5.0185	19.1691	0.6718	-3.4803	34.6702	4.6903
2	520.0994	8405.5000	1453.0706	7.1929	513.2512	22.6557	63.8251
	-33.7168	61.2363	287.7671	41.1243	-67.9616	148.1596	47.4708
3	120.3178	1453.0706	630.4604	6.6122	138.6676	0.7986	17.0764
	-5.7446	19.6832	60.5242	38.8341	-16.1074	57.8670	-2.5152
4	-0.0785	7.1929	6.6122	196.3667	18.3983	20.7099	0.8545
	2.7421	3.2367	4.1029	2.1560	7.6617	424.9616	14.8001
5	38.5677	513.2512	138.6676	18.3983	332.4910	6.4861	20.3307
	12.0961	15.0481	8.9248	63.0406	4.9588	41.6134	1.8104
6	-1.8962	22.6557	0.7986	20.7099	6.4861	155.5973	2.3261
	1.2034	10.1102	2.6176	19.3334	1.8704	33.5396	-2.9609
7	3.5048	63.8251	17.0764	0.8545	20.3307	2.3261	27.7703
	1.4326	0.3883	2.5109	7.2571	1.3816	-4.3211	-1.6394
8	-3.8120	-33.7168	-5.7446	2.7421	12.0961	1.2034	1.4326
	92.8851	4.1397	-3.1548	166.6222	4.3673	-97.7723	-9.5840
9	5.0185	61.2363	19.6832	3.2367	15.0481	10.1102	0.3883
	4.1397	66.2658	2.7060	14.2438	-6.7060	8.7813	-2.2301
10	19.1691	287.7671	60.5242	4.1029	8.9248	2.6176	2.5109
	-3.1548	2.7060	147.9306	-0.2458	-7.5014	22.3151	17.3848
11	0.6718	41.1243	38.8341	2.1560	63.0406	19.3334	7.2571
	166.6222	14.2438	-0.2458	587.6057	13.7645	-293.2961	-27.9785
12	-3.4803	-67.9616	-16.1074	7.6617	4.9588	1.8704	1.3816
	4.3673	-6.7060	-7.5014	13.7645	420.7158	0.4355	-8.0346
13	34.6702	148.1596	57.8670	424.9619	41.6134	33.5396	-4.3211
	-97.7723	8.7813	22.3151	-293.2961	0.4355	4151.7813	100.4077
14	4.6903	47.4708	-2.5152	14.8001	1.8104	-2.9609	-1.6394
	-9.5840	-2.2301	17.3848	-27.9785	-8.0346	100.4077	228.0408

[1]See Table 23 for variable name.

TABLE 40

DISCRIMINANT-FUNCTION WEIGHTS, BASED ON 14 (ANALYSIS 1),
9 (ANALYSIS 2) AND 7 (ANALYSIS 3) VARIABLES

Variable	Difference Between Group Score Means	Discriminant-Function Weights λ_{14}	λ_{9}	λ_{7}
LENGTH AT BIRTH	5.5054	-0.00159272	-0.00176856	-0.00289767
BIRTH WEIGHT	86.0159	0.00908734	0.00909267	0.00913510
GESTATIONAL AGE	16.5824	0.00295960	0.00314266	0.00317559
AGE OF MOTHER	2.9434	0.00586144	0.00538402	0.0
APGAR SCORE	8.3532	0.00920578	0.00910093	0.00945343
TOXEMIA	1.1414	0.00434749	0.00413793	0.0
FETAL DISTRESS	0.8899	0.00258084	0.0	0.0
ANESTHESIA	-1.2627	-0.01537047	0.0	0.0
LABOR COMPLICATIONS	0.0832	-0.01148335	0.0	0.0
PREMATURE RUPTURE OF MEMBRANE	3.2629	0.00158713	0.00169929	0.00185801
ABNORMAL DELIVERY	0.0578	0.00458651	0.0	0.0
SEX	-0.7562	-0.00057484	0.0	0.0
PARITY	19.2413	0.00347666	0.00353255	0.00411923
NUMBER OF PREVIOUS ABORTIONS	1.4826	0.00242905	0.00262678	0.00266402
Mahalanobis D^2		1.018200	0.998493	0.990708

TABLE 41

DISCRIMINANT-FUNCTION WEIGHTS, BASED ON 10 (ANALYSIS 4), 9 (ANALYSIS 5) AND 8 (ANALYSIS 6) VARIABLES

Variable	Difference Between Group Score Means	Discriminant-Function Weights λ_{10}	λ_9	λ_8
LENGTH AT BIRTH	5.5054	-0.00166620	-0.00206938	-0.00188542
BIRTH WEIGHT	86.0159	0.00907986	0.00911298	0.00912305
GESTATIONAL AGE	16.5824	0.00310849	0.00308747	0.00298761
AGE OF MOTHER	2.9434	0.00537885	0.00583030	0.00590863
APGAR SCORE	8.3532	0.00894187	0.00898450	0.00899472
TOXEMIA	1.1414	0.00410366	0.0	0.0
FETAL DISTRESS	0.8899	0.00297461	0.00324932	0.00308461
ANESTHESIA	-1.2627	0.0	0.0	0.0
LABOR COMPLICATIONS	0.0832	0.0	0.0	0.0
PREMATURE RUPTURE OF MEMBRANE	3.2629	0.00168143	0.00174151	0.00203299
ABNORMAL DELIVERY	0.0578	0.0	0.0	0.0
SEX	-0.7562	0.0	0.0	0.0
PARITY	19.2413	0.00353769	0.00352859	0.00358034
NUMBER OF PREVIOUS ABORTIONS	1.4826	0.00264859	0.00256824	0.0
Mahalanobis D^2		0.998725	0.996152	0.994683

TABLE 42

DISCRIMINANT-FUNCTION WEIGHTS, BASED ON 5 (ANALYSIS 7), 4 (ANALYSIS 8) AND 5 (ANALYSIS 9) VARIABLES

Variable	Difference Between Group Score Means	Discriminant-Function Weights λ_5	λ_4	λ_5
LENGTH AT BIRTH	5.5054	0.0	0.0	0.0
BIRTH WEIGHT	86.0159	0.00910448	0.00913135	0.00905286
GESTATIONAL AGE	16.5824	0.00293390	0.00314219	0.00301173
AGE OF MOTHER	2.9434	0.00599626	0.01370967	0.0
APGAR SCORE	8.3532	0.00906746	0.00895835	0.00936325
TOXEMIA	1.1414	0.0	0.0	0.0
FETAL DISTRESS	0.8899	0.0	0.0	0.0
ANESTHESIA	-1.2627	0.0	0.0	0.0
LABOR COMPLICATIONS	0.0832	0.0	0.0	0.0
PREMATURE RUPTURE OF MEMBRANE	3.2629	0.0	0.0	0.0
ABNORMAL DELIVERY	0.0578	0.0	0.0	0.0
SEX	-0.7562	0.0	0.0	0.0
PARITY	19.2413	0.00356403	0.0	0.00410867
NUMBER OF PREVIOUS ABORTIONS	1.4826	0.0	0.0	0.00276676
Mahalanobis D^2		.993749	.952730	.990003

TABLE 43

DISCRIMINANT-FUNCTION WEIGHTS, BASED ON 4 (ANALYSIS 10), 5 (ANALYSIS 11) AND 3 (ANALYSIS 12) VARIABLES

Variable	Difference Between Group Score Means	Discriminant-Function Weights λ_4	λ_5	λ_3
LENGTH AT BIRTH	5.5054	0.0	0.00117730	0.0
BIRTH WEIGHT	86.0159	0.00908194	0.00907527	0.00944022
GESTATIONAL AGE	16.5824	0.00292826	0.00304925	0.00415530
AGE OF MOTHER	2.9434	0.0	0.01371641	0.0
APGAR SCORE	8.3532	0.00935984	0.00894675	0.0
TOXEMIA	1.1414	0.0	0.0	0.0
FETAL DISTRESS	0.8899	0.0	0.0	0.0
ANESTHESIA	-1.2627	0.0	0.0	0.0
LABOR COMPLICATIONS	0.0832	0.0	0.0	0.0
PREMATURE RUPTURE OF MEMBRANE	3.2629	0.0	0.0	0.0
ABNORMAL DELIVERY	0.0578	0.0	0.0	0.0
SEX	-0.7562	0.0	0.0	0.0
PARITY	19.2413	0.00417574	0.0	0.00423966
NUMBER OF PREVIOUS ABORTIONS	1.4826	0.0	0.0	0.0
Mahalanobis D^2		.988280	.952770	.962490

TABLE 44

DISTRIBUTION OF $\sum_{i=1}^{14} \lambda_i X_i$ VALUES BY MORBIDITY GROUP,
NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL,
GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Class interval	Number of Children		Percent Distribution	
	Hospitalized	Non-Hospitalized	Hospitalized	Non-Hospitalized
0.44 or below	80	332	28.37	39.57
0.44 - 0.49	11	83	3.90	9.89
0.49 - 0.54	8	55	2.83	6.56
0.54 - 0.59	5	35	1.77	4.17
0.59 - 0.64	14	55	4.97	6.56
0.64 - 0.69	12	47	4.26	5.60
0.69 - 0.74	6	24	2.13	2.86
0.74 - 0.79	12	30	4.26	3.58
0.79 - 0.84	6	33	2.13	3.93
0.84 - 0.89	4	12	1.42	1.43
0.89 - 0.94	0	8	0.00	0.95
0.94 - 0.99	4	15	1.42	1.79
0.99 - 1.04	4	10	1.42	1.19
1.04 - 1.09	0	7	0.00	0.83
1.09 - 1.14	5	12	1.77	1.43
1.14 - 1.19	1	2	0.35	0.24
1.19 - 1.24	1	3	0.35	0.36
Above 1.24	109	76	38.65	9.06
Total	282	839	100.00	100.00

Number of variables used in discriminant function = 14

TABLE 45

DISTRIBUTION OF $\sum_{i=1}^{7} \lambda_i X_i$ VALUES BY MORBIDITY GROUP,
NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL,
GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Class Interval	Number of Children		Percent Distribution	
	Hospitalized	Non-Hospitalized	Hospitalized	Non-Hospitalized
0.43 and below	91	359	32.27	42.79
0.43 - 0.48	8	103	2.84	12.28
0.48 - 0.53	15	80	5.32	9.53
0.53 - 0.58	2	14	0.71	1.67
0.58 - 0.63	1	12	0.36	1.43
0.63 - 0.68	15	55	5.32	6.56
0.68 - 0.73	9	42	3.19	5.00
0.73 - 0.78	3	10	1.06	1.19
0.78 - 0.83	9	10	3.19	1.19
0.83 - 0.88	9	41	3.19	4.89
0.88 - 0.93	3	20	1.06	2.38
0.93 - 0.98	5	5	1.77	0.60
0.98 - 1.03	0	3	0.00	0.36
1.03 - 1.08	0	2	0.00	0.24
1.08 - 1.13	0	0	0.00	0.00
1.13 - 1.18	2	1	0.71	0.12
1.18 - 1.23	1	0	0.36	0.00
Above 1.23	109	82	38.65	9.77
Total	282	839	100.00	100.00

Number of variables used in discriminant function = 7

TABLE 46

DISTRIBUTION OF $\sum_{i=1}^{5} \lambda_i X_i$ VALUES BY MORBIDITY GROUP,
NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL,
GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Class Interval	Number of Children		Percent Distribution	
	Hospitalized	Non-Hospitalized	Hospitalized	Non-Hospitalized
0.45 or below	72	316	25.52	37.65
0.45 - 0.50	14	128	4.97	15.26
0.50 - 0.55	23	74	8.16	8.82
0.55 - 0.60	12	63	4.26	7.51
0.60 - 0.65	2	7	0.71	0.83
0.65 - 0.70	11	33	3.90	3.93
0.70 - 0.75	4	28	1.42	3.34
0.75 - 0.80	13	39	4.61	4.65
0.80 - 0.85	4	32	1.42	3.81
0.85 - 0.90	6	11	2.13	1.31
0.90 - 0.95	2	3	0.71	0.36
0.95 - 1.00	0	0	0.00	0.00
1.00 - 1.05	6	17	2.13	2.03
1.05 - 1.10	2	4	0.71	0.48
1.10 - 1.15	3	4	1.06	0.48
1.15 - 1.20	0	3	0.00	0.36
1.20 - 1.25	0	1	0.00	0.12
Above 1.25	108	76	38.29	9.06
Total	282	839	100.00	100.00

Number of variables used in discriminant function = 5

TABLE 47

DISTRIBUTION OF $\sum_{i=1}^{3} \lambda_i X_i$ VALUES BY MORBIDITY GROUP,
NAVAJO CHILDREN BORN AT PHS INDIAN HOSPITAL,
GALLUP, NEW MEXICO, FISCAL YEARS 1966-67

Class Interval	Number of Children		Percent Distribution	
	Hospitalized	Non-Hospitalized	Hospitalized	Non-Hospitalized
0.47 or below	106	430	37.59	51.25
0.47 - 0.52	0	0	0.00	0.00
0.52 - 0.57	22	178	7.80	21.21
0.57 - 0.62	2	3	0.71	0.36
0.62 - 0.67	15	55	5.32	6.55
0.67 - 0.72	0	0	0.00	0.00
0.72 - 0.77	6	28	2.13	3.34
0.77 - 0.82	2	6	0.71	0.72
0.82 - 0.87	0	2	0.00	0.24
0.87 - 0.92	18	43	6.38	5.12
0.92 - 0.97	4	16	1.42	1.91
0.97 - 1.02	2	0	0.71	0.00
1.02 - 1.07	0	3	0.00	0.36
1.07 - 1.12	0	0	0.00	0.00
1.12 - 1.17	0	0	0.00	0.00
1.17 - 1.22	1	1	0.35	0.12
1.22 - 1.27	0	0	0.00	0.00
Above 1.27	104	74	36.88	8.82
Total	282	839	100.00	100.00

Number of variables used in discriminant function = 3