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A Comparison of the Childhood Health Status of Normal Birth Weight and Low Birth Weight Infants

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Synopsis

We analyzed previously unavailable data to describe the national health status in 1981 of noninstitutionalized children who were low birth weight infants. They were compared with normal birth weight children. All data contained in the analysis were based on weighted national estimates. Low birth weight children in general were found to have more chronic conditions, more hospitalizations, more days in bed because of illness, more limitations of activity, poorer health status as perceived by parents, and more school days lost because of illness. However, numbers of physician visits were not different even for low birth weight children younger than 2 years, which is inconsistent with the higher proportions of multiple hospitalizations, chronic conditions, and other illness measures.

The proportions of children in the younger age groups at risk for health problems associated with low birth weight should be increasing. The proportion of very low birth weight children in the younger age groups with higher excessive morbidity measures tends to support the possibility. The increased survival of high-risk infants raises concern about their future requirements for special medical and educational services, and about the resulting stress on their families.

Normal birth weight children were found to make a major contribution to the prevalence of morbidity. It is not the children identified as at risk as a result of low birth weight that comprise most of those with illnesses. The physical, social, and psychological environment after birth probably has the largest impact on the health status of our

children. The attributable risk of excessive morbidity associated with low birth weight and very low birth weight reinforces the concept that while the overall impact is not large, the consistent pattern of poorer health for children born with low birth weight, compared to those of normal birth weight, shown in this analysis, is striking. The pattern reinforces concerns with the many factors associated with low birth weight and their effects on the present and future health of the population.

THE OBJECTIVE of this study was to analyze previously unavailable data to describe the national health status in 1981 of noninstitutionalized children who were low birth weight (LBW) infants, comparing their status to that of children who were normal birth weight (NBW).

LBW is part of the complex interactions of such factors as prenatal growth retardation, prematurity, complications of labor and delivery, congenital malformations, and adverse prenatal and postnatal social and psychological influences. These factors cannot be separated easily to show separate impacts.

The relationship between LBW and neonatal and infant mortality in the United States has been described (*1, 2*). Such studies depend upon the availability of records of vital statistics. However, birth weight-specific analysis of infant deaths is limited by the lack of linked records of births and infant deaths.

To help meet this need, the National Infant Mortality Surveillance Project (NIMS) was undertaken in 1983 to determine neonatal, postnatal, and infant mortality risks in the 1980 U.S. birth cohort for all races in 12 categories of birth weights. Using linked birth and infant death certificates, NIMS showed an exponential improvement in infant survival with increasing birth weights (*3*).

The long-term association of birth weight with childhood health for all children in the United States is not well established, partly because of the lack of population-based morbidity data that are linked to birth weights of sufficient numbers of either low or normal birth weight infants (*4*). Followup, or longitudinal, studies past the period of early infancy are difficult to perform, are expensive, and very few of those which have been done have not been based on probability samples of the United States population.

In 1981, the National Center for Health Statistics (NCHS) surveyed the current health status of the nation's children as part of its National Health Interview Survey (NHIS). The Child Health Supplement (CHS) included retrospective questions about the prenatal, birth, developmental, and school years of the children. CHS was based on a national probability sample of children from birth through 17 years of age, providing one of the most complete descriptions of the health of the nation's children.

Population-based studies which have followed at-risk infants beyond very early childhood have tried to delineate the effects of LBW, and particularly the impact of the increasing survival rates of the very low birth weight infant. The Aberdeen study followed children through age 10 to determine whether a specific disability was mediated through LBW alone, through the child's environment alone, or through a combination of both (*5*). The investigators determined that "improvements in physical and intellectual outcomes for LBW children are substantially dependent upon improvements in the quality of the social environments into which children are born and in which they grow and develop."

Three measures of physical and mental development were assessed in the British National Child Development Study. Goldstein and Peckham used a number of factors in a regression analysis to show differing associations among factors and outcomes. Overall, they found a weak association for length of gestation, and a somewhat stronger association for birth weight. Social class, family size, and maternal age and height were somewhat predictive for mental or physical development (*6*).

Werner and Smith showed that the balance between risk factors, stressful life events, and protective factors in the child and in the environment determined adaptive capabilities in human development. Such capabilities were seen as overriding the impact of perinatal events alone when children were assessed at 20 years of age (*7*).

The Collaborative Perinatal Project, carried out from 1959 to 1974, is the most frequently cited followup study of the prenatal, birth, and early childhood periods. Participants were selected from clinic populations large enough to represent a range of pregnancy conditions and to allow followup.

Table 1. Population estimates for 1981 for children with known birth weights included in the Child Health Supplement of the National Health Interview Survey

Characteristic	All LBW children (thousands)	All NBW children (thousands)
All children younger than 18 years..	4,593	52,932
Age in years:		
Younger than 2	466	6,455
2–5	902	11,314
6–11	1,574	16,988
12–17	1,651	18,174
Sex:		
Female	2,505	25,683
Male	2,088	27,249
Maternal education:		
Less than 12 years	1,565	12,874
12 years	1,980	24,157
More than 12 years	937	15,150
Not known	111	750
Race:		
White	3,267	44,614
Black	1,180	6,982

NOTE: LBW is low birth weight; NBW is normal birth weight.

However, sample selection based on representative United States or community populations was not possible (*8*).

The high costs and the organizational difficulties of large, detailed cooperative studies has led to the consideration of alternative methods of obtaining data. In 1981, the Select Panel for the Promotion of Child Health recommended that "followback" surveys be expanded to follow infants through childhood and adolescence. The panel suggested following cohorts identified in population-based surveys, such as NHIS, and the National Health and Nutrition Examination Survey (NHANES) (*9*). Both surveys are to incorporate followback capability for children in the 1988 CHS and NHANES, cycle III.

In the meantime, the 1981 CHS fills part of the information gap. CHS is the most comprehensive data base of a representative sample of U.S. children, reflecting longitudinal aspects of their lives as related to their health status. NHIS is a continuous survey whose sample represents all households in the country. In the 1981 CHS, one child was selected in each NHIS household containing a child. Questionnaires were completed for about 15,400 of the sample, a response rate better than 95 percent. A working paper on the sample selection, survey design, and implementation of CHS is available from NCHS (*10*).

Methods Used

For this analysis, health status measures were selected for (*a*) continuity with the most frequently used NHIS health indicators (*11, 12*); (*b*) expected long-term impact on society and on individual children, owing to the chronicity and impact on health or health services (*13–15*); and (*c*) a prevalence measure of the health status estimate large enough to be reliable, based on the sample variance, and to permit testing for significant differences by birth weight. The health status indicators were categorized by levels of severity, with the level indicating poorest health being referred to as excessive morbidity. The variables chosen were

- lifetime number of chronic conditions
- lifetime number of hospitalizations
- limitations of activity
- parental perception of poor or fair health status
- bed days
- physician visits
- school days lost

In the analysis, the association between LBW and current health status is shown without implying causality. Data from the cross-sectional survey of multiple cohorts implied differential opportunity for exposures during the postnatal period, and did not permit distinction between association and cause. As mentioned, LBW is a marker for the complex interactions of biological, social, and psychological factors surrounding the continuum of children's development and was treated as such.

The analysis was limited to those children for whom birth weight was known, about 91 percent of all children in the sample. A review of the data by type of respondent and race was made to determine that missing birth weights did not seriously bias the analysis. The biological father or mother was the respondent for 98 percent of the known birth weights. The weighted national estimates based on the entire CHS sample describe 63,142,000 children. Estimates based on the known birth weights describe 57,525,000 of them. All data contained in this analysis were based on weighted national estimates, as shown in table 1. No population estimates are shown in the table for other races, because the numbers were too small to use. Populations are shown separately in subsequent tables for limitations of activity and school days lost. NHIS data on children with limitations of activity were obtained only for those younger than 17 years. School days lost were compiled only for

those 6 through 17 years of age who were known to be attending school at the first grade level or higher.

About 8 percent of the children with known birth weights in the CHS sample weighed less than 2,500 grams (g). Of the CHS children younger than 6 years, 7.1 percent were born with LBW, compared to 8.5 percent of those 6–11 years, and 8.3 percent of those 12–17 years. The values are within the range of birth weights of children born with LBW in the United States in the years 1964 through 1980, the approximate birth years of the children in our sample. During this period the LBW rate for all births decreased from 8.2 to 6.8 percent, the rate for whites decreased from 7.1 to 5.7 percent, and the rate for all other races decreased from 13.9 to 11.5 percent (*16*). Blacks were not reported separately in the early period, but had a rate of 12.5 percent in 1980. In CHS, the overall LBW rate for whites was 6.8 percent and 14.5 for blacks.

About 0.7 percent of the children in the sample as well as those in the weighted estimates were born weighing less than 1,500 g. They were found to be fairly evenly distributed among the 17 years in the cross-sectional survey. Since very low birth weight (VLBW) infants comprised 1.5 percent of all live births in 1964, 1.1 in 1971, and 1.2 in 1981, a survival rate of 0.7 percent for noninstitutionalized children in the survey appeared reasonable. However, the number of VLBW children was too small to yield reliable estimates of the various health status measures, particularly by age, race, or sex, based on the sampling variance. The estimates became reliable when all birth weights less than 2,500 g. were combined. Therefore, the body of the analysis was limited to the total group with weights less than 2,500 g.

Birth weights were obtained by asking what the child weighed in pounds and ounces. Those who did not know the precise weight were asked to estimate the weight according to whether the infant weighed less than 5.5 pounds, 5.5 to 9 pounds, or more than 9 pounds. Of the 14,029 children with known birth weights in the sample, the precise weight was given for 13,795 and an estimate for 234. Tilley and coworkers found that the reliability of the mother's recall of birthweight was from good to excellent (95 percent agreement) as long as 32 years after the birth, when compared with physicians' records (*17*). Little showed better than 99 percent agreement with hospital records within 1 year of birth (*18*). Possible bias resulting from the few CHS respondents who estimated the birth weight when unable to remember the specific weight is ameliorated by grouping those weighing less than 1,500 g with those weighing 1,500 to 2,499 g. For this analysis, children weighing 4,000 g or more at birth are included with NBW children. Preliminary review of the health status of those children showed them to be similar to NBW children.

Table 2. Characteristics of LBW and NBW children, by lifetime number of chronic conditions, with standard error (SE)

Characteristic	LBW		NBW	
	Percent	SE	Percent	SE
All children younger than 18 years[1]				
No conditions[2]	53.2	2.0	58.0	0.5
1 condition	26.5	1.6	24.8	0.4
2 conditions	10.3	1.0	10.4	0.3
3 or more conditions[3]	10.0	1.1	6.8	0.3
Children with 3 conditions or more				
Younger than 6 years	7.7	1.9	4.2	0.4
6–11 years[2]	11.5	2.0	7.6	0.5
12–17 years	10.5	1.6	8.6	0.5
Sex:				
Female[2]	9.9	1.3	6.5	0.4
Male[2]	10.2	1.5	7.1	0.4
Maternal education:				
Fewer than 12 years[3]	11.3	2.1	5.7	0.5
12 years	8.6	1.4	6.4	0.4
More than 12 years	10.6	2.1	8.3	0.5
Race:				
White[3]	10.0	1.1	7.1	0.3
Black[2]	11.2	2.6	5.3	0.7

[1] Includes those for whom level of maternal education is not known and other races.
[2] $P \leq 0.05$; [3] $P \leq 0.01$.
NOTE: LBW is low birth weight; NBW is normal birth weight.

The independent variables are age, sex, race, and maternal education. Maternal education was selected as the best socioeconomic descriptor available since it reflects the milieu in which a child was born better than income does for children born between 1964 and 1981. Income reported in 1981 would not reflect changes over time related to parents' age, place of residence, race, inflation, and other factors, thereby eliminating income as a common denominator during this time period and age span. The proportion of children in each maternal education group is biased by changes in childbearing patterns during the time period, according to maternal age and race. Differences should not be attributed to maternal education only (*19*).

The analysis by health status variables was limited to the age groups appropriate for the variable.

Table 3. Types of chronic conditions experienced, by race, per thousand LBW and NBW children, with standard error (SE)

Condition	LBW rate	SE	NBW rate	SE
Respiratory [1]	[2] 204	16	163	5
White	[2] 205	20	163	5
Black	217	38	172	14
Skin and subcutaneous tissue [1]	105	10	118	4
White	111	12	121	4
Black	100	21	100	9
Central nervous system and sense organs [1]	[3] 82	9	44	2
White	[3] 87	10	44	2
Black	68	21	40	8
Musculoskeletal [1]	52	9	52	2
White	58	11	56	3
Black	37	17	31	7
Circulatory [1]	29	6	21	2
White	31	7	22	2
Black	24	12	14	4
Digestive [1]	[2] 44	7	26	2
White	37	8	27	2
Black	65	21	25	5
Blood and blood-forming organs [1]	[2] 23	5	10	1
White	13	5	8	1
Black	53	16	29	5
Genitourinary [1]	14	4	13	1
White	17	5	13	1
Black	6	6	9	3
Tonsillitis and repeated ear infections [1]	155	16	146	4
White	165	19	157	5
Black	135	29	87	9
Other [1]	138	15	111	4
White	[2] 150	17	115	4
Black	115	28	95	9

[1] Includes other races; [2] $P \leq 0.05$; [3] $P \leq 0.01$.
NOTE: LBW is low birth weight; NBW is normal birth weight.

Parental perception of health status, limitations of activity, bed days in the preceding 12 months, and physician visits in the preceding 12 months were reported in the NHIS core questionnaire. The number of days lost from school due to health problems, the number of chronic conditions, and the lifetime number of hospitalizations were taken from CHS. The following questions were used in obtaining the child's health status measures.

1. Number of chronic conditions, based on a list of specific conditions, providing 99 possibilities, with chronicity defined by timing of onset, duration, and the specific condition.

2. Number of hospitalizations. Since the child was born, how many different times has the child stayed in the hospital overnight, not including the hospitalization when the child was born?

3. Limitations of activity. Different questions were used for preschool and school aged children to determine the extent to which the child's usual activities were limited at the time of the interview because of a chronic condition or disability.

4. Perceived health status. Compared to other persons of the child's age, is his or her health excellent, good, fair, or poor?

5. Bed days. During the past 12 months, about how many days did illness or injury keep the child in bed all or most of the day?

6. Physician visits (not including hospital inpatient visits). During the past 12 months, about how many times did the child see or talk to a medical doctor?

7. School days lost. During the past 12 months, about how many days was the child absent from school because of illness?

The Standard Errors Program for Computing of Standardized Rates from Sample Survey Data was used to determine the reliability of the proportional estimates (*20*). The program was developed to compute certain rates, means, or totals, and their standard errors, from the data collected in a complex, multistage sample survey.

Results of the Analysis

Chronic conditions. The sustained impact of illness, demonstrated by the number of chronic conditions a child had ever had, is shown in table 2. Five percent more LBW than NBW children had at least 1 chronic condition. The difference was not significant for children having either 1 or 2 chronic conditions. The difference was significant at the $P \leq 0.01$ level for those children with 3 or more conditions.

A higher proportion of the LBW children aged 6 to 11 years had 3 or more chronic conditions than did LBW children 12 to 17 or younger than 6 years. Given the cumulative pattern of chronic conditions over time, the higher rate of 3 or more chronic conditions in the 6- to 11-year-old group in 1981 indicates that their rate in the older age group in 1988 probably would exceed the 10.5 percent of LBW children 12 to 17 years old in 1981.

The consistently higher rates for LBW children having 3 or more chronic conditions, compared to NBW children, were statistically significant in all

cases, female and male, white and black. LBW rates were between 40 to 90 percent higher than NBW rates, and LBW rates for females and males were nearly the same. While NBW whites had a higher percentage of 3 or more chronic conditions than blacks, the proportions for LBW blacks and whites were similar.

The pattern of more chronic conditions in the LBW than the NBW children persists at all levels of maternal education. While the proportion of NBW children with 3 or more conditions appears to increase as the mother's educational level increases, the higher LBW rates do not follow that pattern. The greatest and most significant difference by birth weight is for women with less than high school level education.

The rates of selected types of chronic conditions per 1,000 LBW and NBW children are shown in table 3. The 99 possible conditions were grouped according to the body system affected. Since the data base of conditions did not contain detailed cause and effect information about the named diseases needed to classify conditions according to the International Classification of Diseases criteria, certain assumptions and judgments were made in assigning nonspecific diseases to the body system groups. For example, we assumed that the named diseases represented those found most commonly in children and were assigned to the body system category in which these usually are found. Most generalized symptoms and signs, and some types of chronic conditions with low frequencies, were assigned to the "other" category. The list of conditions and assignments to condition categories is available to requestors.

A child could have more than one condition in a single category or across the categories. Chronic respiratory conditions were the most frequent overall. LBW children had significantly more chronic respiratory conditions than did NBW children. While not as frequent, conditions of the central nervous system and sense organs occurred significantly more often for LBW than for NBW children ($P \leq 0.0001$). The same was true of digestive conditions and diseases of the blood and blood-forming organs.

Hospitalizations. The strongest contrast between the two weight groups appears with the number of hospitalizations a child has had. Forty-one percent of the LBW children had at least one hospital stay (not counting the time spent in the hospital at birth), compared with 33 percent of the NBW children (table 4). The difference was highly significant for children with two or more hospitalizations.

Table 4. Characteristics of LBW and NBW children, by number of hospitalizations experienced, with standard error (SE)

Characteristic	LBW		NBW	
	Percent	SE	Percent	SE
All children younger than 18 years [1]				
No stays [2]	58.2	1.8	66.2	0.5
1 stay	23.4	1.5	22.1	0.4
2 or more stays [2]	17.4	1.4	11.2	0.3
Children with 2 stays or more				
Age:				
Younger than 6 years [3]	10.5	1.8	4.8	0.3
6–11 years [3]	19.1	2.3	12.2	0.5
12–17 years [4]	21.4	2.2	16.4	0.6
Sex:				
Female [3]	14.1	1.7	9.3	0.5
Male [2]	21.4	2.1	13.0	0.4
Maternal education:				
Less than 12 years [4]	17.0	2.6	11.2	0.6
12 years [2]	18.2	1.9	11.7	0.4
More than 12 years [3]	17.3	2.9	10.1	0.6
Race:				
White [2]	19.2	1.6	11.8	0.3
Black	12.6	2.4	8.2	0.8

[1] Includes those for whom the number of hospitalizations or the level of maternal education is not known and includes those of other races.
[2] $P \leq 0.001$; [3] $P \leq 0.01$; [4] $P \leq 0.05$.
NOTE: LBW is low birth weight; NBW is normal birth weight.

The cumulative pattern of hospitalizations is demonstrated in the age distribution. Age-specific comparisons showed the largest increase in the rate of multiple hospitalizations for the youngest group. NBW children younger than 6 years had about half of the proportion of multiple hospitalizations of LBW children.

Males showed a higher pattern of multiple hospitalizations than females in both weight groups. LBW male children had at least 50 percent more multiple hospital stays than LBW females, while NBW males had 40 percent more than NBW females. For both sexes, the proportion of multiple stays for LBW children was at least 50 percent greater than that of NBW children. Multiple hospitalizations of LBW children of mothers with fewer than 12 years of education were 52 percent greater than for NBW children, 56 percent greater for LBW children of mothers with 12 years, and 71 percent greater for LBW children of mothers with more than 12 years education. Multiple hospitalizations occurred at least 50 percent more for both races.

Table 5. Characteristics of LBW and NBW children, by number of days in bed per year owing to health problems, with standard error (SE)

Characteristic	LBW		NBW	
	Percent	SE	Percent	SE
All children younger than 18 years [1]				
No days	49.7	1.8	48.0	0.6
1–7 days [2]	37.6	1.7	43.7	0.6
8 days or more [2]	11.1	1.0	7.7	0.3
Children with 8 or more days				
Age:				
Younger than 6 years [2]	15.5	2.1	7.9	0.5
6–17 years	9.3	1.2	7.6	0.3
Sex:				
Female [3]	12.0	1.4	8.4	0.4
Male [4]	10.1	1.4	7.0	0.4
Maternal education:				
Less than 12 years	9.5	1.8	7.0	0.7
12 years [2]	13.3	1.6	7.8	0.4
More than 12 years	10.1	1.9	8.3	0.5
Race:				
White [3]	11.6	1.3	8.1	0.3
Black [3]	10.7	1.7	5.8	0.8

[1] Includes those for whom number of days in bed and level of maternal education are not known, as well as other races.
[2] $P \leq 0.001$; [3] $P \leq 0.01$; [4] $P \leq 0.05$.
NOTE: LBW is low birth weight; NBW is normal birth weight.

'The strongest contrast between the two weight groups appears with the number of hospitalizations a child has had. Forty-one percent of the LBW children had at least one hospital stay (not counting the time spent in the hospital at birth), compared with 33 percent of the NBW children. The difference was highly significant for children with two or more hospitalizations.'

Days in bed. Table 5 demonstrates the pattern of excess days in bed for LBW children of all ages, both sexes and races, and all levels of maternal education. The difference was almost twice as high for LBW children younger than 6 years, and decreased in the school age group. Excess bed days for LBW children differed significantly from those for NBW children of both sexes. Female and male LBW children had similar rates of excess bed days and both had rates about 45 percent greater than rates for NBW children. Excess bed days for LBW white children were about 40 percent greater than those for NBW white children, but almost 85 percent greater for LBW blacks than NBW blacks. Excess bed days were about the same (11 percent) for both white and black LBW children. The age, sex, and race categories showed an indirectly proportional shift between 1–7 days in bed, and 8 or more days. Children whose mothers had 12 or more years of education did not show such compensating differences between the number of days in bed. In these cases, the differences in the proportions with no days in bed were statistically significant for 12 years of maternal education (LBW = 42.1 percent, NBW = 47.5 percent, $P \leq 0.05$) and more than 12 years (LBW = 51.5 percent, NBW = 39.0 percent, $P \leq 0.001$).

Limitations of activity. The proportions of children with limitations of activity in the United States is very small compared with older groups. Even with small numbers, the pattern of significantly higher rates for LBW children is demonstrated in table 6 for all variables. Limitations of activity were reported for 5.2 percent of LBW children, compared to 3.6 percent of NBW children. As shown previously with 3 or more chronic conditions, the difference was greatest for children aged 6 through 11 years, and smallest for those 12 through 16 years. Since limitations of activity tends to show a cumulative effect with age, note that the proportion of LBW children 6–11 years of age with limitations slightly exceeded that of LBW children 12–16 years. Race did not appear to be a significant factor in limitations of activity for LBW children. The difference between LBW and NBW children by level of maternal education was significant only for those completing high school.

Perceived health status. Perceived health status has been shown to be a reliable health measure, although the concern generated by a child born "at risk" with LBW could influence parental perceptions (*21*). Table 7 shows that parents reported about twice as many LBW children having poor or fair health, compared with NBW children. Whether looking at age, sex, race, or maternal education, the parental perception of poor or fair health status was always higher for the LBW than for the NBW children. The percent with poor or fair health was lower for older children than for those younger than 6 years for all races and for whites, differing from the pattern of cumulative increases with age

Table 6. Characteristics of LBW and NBW children with limitations of activity, and total U.S. population, with standard error (SE)

Characteristic	LBW		NBW		Total population (in thousands)	
	Percent	SE	Percent	SE	LBW	NBW
All children younger than 17 years [1,2]	5.2	0.8	3.6	0.2	4,308	49,970
Age:						
Younger than 6 years	3.3	1.0	1.9	0.2	1,368	17,770
6–11 years [2]	6.6	1.4	3.7	0.3	1,574	16,988
12–16 years	5.5	1.6	5.4	0.5	1,366	15,213
Sex:						
Female	4.4	0.8	3.1	0.3	2,353	24,311
Male	6.1	1.2	4.0	0.3	1,955	25,659
Maternal education:						
Less than 12 years	4.0	1.2	3.7	0.5	1,456	12,053
12 years [3]	6.4	1.2	3.3	0.3	1,843	22,860
More than 12 years	5.2	1.5	3.9	0.5	902	14,377
Race:						
White [2]	5.4	0.8	3.6	0.2	3,059	42,034
Black	5.1	1.9	3.3	0.5	1,102	6,653

[1] Includes those for whom maternal education is unknown, as well as children of other races.
[2] $P \leq 0.05$; [3] $P \leq 0.01$.
NOTE: LBW is low birth weight; NBW is normal birth weight.

shown by chronic conditions or limitations of activity.

A higher proportion of blacks were perceived to have poor or fair health than whites, although only the NBW difference exceeded 2 standard errors, so the LBW rates were only suggestive. This proportion did not follow the pattern of the two previous health indicators. As the number of years of maternal education increased, the proportion of parents perceiving their children to be in poor or fair health decreased.

School days lost. Time lost from school for health reasons in the United States shows the same pattern for LBW and NBW children as the other health indicators (table 8). Significant differences according to birth weight were not apparent for children who lost no time or lost fewer than 11 days for health reasons. Caution should be used when comparing the age, race, sex, and maternal education categories because data on school days lost for reasons of health were collected only for children attending school. The older age group contained relatively more blacks who were not attending school for other reasons. The proportion of LBW children who lost 11 or more days from school during the year for health reasons was about 50 percent greater than the proportion for NBW children. There was a greater relative difference between the proportion of LBW children in younger age groups who had excessive lost days and NBW children in that category than there was with older age groups (70 percent higher in age group 6 through 11 years, and 40 percent for ages 12 through 17 years). The difference between weight groups was significant at the $P \leq 0.05$ level for both races, but the absolute difference in the rates was 10.1 percent for blacks and 3.3 percent for whites. Among maternal education categories,

Table 7. Characteristics of LBW and NBW children with poor or fair health status, with standard error (SE)

Characteristic	LBW		NBW	
	Percent	SE	Percent	SE
All children younger than 18 years [1,2]	7.7	1.0	3.6	0.2
Age:				
Younger than 6 years [3]	8.6	1.9	3.6	0.3
6–11 years [3]	8.3	2.0	3.1	0.3
12–17 years	6.4	1.5	4.0	0.3
Sex:				
Female [3]	7.4	1.5	3.5	0.2
Male [3]	8.1	1.4	3.7	0.3
Maternal education:				
Less than 12 years [4]	10.0	1.9	5.7	0.6
12 years [2]	8.2	1.5	3.0	0.3
More than 12 years	3.7	1.1	2.6	0.3
Race:				
White [3]	7.2	1.2	3.4	0.2
Black	8.7	2.5	5.3	0.7

[1] Includes those for whom the level of maternal education is not known and includes other races; [2] $P \leq 0.001$; [3] $P \leq 0.01$; [4] $P \leq 0.05$.
NOTE: LBW is low birth weight; NBW is normal birth weight.

Table 8. Characteristics of LBW and NBW children, by days lost from school annually due to health problems, and total U.S. population, with standard error (SE)

Characteristic	LBW		NBW		Total population (in thousands) [1]	
	Percent	SE	Percent	SE	LBW	NBW
All children						
6–17 years [2]	100.0	...	100.0	...	3,109	33,665
No days lost	26.7	2.0	24.0	0.6	...	...
1–5 days [3]	46.1	2.1	51.5	0.6	...	...
6–10 days	14.4	1.6	16.3	0.5	...	...
11 or more days [4]	12.7	1.5	8.3	0.3	...	...
Children with 11 or more days lost						
Age:						
6–11 years [3]	13.6	2.3	7.9	0.5	1,519	16,052
12–17 years	11.9	1.9	8.6	0.4	1,590	17,612
Sex:						
Female	13.4	2.4	9.1	0.5	1,735	16,423
Male [3]	11.9	1.8	7.5	0.4	1,375	17,241
Maternal education:						
Less than 12 years [4]	18.4	3.1	10.5	0.9	1,060	8,387
12 years	11.1	2.1	7.5	0.4	1,326	15,663
More than 12 years	7.3	2.1	7.7	0.6	634	9,051
Race:						
White [3]	11.8	1.4	8.5	0.3	2,278	28,571
Black [3]	17.0	4.3	6.9	1.0	741	4,369

[1] Population estimate for 1981 was based on the children for whom birth weight and school attendance were known. The estimate excludes children attending kindergarten, younger than 6 years, or not attending school.

[2] Includes those for whom level of maternal education is unknown and includes other races. [3] $P \leq 0.05$; [4] $P \leq 0.01$.

NOTE: LBW is low birth weight; NBW is normal birth weight.

the percent of excessive days lost from school was about the same by birthweight for children of mothers with more than high school education, but significantly greater for LBW children born to mothers with less than high school education.

Physician visits. The most striking feature of the number of physician visits made during the 12 months prior to the interview is that there were no significant differences between low and normal birthweight children in any of the age groups. In fact, the proportion of LBW children having no physician visits was suggestively higher than for NBW children in all age groups, even for those younger than 2 years, for whom well-child visits should be standard and those with higher risks monitored even more carefully (table 9).

Further analysis by sex and age, or sex, age, and race, separately showed a few differences in children younger than 6 years, although for some groups the sample size in each cell became too small to be reliable, especially for blacks by age and sex. The same pattern seemed generally true for maternal education with no significant differences in any of the categories, although the proportion with no physician visits decreased as maternal education level increased, as has been shown with NHIS data in the past.

Relative Risk of Excessive Morbidity

While the sample sizes were too small for reliable national estimates of excessive morbidity based on the VLBW children within the descriptive strata, comparisons of the relative and attributable risks within 6-year cohorts demonstrate the contribution of VLBW to the LBW estimates (table 10). The relative risk is the ratio of the proportion of VLBW or LBW children with the excessive morbidity measure to the proportion of NBW children with the measure. The attributable risk is based on the formula for 2 × 2 tables presented by Fleiss for cross-sectional surveys (*22*). Attributable risk can be interpreted as the rate of occurrence of excessive morbidity in the population that would be reduced if the risk of VLBW or LBW could be eliminated.

VLBW children were 0.7 percent of all children, 0.7 percent of those younger than 6 years, 0.5 percent of those 6 through 11 years, and 0.8

percent of those 12 through 17 years, based on the weighted sample. They represent about 8 percent of all children in the sample who weighed less than 2,500 g at birth, 10 percent of LBW children younger than 6 years, 6 percent of those 6 through 11 years, and 10 percent of those 12 through 17 years of age.

The relative risk of excessive morbidity for children 6 through 11 years who weighed less than 1,500 g appears higher than for those weighing 1,500 through 2,499 g for all health indicators except for bed days. Chronic conditions and hospitalizations reflected the higher relative risks for VLBW children younger than 6 years. Excessive morbidity for VLBW children continued in the oldest age group in hospitalizations, limitations of activity, and days lost from school. Only the risks of 2 or more hospitalizations and 11 or more days lost from school appear higher for all appropriate age groups.

The attributable risk for excessive morbidity from the VLBW children shows that most of the contribution to the LBW pool comes from those in the 1,500 through 2,499 g weight group. At the same time, the great majority of children with excessive morbidity are born within the normal weight group.

Discussion

The pattern of differences in the health status indicators between LBW and NBW children generally is consistent when looking at age, sex, or maternal education level, except for physician visits. The differences between LBW and NBW children were least for those in the oldest age groups and greatest in the age group 6–11 years. Differences according to race, sex, and maternal education varied more. The differences in measures of excessive morbidity between LBW and NBW children always were significant among white children, except for physician visits. Black LBW children showed the same pattern, although sample sizes precluded determination of significance for hospitalizations, limitations of activity, and perceived health status. Comparisons of white and black NBW children showed higher proportions of illness measures for whites, except for parental perception of poor or fair health, where black parents perceived their children to have relatively higher levels of poor or fair health. Comparisons of LBW black and white LBW children showed all LBW children to have similar outcomes among the various illness measures, except for multiple hospitalizations and excessive numbers of days lost from school (usually within one standard error). The standard errors around the LBW proportions reflect the problem of comparing a sample of only 8 percent of the population, broken down further by age, sex, maternal education, and race.

The high levels of excessive morbidity were persistent for the LBW children compared with the NBW children, when analyzed by sex or maternal education, except for 8 or more bed days and physician visits. The patterns by sex or maternal education were not consistent among all of the

Table 9. Characteristics of LBW and NBW children, by annual number of physician visits, with standard error (SE)

Characteristic	LBW		NBW	
	Percent	SE	Percent	SE
All children younger than 18 years [1]				
No visits [2]	27.2	1.6	24.3	0.5
1–3 visits	49.1	2.0	51.4	0.5
4 or more visits	23.7	1.4	24.2	0.4
Age				
Younger than 2 years:				
No visits [2]	9.7	3.6	6.9	0.7
4 or more visits	51.3	5.4	56.7	1.4
2–5 years:				
No visits [2]	15.0	2.8	14.2	0.8
4 or more visits	35.1	3.6	31.0	0.9
6–17 years:				
No visits [2]	33.1	2.0	30.8	0.6
4 or more visits	16.5	1.5	16.1	0.4
Sex				
Female:				
No visits [2]	26.1	2.2	24.4	0.7
4 or more visits	22.3	1.9	23.8	0.6
Male:				
No visits [2]	28.4	2.6	24.3	0.6
4 or more visits	25.4	2.3	24.7	0.6
Maternal education				
Less than 12 years:				
No visits [2]	33.6	3.4	32.1	0.9
4 or more visits	23.2	2.4	20.0	0.8
12 years:				
No visits [2]	25.8	2.0	24.8	0.7
4 or more visits	23.6	2.3	23.7	0.6
More than 12 years:				
No visits [2]	18.4	2.6	16.5	0.6
4 or more visits	25.1	2.8	29.1	0.8
Race				
White:				
No visits [2]	25.3	1.7	23.5	0.5
4 or more visits	25.0	1.5	25.1	0.4
Black:				
No visits [2]	30.7	3.9	28.7	1.3
4 or more visits	22.0	3.3	19.0	1.2

[1] Includes those children for whom maternal education is not known and those of other races.
[2] Includes those children with an unknown number of physician visits.
NOTE: LBW is low birth weight; NBW is normal birth weight.

Table 10. Relative and attributable risks of excessive morbidity for LBW and VLBW children, according to health status measures and age, with confidence intervals (CI)

Health status by age	Relative risk [1]						Attributable risk [2]	
	Birth weight < 2,500 g		Birth weight < 1,500 g		Birth weight 1,500–2,499 g		Birth weight < 1,500 g	Birth weight 1,500–2,499 g
	RR	CI	RR	CI	RR	CI		
3 or more chronic conditions								
All children	1.5	1.2–1.8	1.6	0.7–2.5	1.5	1.1–1.8	0.4	3.2
Younger than 6 years	1.8	0.9–2.7	3.1	0.1–6.2	1.7	0.7–2.7	1.3	4.1
6–11 years old	1.5	1.0–2.0	2.6	0.5–4.7	1.4	0.9–2.0	0.8	3.4
12–17 years old	1.2	0.8–1.6	0.4	0.0–1.2	1.3	0.9–1.8	−0.4	2.3
2 or more hospitalizations								
All children	1.6	1.3–1.8	2.7	1.7–3.8	1.4	1.2–1.7	1.2	3.2
Younger than 6 years	2.2	1.4–3.0	5.2	0.7–9.7	1.9	1.2–2.5	2.6	5.0
6–11 years old	1.6	1.2–1.9	2.4	0.7–4.0	1.5	1.1–1.9	0.7	4.1
12–17 years old	1.3	1.0–1.6	2.2	1.2–3.2	1.2	0.9–1.5	1.0	1.7
8 or more bed days								
All children	1.4	1.2–1.7	1.2	0.5–1.9	1.5	1.2–1.8	0.4	3.7
Younger than 6 years	2.0	1.4–2.5	1.6	0.7–2.6	2.0	1.4–2.6	0.4	6.2
6–11 years old	1.2	0.6–1.7	1.5	0.0–3.3	1.1	0.6–1.7	0.3	1.0
12–17 years old	1.3	0.8–1.8	0.7	0.0–1.6	1.4	0.8–1.9	−0.3	2.6
Limitations of activity								
All children through 16 years	1.4	1.0–1.9	2.9	0.3–5.5	1.3	0.9–1.7	1.2	2.1
Younger than 6 years	1.7	0.6–2.8	0.9	0.0–2.6	1.8	0.6–3.0	−0.1	4.7
6–11 years old	1.8	0.9–2.6	4.1	0.1–8.1	1.6	0.8–2.4	1.4	4.3
12–16 years old	1.0	0.4–1.6	3.0	0.0–7.2	0.8	0.4–1.3	1.5	−1.3
Poor or fair health status								
All children	2.2	1.6–2.8	1.8	0.5–3.0	2.2	1.6–2.8	0.4	7.7
Younger than 6 years	2.4	1.3–3.5	1.8	0.0–3.9	2.4	1.3–3.6	0.5	8.2
6–11 years old	2.7	1.3–4.1	4.4	0.0–9.0	2.6	1.1–4.0	1.4	10.4
12–17 years old	1.6	0.9–2.4	0.4	0.0–1.3	1.7	0.9–2.6	−0.4	5.1
11 or more school days lost								
Children 6–17 years old in school	1.5	1.2–1.9	2.3	1.2–3.3	1.5	1.1–1.9	0.8	3.5
6–11 years old	1.7	1.1–2.3	2.9	0.5–5.3	1.6	1.0–2.3	0.9	4.9
12–17 years old	1.4	0.9–1.8	1.9	0.5–3.3	1.3	0.9–1.8	0.7	2.4

[1] Relative risk of excessive morbidity compared to normal birth weight children.
[2] Percent attributable risk associated with the birth weight.

NOTE: LBW is low birth weight; VLBW is very low birth weight.

indicators when comparing females to males, or those with less than high school education to those with high school or more than 12 years of education. Female and male LBW children frequently had similar rates of excessive morbidity, although LBW boys had higher proportions than girls of multiple hospitalizations and limitations of activity.

The lack of difference in number of physician visits between LBW and NBW children is inconsistent with the very high proportions of multiple hospitalizations, chronic conditions, and other illness measure of LBW children. The pattern of physician visits, even in the age group younger than 2 years, when high-risk LBW infants should be closely monitored, is consistent with the pattern of lack of prenatal care in higher proportions of LBW children (*4*). The pattern raises the question of access to ambulatory health care and the possibility that use of health services for early detection of conditions and prevention could decrease some of the higher rate of chronic conditions and hospitalizations for LBW children.

The higher chronic condition estimates for NBW children of college-educated mothers probably reflect more complete medical diagnosis and reporting, as evidenced by the greater frequency of physician visits for these children, compared to children of less educated mothers (29 percent of NBW children with college-educated mothers reported 7 or more physician visits, compared with the 20 percent reported among NBW children with mothers not having a high school degree). The percent of LBW children with 7 or more physician visits was about the same for all maternal education levels (23 to 25 percent). Wilson has addressed the issue of adverse influence on measures of health care from the provision of health care and by factors outside the health sector (*23*).

The relative risk of excessive morbidity associated with LBW probably is underestimated in the comparisons shown. The proportion of children within a birth weight category is based on those noninstitutionalized survivors from whom the highest risks may have already been lost at the time of a household interview. Since LBW infants are at greater risk of infant death or of institutionalization, the pool of survivors available for interview was diminished. The increased survival of very sick newborns and other children with severe chronic illnesses, and a trend toward deinstitutionalization, have occurred during this period (*24*).

The underlying components of LBW, as differentiated by infants who were born small-for-gestational age (SGA), or born prematurely, are known to influence the outcome and progress of the newborn (*25*). Kessel and coworkers demonstrated that the reduction in the incidence of LBW in the United States between 1970 and 1980 was mainly because of reduced incidence of SGA births (*26*). While the births of the CHS children overlapped this period of some reduction in LBW, the completeness and specificity of the question used to estimate which LBW children in the CHS were SGA or preterm are not as good as the data on birth weight. The vital record data for this period appear to show about the same degree of missing data and specificity for SGA infants. Because of data loss, the SGA and prematurity components were not included in this analysis, but could be addressed separately.

Concern for the impact of the increasing survival of the VLBW infant would dictate that VLBW children be analyzed separately, but the numbers of surviving VLBW children are too small to yield reliable estimates. The relative and attributable risks shown for VLBW or LBW reinforce Parma

'Children are the healthiest segment of our population, but those born with LBW are at greater risk of increased chronic conditions, hospitalizations, limitations of activity, perceived poor or fair health status, bed days, and time lost from school.'

lee's statement, which was based on a review of a number of followup studies of preterm infants. He said, "the largest number of children with neurological, sensory, and mental handicaps come from a population of full-term infants who may not have been identified as at risk due to perinatal or neonatal problems" (*27*).

Conclusion

Children are the healthiest segment of our population, but those born with LBW are at greater risk of increased chronic conditions, hospitalizations, limitations of activity, perceived poor or fair health status, bed days, and time lost from school. Since the rate of low birth weight births has not declined in the United States to the same degree as the rate of infant mortality has declined during the period 1964–81, the survival of VLBW and LBW infants has increased (*28*). The proportions of children in the younger age groups at risk for health problems associated with LBW should be increasing. The proportions of LBW children in the younger age groups with higher excessive morbidity measures tend to support the possibility. An overview of the literature performed by McCormick indicated that the relative risk of morbidity for LBW infants increases, compared with that of NBW infants, but the magnitude of the increased risk is small and has not offset the gains achieved for the neonatal period (*29*). Although the magnitude is small, she cautions that the increased survival of high-risk infants raises concern about their future requirements for special medical and educational services, and about the resulting stress on their families.

The major contribution of the NBW infants to the pool of all children with excessive morbidity demonstrates that it is not the children identified as at risk as a result of LBW who comprise most of those with illnesses. As shown in the earlier followup studies cited, the physical, social, and psychological environment after birth probably has the largest impact on the health status of our children.

The attributable risk of excessive morbidity associated with LBW and VLBW shown here reinforces the concept that while the overall impact is not large, the consistent pattern of poorer health for children born with LBW, compared to NBW, shown in this analysis, is striking and reinforces the concern with the many factors associated with LBW and their effects on the present and future health of the population.

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