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Incidence of Low Birth Weight Infants Born to Mothers with Multiple Risk Factors

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Low birth weight (LBW) is associated with a large number and variety of risk conditions during pregnancy. The number and types of risk conditions per pregnancy were determined in 1,864 white and 872 black mothers delivered at the University of Kansas Medical Center between 1975 and 1978. The incidence of LBW infants increased steadily among white and black mothers as the number of risk factors increased from none to three or four per pregnancy. Among pregnancies without spontaneous premature rupture of membranes (PROM), 51 percent of the LBW infants were born to mothers who had multiple risk factors associated with their pregnancies, even though only 18 percent of these pregnancies were associated with multiple risk factors. Among pregnancies with PROM, 72 percent were associated with multiple risk conditions, and 31 percent resulted in LBW infants. About 90 percent of LBW infants from PROM pregnancies had mothers with multiple risk factors.

For all numbers of risk conditions, black mothers had a higher incidence of LBW infants than white mothers. Among black mothers without spontaneous premature rupture of membranes (PROM), the incidence of LBW infants increased from 3.2 percent (10/308) in low (zero)-risk condition pregnancies to 33 percent (16/49) among mothers with three or four risk conditions during the pregnancy. Among white mothers without PROM, the incidence of LBW infants increased from 1.7 percent (12/708) in low (zero)-risk condition pregnancies to 30 percent (19/64) in pregnancies with three or four risk conditions. The presence of PROM among both white and black mothers increased the risk of LBW, and this risk was increasingly exacerbated as the number of risk conditions increased from one to three or four per pregnancy. The average number of risk conditions per pregnancy was similar among whites and blacks without PROM, within comparable socioeconomic levels and years of school completed.

In the extensive literature on the epidemiology of low birth weight (LBW), little attention has been given to the effects of multiple risk conditions that occur in some pregnancies. The emphasis has been on the effects of single risk conditions such as: cigarette smoking, lack of prenatal care, toxemia, teenage pregnancies, and many others. The comprehensive report, *Preventing Low Birth Weight,* lists 41 principal risk factors under six separate headings: demographic risks, medical risks predating pregnancy, medical risks originating during a pregnancy, behavioral and environmental risks, health care risks, and evolving concepts of risk [1]. Forty-one individual risk conditions under six such widely different headings suggest that multiple risk conditions will occur in some pregnancies. The paucity of data on the effects of multiple risk conditions on LBW probably relates to the difficulty in identifying the many combinations of risk conditions that are likely to be encountered.

Abbreviations: AIDS: acquired immune deficiency syndrome LBW: low birth weight PROM: premature rupture of membranes SES: socioeconomic status

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TABLE 1
Risk Conditions Associated with Low Birth Weight

1. Environmental Factors
   - High altitude
   - Exposure to specific toxic agents
2. Spontaneous Premature Rupture of Membranes (PROM)
3. Fetal Factors
   - Multiple birth
   - Congenital malformations
   - Fetal infections
   - Inborn errors of metabolism
   - Maternal-fetal blood incompatibility, producing disease in the fetus
4. Medical Complications of Pregnancy
   - Toxemia of pregnancy
   - Chronic hypertension
   - Severe vaginal bleeding in third trimester
   - Abnormally high glucose tolerance curves
   - Malformations of placenta, cord, or uterus
   - Anemia: hemoglobin level <10 g/dL
   - Severe chronic maternal disease
   - Leukemia
   - Malignant solid tumors
   - Large ovarian cysts or uterine fibroids
   - Continuous maternal medication with corticosteroids or immunosuppressive, teratogenic, or fetal-growth-retarding drugs
   - Polyhydramnios or oligohydramnios
   - Iatrogenic pre-term termination of pregnancy
5. Adverse Maternal Practices
   - Cigarette smoking during any part of pregnancy
   - Low weight gain in trimesters 2 and 3[a]
   - Low weight for height at conception[b]
   - Delivery <17 years of age
   - Delivery >34 years of age
   - No professional prenatal care
   - Use of addicting drugs or consumption of large amounts of alcohol during pregnancy

[a]Low weight gain, <228 g per week in trimesters 2 and 3
[b]Low weight, >15 percent below normal on Sargent's table for young women [J Nutr 13:318, 1963]

We have used methods that have simplified, to some extent, the analysis of a large number of risk conditions. We separated all potential risk conditions into two broad groups: those that occur only in some pregnancies and those that are present in all pregnancies.

Risk conditions that occur only in some pregnancies include the following: the 28 high-risk conditions listed in Table 1 under five headings, and low-risk pregnancies (defined as the absence of all risk conditions in Table 1).

Potential risk conditions present in all pregnancies are socioeconomic status (SES) and seven biologic conditions that can affect birth weight significantly, either upward or downward: maternal race, age, parity, height, and weight-height ratio at conception, and the sex and gestational age of the infant [2,3]. The socioeconomic conditions are socioeconomic level of head of household, marital status of mother, and years of school completed by mother.

In two previous studies, we reported that the odds ratios of LBW infants (blacks/whites) were consistently higher for blacks in low-risk pregnancies and in a wide

variety of high-risk pregnancies [4,5]. Full-term infants of black mothers who smoked heavily throughout pregnancy (≥10 cigarettes per day) had shorter gestations and lower mean birth weights for gestational age than did full-term infants of white mothers who smoked cigarettes at comparable levels. The higher odds ratios of LBW infants among blacks persisted when controlling for socioeconomic conditions and the seven biologic factors [4,5]. A separate study of these infants reported that the mean birth weights, crown-heel lengths, and head circumferences of black full-term infants born to low-risk mothers were consistently lower than the mean birth measurements of white full-term infants of the same gestational age and sex when controlling for socioeconomic status and for biologic conditions present in all pregnancies [6].

The present study was undertaken to investigate the effects of multiple risk conditions on the incidence of LBW infants for the wide variety of risk conditions listed in Table 1.

METHODS

White and black mothers and their singleton infants in this study were the same as those in two previous studies [4,5]. The methods for collecting data on these mothers and infants were the same as have been reported in these studies and will be briefly summarized here.

Each mother and her infant were assigned to one of five high-risk categories in Table 1, or to the low-risk category, according to a specific protocol. Mothers were assigned to category 1 (environmental conditions) regardless of what other risk conditions were present. (No mothers in this study qualified for category 1.) Mothers were assigned to category 2 (PROM) regardless of the presence of risk conditions in categories 3–5. Mothers were assigned to category 3 (fetal factors), even if medical or obstetric complications or adverse maternal practices were present. Mothers were assigned to category 4 (medical and obstetric complications of pregnancy) even if they had adverse practices. Mothers were assigned to category 5 (adverse maternal practices) if an adverse practice was found and if none of the risk conditions in categories 1–4 were present. Mothers were classified as low-risk if none of the risk conditions in Table 1 were present.

Pre-term births were separated from term births as described in a previous study [5]. Spontaneous premature rupture of membranes (PROM) was considered as a special high risk. Mothers with PROM were investigated separately from mothers without PROM.

Multiway tables were analyzed for statistical significance and the contribution of each variable to the total chi-square, using the log-linear model program, PROC FUNCAT, in the Statistical Analysis System (SAS) at the Yale Computer Center.

RESULTS

Mothers whose pregnancies were complicated by PROM constituted a special high-risk group in this study, because of their high rate of LBW infants. As shown in Table 2, the incidence of LBW infants born to black mothers with PROM was 48 percent (25/52) and among white mothers it was 25 percent (34/136). The ratio of LBW pre-term to LBW full-term infants was about 4:1 in both blacks and whites. Among mothers whose only high risk was PROM, the incidence of LBW infants was 22 percent (4/18) among blacks and 6 percent (2/34) among whites. The incidence increased in both blacks and whites when mothers had additional high-risk conditions

TABLE 2
Incidence of Low Birth Weight (<2,501 g) by Race and by Number of Risk Conditions in Pregnancies *Complicated* by Spontaneous Premature Rupture of Membranes

Number of Other Risk Conditions Per Pregnancy	Race	Total No. Births	No. Low Birth Weight Infants			
			Pre-Term	Full-Term	Total No.	Total (%)
None	Black	18	3	1	4	(22)
	White	34	2	0	2	(6)
One	Black	24	12	3	15	(63)
	White	68	15	5	20	(29)
Two or more	Black	10	5	1	6	(60)
	White	34	10	2	12	(35)
Total	Black	52	20	5	25	(48)
	White	136	27	7	34	(25)

Log-linear analysis on low birth weight as the dependent variable:
The interaction term was not statistically significant, so it was removed and the analysis redone.
Effects:
Number of risk conditions: $X_2^2 = 13.75$ $p = 0.001$
Race: $X_1^2 = 12.08$ $p = 0.0005$

TABLE 3
Incidence of Low Birth Weight (<2,501 g) by Race and by Number of Risk Conditions in Pregnancies *Not* Complicated by Spontaneous Premature Rupture of Membranes

Number of Risk Conditions/Pregnancy[a]	Race	Total No. Births	No. Low Birth Weight Infants			
			Pre-Term	Full-Term	Total No.	Total (%)
None (low-risk)[b]	Black	308	7	3	10	(3)
	White	708	8	4	12	(2)
One[a]	Black	346	24	9	33	(10)
	White	715	23	9	32	(5)
Two[a]	Black	108	13	9	22	(20)
	White	228	18	17	35	(15)
Three or four[a]	Black	49	12	4	16	(33)
	White	64	13	6	19	(30)
Total	Black	811	56	25	81	(10)
	White	1,715	62	36	98	(6)

[a]One or more of the risk conditions in Table 1
[b]None (low-risk): absence of all risks in Table 1
Tests of significance by log-linear model: The interaction term was not statistically significant, so the term was removed.
Dependent variable: Probability of low birth weight
Effects:
Number of risk conditions: $X_3^2 = 134.17$ $p = 0.0001$
Race: $X_1^2 = 11.13$ $p = 0.0008$

TABLE 4
Incidence of Low Birth Weight Infants (<2,501 g) Born to Mothers Without Spontaneous Premature Rupture of Membranes Who Smoked Cigarettes During Part or All of Pregnancy, by Race

Cigarette Smoking	Total No. Births	<2,501 g			
		No. Pre-Term	No. Full-Term	Total No.	Total (%)
White Mothers					
Smoking only adverse practice	477	15	5	20	(4)
Smoked ≥10 cigarettes/day	346	11	4	15	(4)
Smoked 1–9 cigarettes/day	59	2	1	3	(5)
Smoked part-time	72	2	0	2	(3)
Smoked cigarettes + one other adverse practice	142	4	9	13	(9)
Smoked cigarettes + two other adverse practices	19	2	1	3	(16)
Black Mothers					
Smoking only adverse practice	225	15	6	21	(9)
Smoked ≥10 cigarettes/day	112	12	1	13	(12)
Smoked 1–9 cigarettes/day	72	3	3	6	(8)
Smoked part-time	41	0	2	2	(5)
Smoked cigarettes + one other adverse practice	63	4	8	12	(19)
Smoked cigarettes + two other adverse practices	13	2	2	4	(31)

Tests of significance by log-linear models: The interaction term was not statistically significant, so the term was removed.
Dependent variable: Probability of low birth weight
Effects:
Smoking: $X_2^2 = 16.04$ $p = 0.0003$
Race: $X_1^2 = 11.80$ $p = 0.0006$

in their pregnancies. Among mothers who had PROM and two or more risk conditions in their pregnancies, the incidence of LBW infants was 60 percent (6/10) among blacks and 35 percent (12/34) among whites. Among pregnancies terminated by PROM, 72 percent (136/188) were associated with one or more other risk conditions, and 31 percent (59/188) of pregnancies with PROM resulted in LBW infants; however, of the 59 LBW infants in PROM-associated deliveries, 90 percent resulted from pregnancies with multiple risk factors.

As shown by comparing Table 3 with Table 2, the incidence of LBW infants was much lower among white and black mothers without PROM than among mothers with PROM. The incidence of LBW infants was 10 percent (81/811) among blacks and 5.7 percent (98/1,715) among whites. The incidence of LBW infants increased steadily among blacks and whites as the number of risk conditions per pregnancy increased from none to three or four. The incidence of LBW infants was 3.2 percent (10/308) among blacks with low risk but increased to 33 percent (16/49) among black mothers with three or four risk conditions per pregnancy. Among low-risk whites, the incidence of LBW infants was 1.7 percent (12/708) and increased to 30 percent (19/64) among white mothers with three or four risk conditions. Among pregnancies without PROM, over half of all LBW infants were born to blacks and whites who had two or more risk conditions per pregnancy. The ratio of LBW pre-term to LBW full-term infants born to whites and blacks without PROM was approximately 2:1 compared to 4:1 among

TABLE 5
Relationship Between Socioeconomic Status (SES) of Mothers Without Spontaneous Premature Rupture of Membranes and Number of Risk Conditions per Pregnancy, by Race

SES	Number of Risk Conditions[a]								Total Mothers		Mean No. Conditions
	0		1		2		3/4				
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	
White Mothers											
I	465	(47)	369	(37)	115	(12)	37/6	(4)	992	(100)	0.74
II/III	115	(32)	157	(43)	73	(20)	16/1	(5)	362	(100)	0.98
IV	97	(28)	161	(47)	67	(20)	16/2	(5)	343	(100)	1.02
Total	677	(40)	687	(40)	255	(15)	69/9	(5)	1,697	(100)	0.85
Black Mothers											
I	114	(47)	88	(37)	28	(12)	9/2	(5)	241	(100)	0.74
II/III	71	(34)	103	(49)	29	(14)	5/1	(3)	209	(100)	0.86
IV	108	(31)	160	(45)	58	(16)	24/2	(7)	352	(100)	1.01
Total	293	(37)	351	(44)	115	(14)	38/5	(5)	802	(100)	0.88

[a]Risk conditions were those in Table 1.

Tests of significance by log-linear model: The interaction term was not statistically significant, so the term was removed.

Dependent variable: Number of risk conditions

Effects:

SES: $X_2^2 = 73.04$ $p = 0.0001$

Race: $X_1^2 = 2.87$ $p = 0.4123$ N.S.

mothers with PROM. In Table 3, by using a log-linear model to analyze the three-way table, the number of risk conditions was strongly associated with the risk of low birth weight ($X_3^2 = 134.17$; $p = 0.0001$) and race was also associated with the risk of pre-term birth, after controlling for the number of risk conditions, but at a much lower level ($X_1^2 = 11.13$; $p = 0.0008$).

The risk condition that occurred most frequently in this study was cigarette smoking by mothers during all or part of pregnancy. When cigarette smoking occurred as a single risk condition (refer to Table 4), the incidence of LBW infants was 4.2 percent (20/477) among whites and was 9.3 percent (21/225) among blacks. The incidence of LBW increased in both whites and blacks when cigarette smoking was complicated by one other adverse practice or by two other adverse practices. Among whites with one other adverse practice, the incidence of LBW infants was 9.2 percent (13/142), and with two other adverse practices it was 16 percent (3/19). Among blacks with one other adverse practice it was 19 percent (12/63), and with two other adverse practices it was 31 percent (4/13). When cigarette smoking was the only risk condition, the incidence of LBW infants was not significantly different at three different levels of smoking among white mothers, but among black mothers there was a trend for the heavier smokers to have a higher incidence of LBW.

Table 5 shows that for both white and black mothers the average number of risk conditions per pregnancy (as shown in Table 1) increased as the SES decreased from group I (upper) to group IV (lower). Almost half (47 percent) of white and black

TABLE 6
Relationship Between Number of Years of School Completed by Mothers and Number of Risk Conditions per Pregnancy, by Race

Years of School	Number of Risk Conditions[a]								Total Mothers		Mean No. Conditions
	0		1		2		3/4				
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	
White Mothers											
>12	283	(55)	172	(34)	47	(9)	11/0	(2)	513	(100)	0.58
=12	253	(40)	271	(43)	82	(13)	23/3	(4)	632	(100)	0.82
<12	136	(25)	240	(45)	122	(23)	35/6	(8)	539	(100)	1.14
Total	672	(40)	683	(41)	251	(15)	69/9	(5)	1,684	(100)	0.85
Black Mothers											
>12	80	(52)	54	(36)	14	(9)	3/1	(3)	152	(100)	0.63
=12	157	(43)	156	(43)	39	(11)	12/1	(4)	365	(100)	0.75
<12	63	(22)	130	(46)	59	(21)	29/2	(11)	283	(100)	1.21
Total	300	(38)	340	(43)	112	(14)	44/4	(6)	800	(100)	0.89

[a]Risk conditions were those in Table 1.

Tests of significance by log-linear model: The interaction term was not statistically significant, so the term was removed.

Dependent variable: Number of risk conditions

Effects:

Years of School: $X_2^2 = 171.04$ $p = 0.0001$

Race: $X_1^2 = 2.13$ $p = 0.5452$ N.S.

mothers with the highest SES had low-risk pregnancies compared to about 30 percent of white and black mothers with the lowest SES (Group IV), and the proportions are almost identical within SES groups between blacks and whites.

Table 6 shows that for both white and black mothers, the average number of risk conditions increased as the number of years of schooling decreased from greater than 12 years to less than 12 years. For comparable levels of formal education, whites and blacks had comparable average numbers of risk conditions. This result suggests, but does not prove, that increased education may be a way to reduce the average number of prenatal risk conditions for both whites and blacks. Increased education may be more feasible than other methods as a way to improve SES and improve obstetrical outcomes.

DISCUSSION

The literature on the epidemiology of LBW has emphasized risk conditions one at a time, such as studies on the effects of cigarette smoking, teenage pregnancies, drug addiction, chronic alcoholism, and other important risk conditions. It should be noted that the data in this study were collected before AIDS became a problem and before cocaine addiction was prevalent enough to be an important risk factor in studies such as this.

Epidemiologic studies have not always had sufficient data to account adequately for the multifactorial aspects of LBW. It is not surprising that the incidence of LBW

infants is increased in pregnancies complicated by multiple risk conditions. However, because the risk of LBW was consistently increased in pregnancies complicated by multiple risk factors, and the fact that over half of the LBW infants born to high-risk mothers in the present study were associated with multiple-occurring risks indicates that this situation is a serious problem whose reduction could have a major impact on newborn health.

There is a close association between low SES and an increased risk of LBW. A previous study demonstrated no clearly significant SES effect on the incidence of LBW after controlling for risk group and for race [4]. Within both race groups, mothers in the lowest socioeconomic group were more likely to adopt adverse practices in their pregnancies compared to mothers in the higher SES groups (Tables 5 and 6), and these practices appear to have a direct association with LBW. The average number of risk conditions per pregnancy was very similar among whites and blacks within comparable SES or educational achievement groups.

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