

Some Factors Which Influence Birth-Weight

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As a preliminary to an investigation of the nutritional factors effecting birth-weight, the relationships between the infant's birth-weight and mother's weight, mother's age, father's age, number of gestations, the presence of signs of toxæmia of pregnancy, and the mother's blood haemoglobin content (per cent.—Haldane) have been studied on a series of 837 consecutive births occurring during a period of 7 months in one ward of the De Zoysa Maternity Hospital, Colombo. Only pregnancies which went to full-term have been considered here; otherwise no selection of cases has been made. Of this group there were 797 single births and 30 multiple births (29 pairs of twins and one group of triplets). The single and multiple births have been analysed separately.

(A) Single Births.—

(1) Signs of Toxaemia of Pregnancy :

As many of the expectant mothers admitted to the Maternity Hospital show signs of toxæmia, the influence of this on the birth-weight must be determined first. The patients have been regrouped according as to whether they showed any of the conventional signs of toxæmia, i.e. elevated blood pressure (systolic or diastolic), albuminuria, or oedema. In this connection it must be remembered that the average blood pressure of the adult female Ceylonese is 106·3 mm. Hg. \pm 2·10 systolic, and 69·3 mm. Hg. \pm 1·40 diastolic (Cullumbine, 1949), so that a systolic blood pressure greater than 120 mm. Hg. or a diastolic pressure greater than 80 mm. Hg. may be considered to be abnormally high in these expectant mothers. The average birth weights of infants born to mothers with and without (a) an elevated systolic blood pressure, (b) an elevated diastolic blood pressure, (c) albuminuria and (d) oedema, are given in Table 1.

TABLE 1

Mean Birth-Weights of Infants Born to Mothers (1) with Signs of Pregnancy Toxaemia and (2) without such Signs.

Clinical Group	Number of Infants	Mean Birth-Weight (lbs.)	S.e. of Mean \pm
Systolic B.P. greater 120 mm. Hg. ..	643	6·16	0·046
Systolic B.P. less 120 mm. Hg. ..	151	6·11	0·085
Diastolic B.P. greater 80 mm. Hg. ..	620	6·14	0·046
Diastolic B.P. less 80 mm. Hg. ..	174	6·18	0·089
Albuminuria present	482	6·18	0·050
Albuminuria absent	314	6·13	0·066
Oedema present	245	6·13	0·082
Oedema absent	552	6·17	0·046

S.e. = Standard error.

In none of these groups is there a statistically significant difference between the birth-weights of infants born to mothers with signs of toxæmia and of infants born to mothers who show no such signs. We are justified, therefore, in ignoring signs of toxæmia in any further analysis of the factors influencing birth-weight.

(2) *Mother's Age and Infant's Birth-Weight.*—The mean birth-weights of infants born to mothers of different age groups are shown in Table 2.

TABLE 2

Mean Birth-Weight of Infants born to Mothers of different Ages.

Mother's Age in Years	Number of Infants	Mean Birth- Weight (lbs.)	S.e. of Mean \pm
16-18	15	5.75	0.214
19-20	65	5.76	0.137
21-25	255	6.00	0.073
26-30	246	6.30	0.075
31-35	133	6.26	0.107
36-40	74	6.09	0.157
41-50	19	6.46	0.118

S.e. = Standard error.

As the mother's age increases it will be seen that there is a general tendency for the infant's weight to increase also. Thus, by means of Student's *t*-test, we find that the average birth-weight of infants born to mothers aged 26 to 30 years is greater than that of infants born to mothers aged 16 to 18 years ($P = 0.02$), or of infants from mothers aged 19 to 20 years ($P = 0.001$) or of infants born to mothers aged 21 to 25 years ($P = 0.01$). Similarly, mothers aged 21 to 25 years produce lighter infants than do mothers aged 31 to 35 years ($P = 0.05$) or mothers aged 41 to 50 years ($P = 0.001$).

(3) *Father's Age and Infant's Birth-Weight* (Table 3):—

TABLE 3

Mean Birth-Weight of Infants born to Fathers of different Ages.

Father's age in years	Number of Infants	Mean Birth- Weight (lbs.)	S.e. of Mean \pm
19-20	10	5.68	0.355
21-25	79	5.82	0.122
26-30	234	6.02	0.071
31-35	201	6.26	0.073
36-40	170	6.31	0.087
41-50	94	6.32	0.150
Over 50	6	5.80	0.451

S.e. = Standard error.

Again, just as was found for mother's age, so here, the greater the age of the father then the greater is the infant's birth-weight. The infants born to fathers aged 31 to 35 years are heavier than those born to fathers aged 21 to 25 years ($P = < 0.01$) or to fathers aged 26 to 30 years ($P = 0.02$), and fathers aged 36 to 40 years have heavier infants than do fathers aged 26 to 30 years ($P = 0.01$).

(4) *Mother's Weight and Infants Birth-Weight.*—This series shows that the heavier the mother then the greater is the infant's birth-weight (Table 4).

TABLE 4
Mean Birth-Weight of Infants born to Mothers of different Weight.

Mother's Weight (pounds)	Number of Infants	Mean Birth- Weight (lbs.)	S.e. of Mean \pm
Less than 80	12	4.62	0.339
81-90	42	5.57	0.152
91-100	147	5.87	0.085
101-110	155	6.03	0.093
111-120	195	6.36	0.097
121-130	54	6.84	0.113
131-140	53	6.47	0.140
Over 140	26	6.98	0.274

S.e. = Standard error.

Mothers weighing less than 80 pounds had infants with significantly smaller birth-weights than did heavier mothers (e.g. less than birth-weight of infants of mothers weighing 81 to 90 pounds, $P = 0.02$, of mothers weighing 91 to 100 pounds, $P = 0.001$, of mothers weighing 101 to 110 pounds, $P = < 0.001$ and so on).

The mean birth-weight of the infants increases as the mother's weight increases until the mother weighs over 120 pounds. Thus, the weight of infants weighing 81 to 90 pounds is less than that of infants born to mothers weighing 101 to 110 pounds ($P = 0.02$) or to mothers weighing 111 to 120 pounds ($P = < 0.001$). Mothers weighing 91 to 100 pounds have smaller babies than do mothers weighing 111 to 120 pounds ($P = < 0.001$), and lighter babies are born to mothers weighing 101 to 110 pounds than to mothers weighing 111 to 120 pounds ($P = 0.01$) or to mothers weighing 121 to 130 pounds ($P = < 0.001$). The latter mothers (121 to 130 pounds) also have heavier babies than do mothers weighing 111 to 120 pounds ($P = 0.001$).

When the mothers weigh over 120 pounds, there is no evidence of any further increase in the baby's weight with increasing weight of the mother, although our groups are rather small, numerically.

(5) *Mother's Haemoglobin Level and Infant's Birth-Weight.*—From the foregoing, it would appear that the more undernourished the mother then the smaller is the birth-weight of her baby and it is not surprising to find, also, that the lower the mother's blood haemoglobin level then the lighter is her baby (Table 5).

TABLE 5

Mean Birth Weight of Infants born to Mothers with a different Blood Haemoglobin Level

Mother's Haemoglobin % Haldane	Number of Infants	Mean Birth- Weight (lbs.)	S.e. of Mean \pm
Less than 40	34	5.45	0.195
41-50	90	6.14	0.124
51-60	221	6.17	0.044
61-70	260	6.32	0.070
71-80	68	6.02	0.148
Over 80	4	5.75	0.548

S.e. = Standard error.

Here it can be seen that the babies of mothers with less than 40 per cent. haemoglobin are not as heavy as the babies of mothers with 41 to 50 per cent. ($P = 0.01$), or 51 to 60 per cent. ($P = 0.001$) or 61 to 70 per cent. ($P = < 0.001$) or 71 to 80 per cent. ($P = 0.02$) of haemoglobin.

These are the only significant differences, which means that only the very anaemic mothers (with less than 40 per cent. haemoglobin) have babies with a significantly low birth weight.

(6) *Number of Gestations.*—So far, our analysis indicates that the heavier babies are born when the mother weighs more than 120 pounds, is over 25 years of age and has a husband who is over 30 years of age. These age relationships may, at first sight, appear remarkable, but it must be remembered that the older the parents then, usually, the more children they have produced and birth weight increases as the number of gestations increases (Table 6).

TABLE 6

Mean Birth Weights of Infants born at Different Gestations.

Gestation	Number of Infants	Mean Birth- Weight (lbs.)	S.e. of Mean \pm
1	278	5.85	0.057
2	188	6.06	0.088
3	107	6.27	0.107
4	76	6.33	0.148
5	51	6.47	0.174
6	38	6.37	0.218
7	19	6.94	0.134
8	13	7.04	0.538
9	10	6.88	0.288
10	9	6.73	0.057
11	4	7.78	0.250
12	1	5.25	—
7 and over	56	6.95	0.149

S.e. = Standard error.

Babies born to primipara are lighter than those born at second ($P = 0.05$) and third gestations ($P = 0.001$); those born at the second gestation are lighter than those born at the fifth ($P = 0.05$), and the seventh gestation ($P = < 0.001$), while the seventh gestation babies are heavier than the sixth-gestation ones ($P = 0.05$) and the eleventh ones are greater than those born at the tenth gestation ($P = < 0.001$).

This rise in birth-weight of the infants, as the number of gestations increases, is the most obvious explanation for the rise in birth weight which we have seen to occur with increasing age of the parents. If it is the sole explanation then we should expect to find, for example, no relationship between birth-weight and parent's age in primipara (Table 7).

TABLE 7

Mean Birth-Weight of Infants born to Primipara Mothers and Fathers of Different Ages.

Parent's Age (Years)	Number of Infants	Mean Birth Weight (lbs.)	S.e. of Mean \pm
<i>Mothers :—</i>			
16-18	15	5.75	0.214
19-20	45	5.68	0.142
21-25	111	5.86	0.098
26-30	59	5.91	0.152
31-35	34	6.07	0.171
36-50	16	5.38	0.221
<i>Fathers :—</i>			
19-20	10	5.68	0.355
21-25	48	5.79	0.140
26-30	105	5.84	0.094
31-35	62	5.98	0.111
36-40	32	5.78	0.190
41-50	18	5.86	0.266

S.e. = Standard error.

There are not any significant differences between the mean birth weights of the infants from the various age groups. (The groups are rather small so that any relationship may not be revealed by our figures). Our data do not indicate, therefore, any relationship between parent's age and their infant's birth weight, when the influence of increasing numbers of gestations is eliminated.

As a mother's weight generally tends to increase with increasing number of pregnancies, the question now arises as to whether the relationship that we have noted between mother's weight and infant's birth weight is also another example of the influence of increasing numbers of gestations. In an attempt to answer this, the birth weight of infants born to primipara have again been considered. (Table 8).

TABLE 8

Mean Birth-Weights of Infants born to Primipara of Different Weights.

Weights of Primipara (lbs.)	Number of Infants	Mean Birth-Weight (lbs.)	S.e. of Mean \pm
Less than 80	5	4.34	0.463
81-90	16	5.54	0.155
91-100	51	5.60	0.109
101-110	61	5.82	0.118
111-120	70	6.09	0.122
121-130	15	6.29	0.247
131-140	19	6.14	0.173
Over 140	8	6.73	0.138

S.e. = Standard error.

The groups are small but it is evident that the greater the weight of the mother (at least up to 120 pounds) then the greater is the weight of her infant. As illustrations, the babies born to mothers weighing less than 80 pounds have a mean birth-weight which is significantly less than that of babies from mothers in all the other weight groups. In addition mothers weighing 111 to 120 pounds have heavier babies than do mothers weighing 81 to 90 pounds ($P = 0.01$) or 91 to 100 pounds ($P = 0.01$) and so on.

We must conclude, therefore, the birth-weight of infants is related to the mother's weight and that this relationship is not dependent upon the number of children produced by the mothers. The reverse question must next be answered, *viz.*, is the influence of the number of gestations upon birth weight due to a tendency on the part of the mothers to increase in weight as they bear more children? In this series, only the groups of mothers who have produced more than five children show any significant increase in body-weight (Table 9).

TABLE 9

Mean Weights of Mothers at Different Gestations.

Gestation	Number of Mothers	Mean Weight of Mothers (lbs.)	S.e. of Mean \pm
1	248	109.5	1.01
2	160	110.0	1.32
3	93	110.1	1.79
4	71	107.0	1.81
5	45	111.0	4.05
6	39	115.4	2.94
7 and more	53	117.2	2.36

S.e. = Standard error.

Here, the mothers at the sixth gestation have a greater mean weight than do mothers at the fourth gestation ($P = 0.02$), while seventh (and more) gestation mothers have a greater weight than do mothers at their first ($P = 0.01$), second ($P = 0.02$), third ($P = 0.02$) or fourth gestation ($P = 0.001$). There are no significant differences between the mean weights of the mothers at the first five gestations. This contrasts with the fact that we have noted an increase in the infant's birth-weight from the second gestation onwards. It would appear, therefore, that the increased birth-weight of the infants of multipara is not due to an increase in the weight of the mother.

This can be illustrated in another way by considering the birth-weight at different gestations of infants born to mothers of the more or less the same weight, e.g. 111 to 120 pounds (Table 10).

TABLE 10

Mean Birth-Weight at Different Gestations of Infants born to Mothers weighing 111 to 120 pounds.

Gestation	Number of Infants	Mean Birth-Weight (lbs.)	S.e. of Mean \pm
1	67	6.10	0.128
2	45	6.31	0.171
3	25	6.42	0.230
4	22	6.72	0.195
5 or more	36	6.60	0.191

S.e. = Standard error.

The groups are rather small numerically but it is evident that the mean birth-weight increases consistently with the number of gestations experienced by the mother. Statistically, the infants born to primipara are significantly lighter than those born at the fourth ($P = 0.01$) or subsequent ($P = 0.02$) gestation.

(B) Multiple Births.—

There were only 30 full-term pregnancies in this series which terminated in multiple births. An analysis of the frequency of occurrence of these multiple births by means of the X^2 test indicates the following:—

(1) Number of Gestations:—

Number of Gestations	1 & 2	3 & 4	5 & more	Totals
Single Births	466	183	145	794
Multiple Births	11	9	10	30
Totals	477	192	155	824

X^2 has a calculated value of 5.80 which is not quite significant at $P = 0.05$.

(2) *Mother's Age* :—

Mother's Age in Years	Less than 25	26-30	Over 30	Totals
Single Births	335	246	226	807
Multiple Births	10	9	11	30
Totals	345	255	237	837

X^2 has a value of 1.26 ($P = < 0.50$) and so there is no evidence of a significant relationship between the frequency of occurrence of multiple births and the mother's age.

(3) *Mother's Weight* :—

Mother's Weight in pounds	Less than 110	111-120	Over 120	Totals
Single Births	356	195	133	684
Multiple Births	7	17	4	28
Totals	363	212	137	712

X^2 has a value of 13.73, which is significant ($P = < 0.01$), and we may conclude that relatively more multiple births occurred in mother's weighing between 111 to 120 pounds.

(4) *Signs of Toxaemia* :—(i) **SYSTOLIC BLOOD PRESSURE** :

Systolic Blood Pressure in mm. Hg.	Over 120	Less than 120	Totals
Single Births	643	151	794
Multiple Births	20	10	30
Totals	663	161	824

X^2 has a value of 3.90, which is just significant ($P = 0.05$), suggesting that multiple births are more often associated with a maternal systolic blood pressure which is less than 120 mm. Hg.

(ii) **DIASTOLIC BLOOD PRESSURE** :

Diastolic Blood Pressure in mm. Hg.	Over 80	Less than 80	Totals
Single Births	620	174	794
Multiple Births	17	13	30
Totals	637	187	824

Here X^2 equals 7.56, which is also significant ($P = < 0.01$), indicating that relatively more multiple births occur when the mother's diastolic blood pressure is less than 80 mm. Hg.

(iii) ALBUMINURIA :

Albuminuria	Present	Absent	Totals
Single Births	482	314	796
Multiple Births	21	9	30
Totals	503	323	826

χ^2 has a value of 1.07 ($P = < 0.10$) so this series presents no evidence in favour of albuminuria being more liable to occur with multiple births.

(iv) OEDEMA :

Oedema	Present	Absent	Totals
Single Births	245	552	797
Multiple Births	13	17	30
Totals	258	569	827

χ^2 has a value of 2.06 ($P = > 0.10$) and in this series, therefore, oedema is not more frequent with multiple births.

In general, we can conclude that, in this small series of cases, signs of toxæmia are not more frequently associated with multiple births than with single births. Indeed, multiple births were slightly more frequent from mothers with a normal or low diastolic or systolic blood pressure than from mothers with elevated blood pressures.

As was to be expected, the average weight of the babies born at these multiple births was much less than that of the babies born at the single births. (Average weight of 58 twins and 3 triplets was 5.25 pounds \pm 0.131; average weight of 837 single births was 6.15 pounds \pm 0.115; there is a highly significant difference between these mean weights, $P = < 0.001$). This difference in birth weights is further emphasised when it is remembered that three-quarters of these multiple births occurred in mothers weighing over 110 pounds.

Discussion

The analysis of this small series of 837 cases indicates that, of the factors considered, the weight of the mother is important in determining the birth-weight of the infant. This factor has been generally acknowledged by obstetricians, since it is well known that a small woman usually produces a small baby, and it has been found to be true also in stock breeding (Walton and Hammond, 1938). This relationship between weight of mother and weight of baby has usually been attributed to hereditary influences (Bourne, 1944) but it must also be remembered that the weight of the mother is, in addition, an index of her nutritional state. True, it is usually accepted that the birth weight is only adversely affected when the mother's nutritional state is very low, but this may have been an influencing factor on the babies born to the mother's in the lower weight groups of this series. (Average weight of female Sinhalese, aged 26 to 30 years, is 95.5 pounds \pm 1.23, and over fifty of these mothers were less than 90 pounds in weight). This is further illustrated by the fact

that the very anaemic, like the very undernourished, mothers had babies with significantly smaller birth-weights. The reverse effect, i.e. increased birth-weight with unlimited feeding of the mother during pregnancy, does not occur, at least in rabbits (Wishart and Hammond, 1933), while the People's League of Health (1942) investigation, where a group of pregnant women were given supplements of iron, calcium, and vitamins A, B complex, C and D, showed that these supplements did not significantly effect the birth-weight.

The birth-weight of infants increases as the mother's age increases. (This has been reported also for lambs born to young and adult ewes; Hammond, 1932). Further analysis has shown, however, that this is because the older mothers have experienced more than one pregnancy and the birth weight usually increases with successive pregnancies. This latter influence is not due to increasing weight of the mother and it may be endocrine in origin.

Babies born during multiple births are also smaller than those born as single births and this is true for other species too (Wishart and Hammond, 1933; Hammond, 1934). This is probably not due to limitation of available food to the multiple foetuses since Wishart and Hammond, 1933, have shown that unlimited feeding to rabbits during pregnancy does not increase the weight of the young in large litters. Again an internal secretion may be the controlling factor.

The presence of some or all of the signs of toxæmia of pregnancy does not apparently influence the birth-weight, although it would seem, from this small number of cases, that multiple births may be more common in mothers who are free of these signs.

This series was composed of only full-term infants. It is well known that the more premature the infant then the smaller is the birth-weight. The agreed international standard of prematurity is $5\frac{1}{2}$ pounds (2,500 g.) but this can only apply to babies born to mothers in Europe and the Western Hemisphere. The average birth weight of these Ceylonese babies was $6\cdot15$ pounds $\pm 0\cdot115$ and 167 had a birth-weight below $5\frac{1}{2}$ pounds.

The importance of the birth-weight is that it bears a definite relationship to the vigour, viability and post-natal progress of the new-born baby (Bourne, 1944). A study of the factors which may influence the birth-weight is, therefore, of great importance.

Summary

The relationships between the infant birth-weight and mother's weight, mother's age, father's age, number of gestations experienced by the mother, the presence of signs of toxæmia of pregnancy and the maternal blood haemoglobin content has been studied on a series of 837 consecutive full-term births.

The presence of signs of toxæmia did not effect the birth-weight. The birth-weight does, however, increase with mother's weight, mother's age, mother's haemoglobin level, and the number of gestations experienced by the mother. The influence of age is due to the fact that the older parents have produced more children.

Multiple births occurred more often in mothers with a body-weight between 111 and 120 pounds, with a systolic blood pressure below 120 mm. Hg. and with a diastolic blood pressure below 80 mm. Hg.

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