# Nutrition and Its Relationship to the Complications of Pregnancy and the Survival of the Infant*

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INCREASING awareness of the possible importance of nutrition during pregnancy to both mother and fetus has stimulated considerable interest in this field. In the last few years several prenatal studies on large numbers of women have been carried out which have included evaluation of their diets during pregnancy.

The first report of this type to gain widespread attention was the Toronto study of Ebbs, Tisdall, and their coworkers.[1, 2, 3] A group of 120 women on poor diets and low incomes were studied during the last half of pregnancy as controls for 90 women from the same income level and on equally poor diets who were supplied with supplementary rations of milk, cheese, oranges, tomatoes, wheat germ, and vitamin D capsules, and 170 women with fairly adequate incomes who were instructed in the type of diet considered desirable for pregnancy. The incidence of miscarriages, premature births, stillbirths, and deaths in early infancy was significantly lower in the groups on supplemented and good diets, and these women also enjoyed better health throughout pregnancy, had fewer complications, and proved to be better obstetrical risks than those left on poor diets. There was also a marked increase in the incidence of minor and major diseases in the infants born of mothers in the poor diet group. In a large proportion of the cases one could tell the diet group of the mother by the appearance of her baby at 6 months of age.

Williams and Fralin[4] studied the nutrition of 514 women in relation to the course of their pregnancies, the puerperium, and the condition of their infants at birth. Their data seemed to show no relationships between the diet during pregnancy and the complications of pregnancy (except a relationship between vitamin $B_1$ and a history of nausea and vomiting in early pregnancy). No relationship was found with the puerperium or with the incidence of stillbirths, premature births, or neonatal deaths. Apparently a nutrition intake for only one 7 day period was used as representative of the diet during pregnancy.

The People's League of Health of England[5] investigated the effect of the nutrition of 5,022 pregnant women upon maternal and infant morbidity and mortality. Supplementary minerals and vitamins were given to one-half of the women studied. This supplementary feeding appeared to reduce the incidence of toxemia approximately 30

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per cent. The reduction in the number of premature births in the supplemented group was statistically significant. No other significant relationships were found.

Balfour [6] reports another study, recently made in England and Wales, in which 11,618 pregnant women chosen from the lowest income groups were fed a supplement of marmite or other yeast extract sufficient to furnish 240 I.U. of thiamin daily, or a proprietary preparation which furnished a rich supply of vitamins A and D, as well as calcium, phosphorus, and iron. Their controls were 8,095 pregnant women from the same area. A study of any differences in the two groups made it seem fair to assume that any favorable results found in the fed group were due to the food supplements. The supplementary feeding of marmite or a similar yeast extract resulted in a statistically significant reduction in the number of stillbirths and in the neonatal mortality rate. There was also a reduction, but not significant, in the infant mortality rate in the group fed the supplement rich in vitamins A and D and in minerals. With either supplement there was also a slight but not statistically significant reduction in the incidence of toxemia and in the maternal mortality rate. Balfour states that, owing to the large number of cases studied and deaths observed, the differences in stillbirth rates and neonatal mortalities are significant beyond any reasonable doubt.

Dieckmann, Adair, *et al.*[7] have studied a group of 553 pregnant women to determine if additions of calcium, phosphorus, iron, or vitamins A and D to the diet had any beneficial effects on the course of pregnancy or insured a higher incidence of normal infants. They concluded that "a study of the effect of the additions to the diet on the various complications of pregnancy showed some differences, but no conclusions could be drawn. No significant effects were noted on the fetus that could be attributed to diet."

As a part of the research program on the growth and development of the well child undertaken by the Department of Maternal and Child Health of the Harvard School of Public Health, we [8, 9] have made a study of 216 women and their infants in an attempt to clarify further the influence of diet during pregnancy upon fetal growth and development as well as upon the course of pregnancy, labor, delivery, and the puerperium. We obtained detailed nutrition histories at regular intervals during pregnancy, supplemented by records of food intake which the women kept.

The diets were evaluated in relation to a set of nutritional standards which approximate those later recommended by the National Research Council. A statistically significant relationship was found between the diet of the mother during pregnancy and the condition of her infant at birth. In the 216 cases studied every stillborn infant, every infant who died within a few days of birth except one, the majority of infants with marked congenital defects, all premature and all "functionally immature" infants were born to mothers whose diets were very inadequate. In somewhat greater detail, in the 31 cases in which the mother's diet was "good" or "excellent," 42 per cent of the infants were "superior," that is, they had no physical count of any kind against them either at birth or within the first two weeks of life, while in the group of 149 mothers whose diets were considered "fair" only 6 per cent of the infants were "superior," and in the group of 36 infants whose mother's diets were "poor to very poor" only one infant fell into this "superior" classification.

If we consider the infants with one, occasionally two, minor physical counts

against them who were rated in " good " physical condition, we find that in the " good " or " excellent " diet group 52 per cent of the infants, in the " fair " diet group 44.5 per cent of the infants, and in the " poor to very poor " diet group only 5 per cent of the infants were in " good " physical condition. In the case of infants considered to be in the " poorest " physical condition (i.e., were stillborn, died within a few days of birth, had marked congenital defects, were premature, or were termed " functionally immature ") it was found that 67 per cent of the infants whose mothers' diets were rated " poor to very poor " fell into this classification, while only 5 per cent of the infants of the " fair " diet group, and 3 per cent of the infants in the " good or excellent " diet group were in this classification.

The average birth weight of the infants whose mothers' diets were rated "good or excellent " was 8 lb., 8 oz., that of infants born to the women in the " fair " diet group was 7 lb., 7 oz., and that of infants born to women in the " poor to very poor " diet group was 5 lb., 13 oz. The average birth length of the infants in the " good or excellent " prenatal diet group was 51.8 cm., 50 cm. in the " fair " diet group, and 47.2 cm. for the infants whose mothers' diets were rated " poor to very poor."

A statistically significant relationship was also found to exist between the prenatal diet and the course of pregnancy; this relationship was not as marked as that existing between the mother's dietary rating during pregnancy and the condition of the infant at birth. Sixty-eight per cent of the women having " good or excellent " diets during pregnancy experienced a normal course, while only 42 per cent of the women with " poor to very poor " diets had a normal pregnancy. These findings suggest that the fetus may suffer to a greater degree and more frequently than the mother from inadequate maternal diet. In other words, the fetus may be parasitic upon the mother only to a certain extent, determined by the mother's own nutritional state at the time she enters pregnancy and by the quality and quantity of her diet thereafter.

Warkany,[10] whose recent work on animals has contributed so much to our realization of the part which maternal dietary deficiency may play in congenital malformations, suggests the following intriguing explanation for the observed maternal-fetal relationship: " The stores of the maternal tissues act as ' buffers ' which prevent deprivation of the developing embryo as long as possible. In fact, it was assumed until recently that these maternal stores either protect the offspring completely, thus resulting in the delivery of normal young, or that in case of extreme dietary deficiency the embryos die *in utero*. Although there is some truth in this ' all or none ' theory it is not entirely correct. Between these two extremes there exists a narrow range in which maternal nutritional deficiency may result in arrest of the embryo's development without causing death. In this case congenitally deformed offspring may be the result."

In our study no woman whose diet was rated " good " or " excellent " had toxemia, while an 8 per cent incidence occurred among women whose diets were considered "fair," and among the women in the poorest diet group there was a 44 per cent incidence of toxemia. No statistically significant relationship was found between the prenatal diet and the duration of labor. However, there were many more difficult types of delivery in the " poor to very poor " diet group despite the fact that these infants averaged almost 3 lb. lighter in weight at birth than the infants of mothers whose diets were " good " or " excellent." While there seemed to be a

tendency for a relationship to exist between prenatal nutrition and the occurrence of major complications in the postpartum period, certainly there was no clearly defined relationship such as was shown with the complications of pregnancy.

Up to the present time it has been generally accepted that the weight of the new-born infant is not materially affected by the diet of the mother during pregnancy unless it is extremely deficient or possibly excessive in calories. The average weight gain for the series of women whom we studied was 24.6 lb. We found that the underweight woman who gained approximately the same or more than the normal or overweight woman during pregnancy gained more weight herself in relation to her preconceptional weight and gave birth to a smaller infant. The very overweight woman consuming inadequate calories lost weight herself but had a larger baby than the normal or underweight woman with adequate calories. While these data have not yet been published in detail, it is possible to state that here again is evidence suggesting that the fetus is parasitic upon the mother only to a degree, and that, if a woman enters pregnancy below her ideal normal weight, attention should be given to this fact and she should be allowed to gain about 24 lb. above her ideal weight, otherwise her own body tissues tend to utilize food at the expense of her unborn child.

Arnell, *et al.*[11] have emphasized the importance of a diet well supplied with protein during pregnancy. In studying a group of 225 women in the New Orleans area they found lower average hemoglobin and serum protein levels, a higher incidence of preëclampsia, a strikingly higher incidence of edema, increased maternal morbidity, and increased fetal mortality among the cases on diets poor in protein. Although these trends were found, no definite conclusions were drawn. A study of their work illustrates the apparent difficulty in human studies of proving conclusively that a given effect is due to a specific nutrient.

While we[12] found a significant relationship between the general prenatal dietary rating and the incidence of toxemia, we found no significant relationship with protein alone. When protein was low in the diet, many other factors were often low also. Our study also revealed a very significant relationship between the protein content of the mother's diet during pregnancy and the birth length of her infant. There was a somewhat less striking but still significant relationship with birth weight. These relationships are of such a magnitude that when the cases are sorted according to the number of grams of protein in the mother's diet, they are observed with every 10 gm. difference in protein. For practical purposes this study indicates that less than 75 gm. of protein daily during the latter part of pregnancy results in an infant who will tend to be short, light in weight, and likely to receive a low pediatric rating. It is impossible to prove conclusively that protein alone is the significant factor, but from a practical standpoint it makes little difference, for if the diet contains the protein-rich foods it is probable that any other factors of importance in these respects are supplied also.

The most significant finding of the majority of the recent studies is a markedly lowered incidence of stillbirths, premature births, and early neonatal deaths, thus promising with improved maternal nutrition healthier babies with fewer physical handicaps. Greater attention to the nutrition of the pregnant woman should also result in lowered maternal morbidity and mortality, due to the better health of the mother during pregnancy and to the lessened incidence of complications, especially toxemia.

If the results of these studies warrant implications of such great public health importance, what can those of us who are especially interested in problems of public health do toward the accomplishment of these goals?

First of all, effective and practical education in the importance of nutrition during pregnancy and the ways in which the specific requirements for the nutritional essentials are to be met in the simple everyday diet of each case should be a routine part of prenatal care. In the long-range program the amount of nutrition education, both theoretical and practical, which the medical and nursing students receive should be increased. Nutrition should be introduced into the general educational program, so that the young married woman understands the increased nutritional demands of pregnancy and has already as the result of proper health education established normal food habits which have become a part of her daily life.

The best public health approach to the education of pregnant women in the importance of nutrition both to themselves and to their unborn infants, and the offering of practical advice on diet during pregnancy would be to include one or more suitably trained nutritionists among the personnel required to staff prenatal clinics. These nutritionists would coöperate with the clinic obstetricians to see that, unless there are real medical contraindications, the pregnant woman will be able to include in her diet the food necessary to meet her increased requirements, without undue gain in weight.

The time has come when there should be a clear realization by the obstetrician or general practitioner handling prenatal cases of his responsibility in regard to the diets of the pregnant women in his care. In private practice the obstetrician would add materially to the benefits of his prenatal care if such care included detailed practical dietary advice. He might handle in the routine prenatal visits those nutritional cases which presented no special dietary problems and refer his more difficult nutritional cases to a suitably trained nutritionist whose services were obtained on a consultation or special service basis. The general practitioner who wishes to offer practical dietary help to his prenatal cases would find the nutritionists employed by departments of health able to offer valuable practical nutritional assistance to his patients.

Bethell [13] says: "The prevalence of suboptimal nutrition, as measured by present standards and the degree of improvement after dietary instruction testify to the value of nutritional evaluation and therapy as a part of prenatal care for the population at large as well as for the distinctly underprivileged in large cities." Where outpatient food clinic facilities or other means of nutrition consultation are available, such services as a part of standard prenatal care could be provided at a cost which would seem a moderate price to pay for increased maternal and infant health and for lowering fetal and infant mortality rates.

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# DISCUSSION

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I AM sorry that Dr. Kirkwood cannot be present to discuss this paper himself because he is far better fitted to do so from the obstetrical point of view than I am, and this is essentially an obstetrical problem. It is, however, of great interest to the pediatrician, the health officer, especially in connection with health education, and the nutritionist.

Dr. Kirkwood has read this paper and has asked me to emphasize the importance of certain points. I will, therefore, endeavor to make my discussion cover his thoughts as well as my own.

First let me emphasize what Mrs. Burke has pointed out that, although the accumulated evidence respecting the relationships between maternal nutrition and the condition of the infant at birth is very impressive, few and very guarded conclusions are justified as to the nature of these relationships. For example, the studies of Warkany and others on animals add weight to our findings in humans that a high incidence of congenital defects in infants is in some way associated with inadequate maternal diet. A close study of our cases, however, shows that in some at least genetic as well as other parental health factors were involved. It may be that a genetic factor, predisposing to anomalies in a given tissue or system, is present in many fertilized ova, but that whether or not defects actually develop is determined by the chemical constituents of the fluids constantly bathing the embryonic tissues. These chemical concentrations are most certainly influenced by the tissue stores and circulating levels of nutrients, and hence by the diet of the mother. They may also be influenced by digestive and metabolic disturbances or by other disease processes on the part of the mother or by placental abnormalities. It appears that any one of a number of nutrient substances may be involved. These are at present matters of speculation, and the practical public health worker who believes in keeping his feet on the ground will await the results of further investigations before drawing conclusions about them.

The significant and practical conclusion to be drawn from the studies described by Mrs. Burke is that a good diet during pregnancy is far more important to the health of the offspring than has previously been recognized. The old idea that the fetus is a true parasite certainly has to be modified, although the fetus probably is parasitic under most circumstances to a con-