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Fetal Nutrition

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The extensive literature on nutrition in pregnancy is reviewed with special reference to international experience, including observations on nutritional trials in pregnancy, pregnancy during famines caused by war, and studies of birth-weight in relation to pregnancy interval, parity and multiple pregnancies. Recent research on the significance of fetal nutrition suggests that " small-for-dates " infants, i.e., those that are developmentally retarded in utero, *suffer long-term developmental sequelae. A high world-wide incidence of small-for-dates births was reported by the World Health Organization in 1960.*

Although a definite correlation has been found between socio-economic status and birth-weight, it is not known to what extent the smaller birth-weights observed in the lower socio-economic groups can be improved by specific nutritional measures. In addition to the general advice given on maternal nutrition and family-planning, further studies are needed to determine the precise means of achieving improvement in fetal nutrition and a better outcome of pregnancy.

Impaired fetal development is linked to many perinatal conditions affecting both mother and child, and Churchill (1969) suggested that such impairment is caused by disturbances in the nutrition of the fetus. Investigations of fetal nutrition are of major importance in the research programme on child growth and development sponsored by the World Health Organization and in 1969 a special session of the Pan American Health Organization Advisory Committee on Medical Research was devoted entirely to perinatal factors affecting human development (PAHO Advisory Committee on Medical Research, 1969). The study of fetal nutrition is concerned not only with placental factors but also with maternal nutrition, and immunological, respiratory, toxic, physical and other factors may be involved as well.

Although the duration of gestation is sometimes difficult to ascertain accurately, birth-weight in relation to the duration of gestation is one of the main indices of fetal development. Babies of low birth-weight for gestational age are usually called " small-for-dates ". However, in developing countries it appears that retarded intrauterine growth is more commonly the cause of low birth-weight than is shortened gestation. Data from 37 centres that contributed 23 000 items on births to a WHO study of birth-weight (WHO Expert Committee on Maternal and Child Health, 1961, p. 4) show consistently that although the average duration of gestation is the same in both developed and developing countries, average birth-weights differ significantly (Table 1).

Several comparative studies have shown that low birth-weights in developing countries are due to environmental factors rather than to racial characteristics (Table 2). Achar & Yankauer (1962) studied the birth-weights of infants in southern India and found that women in the small group enjoying a high income, and who were presumably adequately nourished, gave birth to babies whose weights compared favourably with those of babies born in developed countries.

However, there are apparently some racial differences; for example, babies of American negroes are on the average smaller than those of whites, despite the fact that the adult stature of both groups is roughly the same. Among North American Indians, the distribution of birth-weights is similar to that found in whites, although adult Indians are on the

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TABLE 1

MEDIAN BIRTH-WEIGHT OF ALL LIVEBORN INFANTS AND THE PROPORTION OF INFANTS WEIGHING 2 500 g OR LESS TOGETHER WITH MEDIAN GESTATION PERIODS OF ALL LIVEBORN INFANTS [a]

Group [b]	Median birth weight (g)	Percentage of infants weighing 2 500 g or less at birth	Median gestation period (weeks)
Ireland	3 478	5.9	40.5
Poland	3 380	6.8	40.1
Lebanon	3 294	7.4	40.2
Venezuela	3 206	7.9	39.7
South Africa	3 199	8.2	39.6
Greece	3 287	9.5	39.8
Congo, Democratic Republic of	3 080	10.0	40.3
China (Taiwan)	3 106	11.3	40.0
Japan	3 029	11.3	40.2
Lebanon	3 150	11.9	39.8
Guatemala	3 078	13.3	39.5
Iran	3 024	14.2	39.4
Philippines	2 889	14.2	39.6
South Africa	3 040	16.0	39.1
Ethiopia	2 991	16.5	40.4
Malaysia (Malaya)	2 986	16.8	39.8
Sudan	3 057	17.3	40.2
Syria	3 057	19.9	39.8
India	2 771	28.0	40.6

[a] Data from the WHO Study on Birth Weight (WHO Expert Committee on Maternal and Child Health, 1961, p. 4).

[b] The groups which are constituted on the basis of reports received from various groups of participating institutions in the countries mentioned are arranged in order of the increasing proportion of infants weighing 2 500 g or less.

average 4 cm shorter than adult whites (Rosa & Resnick, 1965). Birth-weight is also closely correlated with maternal stature. Montagu (1962) has shown that short mothers have babies of lower birth-weight than taller mothers. While the height of individuals varies widely because of genetic factors, the height of a social group may validly be used as an index of its pre-adult social and nutritional experience (Butler & Bonham, 1963). The fact that maternal stature is more closely related to infant size than is paternal stature demonstrates that maternal environment plays a more important role in the rate of fetal growth (Cawley et al., 1954).

The effect that nutritional experience has on stature was shown by Greulich (1957), who studied the physical growth and development of 898 American-born Japanese children and compared his findings with anthropometric data published by the Japanese Ministry of Education on children of the same age and sex born and raised in Japan. The California Japanese children were found to be taller, heavier, and more advanced skeletally. The study shows that favourable environmental factors, particularly good nutrition, can affect stature, which is usually considered to be a racial characteristic and, therefore, genetically determined and controlled. Where undernutrition is widespread, as in some developing areas, there is no doubt that low birth-weights are related to conditions of severe under-nutrition in pregnant women. In India, for example, Shankar (1962) found that average food intake in the last trimester of pregnancy was only 1650 calories daily. The depletion of nutritional reserves resulting from many, closely spaced pregnancies also contributes to low birth-weights in developing countries. The frequency of low birth-weights is even higher among anaemic women. A study of 500 cases of anaemia in pregnant women with haemoglobin levels below 6.5 g per 100 ml showed that the average birth-weight at term was only 2400 g, while in 1000 women with haemoglobin levels not lower than 10.5 g per 100 ml the average weight was 2800 g (Menon, 1968). Malaria infections, which tend to affect the placenta particularly, are also a factor in low birth-weights in countries where this disease is endemic (Jelliffe, 1968).

Inadequate nutrition of the fetus is not limited, however, to the less developed countries; poorly nourished pregnant women are to be found even in the most highly developed countries and among the upper socio-economic classes. An association between low birth-weight and cigarette-smoking in pregnancy has also been confirmed by Butler & Alberman (1969), who found in an analysis of the causes of death in babies of mothers who smoked that the main effect of smoking is on the rate of fetal growth. The causes were found to be those commonly associated with deaths of small-for-dates babies. Early pregnancies and inadequate spacing of pregnancies which occur in even certain developed countries, as well as twinning, elderly primigravidae, maternal diabetes and maternal vascular disease are all associated with low birth-weights.

TABLE 2

MEAN BIRTH-WEIGHTS ACCORDING TO SOCIO-ECONOMIC STATUS [a]

Place	Population	Subjects	Mean birth weights (g)	Source
Madras	Indian	Well-to-do	2 985	Achar & Yankauer (1962)
		" Mostly poor "	2 736	
South India	Indian	Wealthy	3 182	Venkatachalam (1962)
		Poor	2 810	
Bombay	Indian	Upper class	3 247	Udani (1963)
		Upper middle class	2 945	
		Lower middle class	2 796	
		Lower class	2 578	
Calcutta	Indian	Paying patients	2 851	Mukerjee & Biswas (1959)
		Poor class	2 656	
Congo	Bantu	" Very well-nourished "	3 026	Janz (1959)
		" Well-nourished "	2 965	
		" Badly-nourished "	2 850	
	Pygmies		2 635	
Ghana (Accra)	African	Prosperous	3 188	Hollingsworth (1960)
		General population	2 879	
Indonesia (Jogjakarta)	Javanese	Well-to-do	3 022	Timmer (1961)
		Poor	2 816	

[a] From WHO Expert Committee on Nutrition in Pregnancy and Lactation (1965).

CONSEQUENCES OF FETAL MALNUTRITION

For several reasons, little importance has been attached to the phenomenon of low birth-weight in developing countries. First, the problems of the neonatal period have been overshadowed by excessive, preventable mortality and morbidity in infancy and early childhood. Second, the cost of special care for infants of low birth-weight has been prohibitive. Third, the problem is relatively refractory to treatment, even in countries that can afford to organize intensive neonatal-care units. Fourth, and perhaps most important, it has been widely observed in developing countries that the newborn is mature relative to the birth-weight and, although underweight by international standards, i.e., weighing 2500 g or less, the respiratory and feeding problems encountered in infants of the same birth-weight in developed countries do not occur. Many professional workers have therefore suggested that the WHO criterion for low birth-weight should be modified in these areas.

Small-for-dates babies may have significant problems that have not been sufficiently recognized in developing countries. Several longitudinal studies undertaken in developed countries have shown that children who are of low weight for gestational age at birth do less well in intelligence tests than children of average weight for the duration of gestation and it is now well established that small-for-dates babies have an increased risk of neurological damage, which is frequently concomitant with mental retardation (Weiss & Jackson, 1969). Engleson et al. (1963) followed-up 61 dysmature infants to the age of 4–5 years and found that their heights, weights and intellectual levels remained inferior to those of children in the control group. Maughan (1965) reported a mental retardation rate of 15% among small-for-dates babies. These findings are due, at least in some cases, to developmental defects acquired during intrauterine life. Such defects may be of genetic origin, e.g. the trisomy 18 (E) syndrome (Smith, 1964), or of infectious origin, e.g., the congenital rubella syndrome. However, the important question concerns those children whose low birth-weight is not the result of known intrinsic defects. The question to be asked is what the long-term developmental consequences of malnutrition, caused by factors extrinsic to the fetus, are during intrauterine life.

In an increasing number of studies, early malnutrition has been associated with developmental damage and many of the reports at an international conference on malnutrition, learning and behaviour (Scrimshaw & Gordon, 1967) dealt with the striking consequences of inadequate nutrition during late infancy and the weaning period. However, inadequate nutrition *in utero* may be more significant since the critical period of brain growth appears to be before birth and during early postnatal life. Winick (1969) reported that the number of cells in the brain increases linearly until birth and then more slowly until about 6 months of age, after which there is little, if any, increase in the number of brain cells. Comparing animal and human data, Winick (*op. cit.*) suggested that inadequate prenatal nutrition may make the brain more vulnerable to subsequent postnatal insult and stated " certainly severe malnutrition of young infants will produce significant brain damage ".

The most convincing evidence that fetal malnutrition has long-standing developmental consequences comes from studies of identical twins in which genetic influences and, when the twins are raised together, discrepancies of postnatal environment may be discounted. Monozygotic twins show a wider disparity in birth-weight, because of a greater likelihood of unequal placental nutrition, than do fraternal (dizygotic) twins. Several investigators have studied identical twins of dissimilar birth-weight and found that the twin who weighed less at birth scored lower in tests of mental performance. Babson et al. (1964) followed up pairs of twins with one twin in each pair weighing at least 25% less at birth than the co-twin. Altogether, 9 of the 16 sets of twins studied were monozygotic; the average physical and intellectual differences favouring the larger of each pair were statistically significant. There was a mean difference of 6.6 points on the Binet IQ test and 2.7 points on the Peabody IQ test. Allen et al. (1962), in a retrospective study, found the largest average intrapair differences in birth-weight among monozygotic twins—the difference being more than twice the standard error. The severely retarded partner had an average birthweight handicap of 0.94 lb (0.43 kg); in 7 out of 12 monozygotic pairs, the defective partner weighed less than 90% of the co-twin's weight.

Willerman & Churchill (1967) tested two groups of identical twins aged 5–15 years; one, racially mixed, group was from a lower socio-economic class than the other, which was all white, and middle-class. In both groups, the members of pairs with the lower birth-weight had lower verbal and performance IQ scores. Falkner (1965), in a prospective study, followed up monozygotic twins whose birth-weights showed marked intrapair discrepancy and found that the differences in development persisted indefinitely.

Numerous experimental studies on birth-weights have been carried out with animals, the obvious advantage being that the role of nutrition can be easily isolated from that of other factors, and the timing and duration of nutritional deprivation can be precise. Osofsky (1969) recently reviewed these studies extensively. The fact that early malnutrition causes retardation has been confirmed in studies of numerous species. Chow & Lee (1964) showed that dietary restrictions imposed on rats during pregnancy and lactation have a permanent effect on the weight-gain of offspring. It is, of course, unwise to infer from the results of studies of rats that similar effects will be observed in man. The nutritional requirement of a litter is proportionately much higher than that of a human embryo and the rate of growth of various organs in lower animals is much faster than that of corresponding organs in man; in addition, the major differences in brain size and neurological development limit the applicability of animal data to man.

RELATION OF MATERNAL NUTRITION TO THE FETUS AND NEWBORN

A number of studies have sought to relate maternal nutrition to complications of pregnancy and child-birth and to the birth-weight and condition of the newborn. In a small retrospective study of hospital deliveries in Boston, Burke et al. (1943) showed that a statistically significant relationship exists between the diet of the mother during pregnancy and the condition of her infant at birth. Dieckmann et al. (1951) found no correlation between the weight and height of babies and the protein intake of their mothers, but found a strikingly significant correlation between the developmental condition of babies and the average protein intake of mothers. It was reported (Jeans et al., 1955) that the percentage of mothers with premature deliveries was twice as high among those with poor dietary habits as among those with better nutrition. Even more important, many of the infants born of poorly nourished mothers were of low vitality, and death-rates and incidence of multiple congenital anomalies were relatively high. However, these studies did not separate nutrition from associated socio-economic factors, prenatal care or other influences that might have been involved. Bagchi & Bose (1962) found that infants born to poorly nourished mothers in Calcutta weighed, on average, 181 g less than those born to well-nourished mothers in the higher socio-economic strata.

Conversely, Williams & Fralin (1942), after analysing the diets of over 500 women in Philadelphia, were not able to demonstrate a positive relationship between dietary adequacy and the occurrence of certain complications of pregnancy and childbirth; 250 women experienced normal pregnancy and childbirth although their food intake showed no variation from the rest of the group. Similarly, Sontag & Wines (1947), after studying the diet histories of 203 mothers in Ohio, concluded that the protein intake of mothers had no effect upon the developmental status of the infant at birth or during the first year. Other studies that have been negative or equivocal are those of Speert et al. (1951) who made a study of pre-term births in New York, McGanity et al. (1954) who studied outcome of pregnancies in Tennessee, and Mack et al. (1956) who studied complications of pregnancy in Detroit.

Several investigators have studied specific deficiencies in the maternal diet and their effects on children. For example, the relationship between iodine deficiency in the pregnant woman and cretinism in the infant became apparent many years ago. Children born to women suffering from iron-deficiency anaemia are known also to be susceptible to anaemia because of poor iron reserves. The evidence for predisposition to rickets is less clear since this is a complex disease; several investigators have observed rickets in the newborn (Begum et al., 1968). However, so-called "fetal rickets" may represent disturbances in skeletal formation not caused by deficiencies of vitamin D, calcium or phosphorus since the total requirement of calcium and phosphorus by the fetus represents only 2%–3% of the content of the mother's skeletal reserves.

Vitamin A deficiency is a serious problem in Indonesia in infants whose mothers were on a rice diet during pregnancy and consumed practically no vitamin A or its precursors (Oomen, 1961). A case of congenital absence of both eyes, possibly related to maternal vitamin A deficiency, has been reported from Madras, India (Sarma, 1959). Venkatachalam et al. (1962) documented a relation between the very low vitamin A and carotene levels in the serum of pregnant women in southern India and even lower levels in the blood of the umbilical cord in the newborn.

Deficiency of folic acid is widespread in developing countries and pregnancy predisposes women to manifestations of this deficiency, such as megaloblastic anaemia, especially in tropical areas and where diet is poor. This predisposition may be due to increased renal excretion of folic acid, or to other maternal changes, rather than to increased fetal demand, since the deficiency appears in early pregnancy when the embryo is still small. However, the higher incidence of folic acid deficiency in multiple pregnancies indicates that the fetus also plays a role. Severe malformations of the fetus have resulted from intake of folic acid antagonists early in pregnancy (Emerson, 1962; Thiersch, 1952). Hibbard & Smithells (1965) compared mothers of severely malformed offspring with mothers of normal children by employing the formimino–glutamic acid (FIGLU) excretion test in the perinatal period; in the former group, 65% of the tests were positive compared with only 17% in the latter group. The malformations were mostly of the central nervous system. A positive FIGLU test does not necessarily indicate dietary deficiency but may indicate some other disturbance of maternal folic acid metabolism. These studies are in need of confirmation. Several studies have given conflicting results for the relationship between folate supplementation during pregnancy and birth-weight, probably because of variations in the degree of deficiency in the different populations studied. Baumslag et al. (1970) compared Bantu women, whose diet is generally low in folate, with white women subsisting on an average European diet.

In the study, 63 Bantus received iron supplementation and 20% of their infants weighed less than 1815 g; 65 received iron and folic acid, and in this group all infants weighed over 1815 g at birth. No such difference was apparent in the white women.

Mothers belonging to a low socio-economic group in southern India were studied by Gopalan (1961); their daily caloric intake ranged from 1400 kcal to 1800 kcal per day and the mean protein intake (mostly of vegetable origin) was 40 g. The mean serum albumin levels of pregnant women were 3.0 g per 100 ml, which correlated significantly with values of 3.1 g per 100 ml found in their new born babies. This finding provides evidence that infants in these poor communities start life with incipient protein malnutrition.

Moghissi et al. (1969) reported a striking relationship between maternal α-amino acid levels of the blood and the birth-weight, length and cranial volume of their infants. This study suggests that fetal development is stunted when amino acids available to the fetus are diminished.

NUTRITIONAL TRIALS

In an effort to isolate the influence of nutrition, various trials have been designed in which the diet of one group of pregnant women was supplemented while that of a matched control group was not changed, and the outcome of pregnancy in both groups was compared. These studies have produced conflicting results, since existing conditions within developing countries and within certain segments of developed countries make it impossible to isolate malnutrition from the complex of social and economic ills that define the condition of poverty.

A team led by Ebbs studied three groups of pregnant women in Toronto (Ebbs et al., 1941): one was a low-income, poorly nourished group, the second was also a low-income group but received additional protein and vitamins during frequent visits, the third group had adequate incomes and diets. Of the women in group 1, 6% experienced pregnancy loss as compared with 0 in group 2 and 1.2% in group 3; 8% of group 1 were delivered before term as compared with 2.2% of group 2 and 3% of group 3. The chief criticism of this study is that the frequent visits to group 2 may have had an effect that biased the results. In a prospective study in Philadelphia, Kasius et al. (1955) found no significant relationship between nutritional supplementation of the mothers' diet during pregnancy and the physical size and growth of their infants.

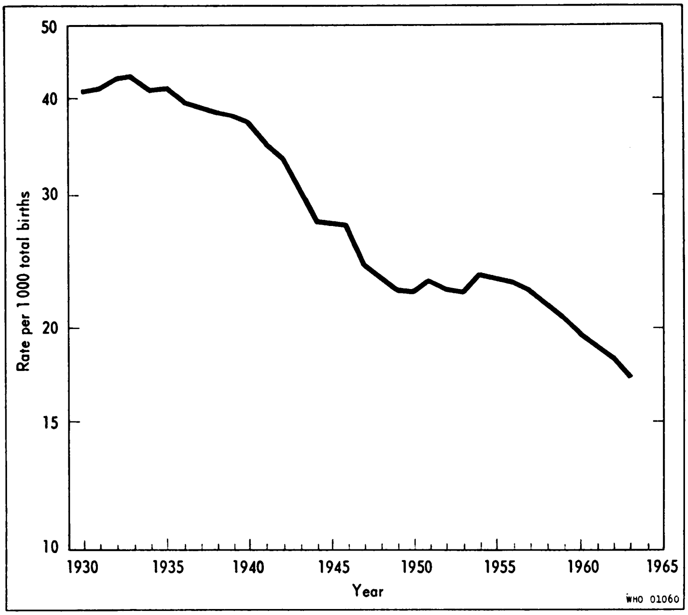
A review of the literature leads to the conclusion that dietary supplements given to pregnant women in developed countries do not consistently improve the outcome of pregnancy. One explanation may be that by the time the woman is pregnant it is too late to improve her nutrition; perhaps supplements should be given before pregnancy or in childhood. The importance of the woman's nutritional status during her childhood seems to be supported by the finding of Wolf & Drillien (quoted by Masland, 1958) that prematurity is more strongly associated with the economic class of a child's maternal grandfather than with that of the child's father. Another explanation may be that the degree of undernutrition in these women in developed countries was not severe enough for the outcome of pregnancy to be affected significantly by dietary supplements. Still another explanation may be that the cohorts studied were not large enough to show small, but possibly important, influences.

To date there have been no adequately controlled trials of dietary supplementation during pregnancy among severely undernourished women in developing aeras. Studies made in the Congo (Neven & Holemans, 1959), in India (Venkatachalam, 1962) and in the Philippines (Acosta-Sison & Villanueva, 1954) showed improvements in birth-weight after the pregnant women were hospitalized and received a better diet. However, it is difficult to rule out the selective bias in hospitalization and in none of the studies was it indicated whether there was a bias towards longer gestation in the women who were hospitalized (lack of hospitalization or less time spent in hospital may have been the result of premature delivery rather than the cause of it). It is also impossible to segregate the effects of bed-rest and the management of other complications (particularly of malaria in the Congo) from the effects of a better diet.

Observations made during times of war

Several studies of birth-weight in relation to prevailing food shortages were made during the First World War, and further observations were made during the Second World War. Antonov (1947) reported that in the USSR birth-weights dropped 500 g during the siege of Leningrad. Smith (1947) found in the Netherlands that infants conceived before the famine of the last year of the war were significantly below the expected norms for

FETAL DEATH RATES IN ENGLAND AND WALES DURING 1935–63; 28 WEEKS GESTATION AND OVER [a]



[a] Data from National Centre for Health Statistics (1968, Table 1).

weight and length; no effect was noted upon the incidence of stillbirths, neonatal deaths or failure of lactation, even though amenorrhoea and infertility were so common as to reduce strikingly the expected number of births. In England it was observed that the stillbirth rate decreased during the war. There have been two explanations suggested for this phenomenon. One attributes the reduction to the special rations and care that the mothers received; the other suggests that wartime restrictions reduced some deleterious factor of overnutrition. However, it is significant that later observation shows that the fetal mortality continued its downward trend after the war (see accompanying figure).

The conclusion to be drawn from these studies is that acute food restriction in a formerly well-nourished population has surprisingly few harmful effects on the outcome of pregnancy, even though it may lead to amenorrhoea and infertility. In contrast, chronic moderate undernutrition in the human has relatively little effect on fertility but results in low birth-weight.

It is believed that there have been no follow-up studies on the effects of prenatal nutritional stresses in wartime on the performance, behaviour and development of offspring.

PREGNANCY INTERVAL, NUMBER OF PREGNANCIES AND FETAL NUTRITION

Intrauterine nutrition may also be involved in the effects that age, parity and intervals between successive pregnancies have on birth-weights. For example, babies of very young mothers have lower birth-weights than those of older mothers; this difference may be the result of the nutritional demands of pregnancy being added to the increased requirements of the mother herself to meet the acceleration of growth and development that follows puberty (Joint FAO/WHO Expert Committee on Nutrition, 1967). Food fads and a desire to conform to the current fashion to be slender may also aggravate an unsatisfactory nutritional status in a young mother. However, parity is also a factor in birth-weight, first-born babies being, on average, of lower birth-weight than subsequent ones. When maternal age and parity are analysed together, it is clear that parity has the greater effect. Achar & Yankauer

(1962) confirmed this observation in an important study in India where the nutrition of adolescents is very poor and the age at first pregnancy is frequently very young.

Parity and the birth interval may also influence fetal nutrition but it is difficult to isolate these factors since high parity and short birth intervals are frequently associated with poverty. However, several studies have demonstrated the relation of high fetal and infant mortality rates to short birth intervals (Yerushalmy, 1945; Wyon & Gordon, 1962) and short birth intervals have also been associated with low birth-weights in both developed and developing countries. Bishop (1964), in a study of 16 000 consecutive deliveries in Philadelphia, found the incidence of prematurity to be 18% when the birth interval was less than 12 months, 10.3% with an interval of 12–23 months, and 7.8% with an interval of more than 23 months. In a study in Uganda, Saxton (personal communication) found that infants whose birth-weight was under 2500 g were born an average of 18 months after the mother's last pregnancy, whereas infants weighing more than 2500 g were born after an average interval between pregnancies of 30 months. These differences remained even when the annual income and educational status were taken into account.

Holley et al. (1969) analysed data from the prospective collaborative perinatal research study supported by the US National Institute of Neurological Diseases and Stroke (NINDS). They found that children born after an interval of less than 12 months were of lower birth-weight and scored lower on developmental tests at 8 months and 4 years of age than children born after a longer birth interval, even when matched with controls for race, age, social class and other factors. Holley & Churchill (1969), using data from the NINDS study, found that dizygotic twins had lower birth-weights, shorter gestational age, lower scores on the Bayley scale of infant development and a lower IQ than single children. Even when the comparisons were controlled for gestational age, twins scored an average of 13 points lower than single children in IQ tests at 4 years of age.

PREVENTION OF FETAL MALNUTRITION

As mentioned above, one reason for the problem of low-birth-weight infants not receiving attention in developing countries is that special care for such infants is extremely expensive. For example, the care of a low-birth-weight newborn in an intensive-care unit in a developed country may cost as much as US $100 per day and even then the results in terms of mortality and morbidity are not satisfactory. In contrast, the distribution of nutritional supplements to pregnant women costs only a few cents a day, and educational measures alone may be sufficient to improve maternal nutrition and the outcome of pregnancy. Thus, on the basis of comparative costs alone, it is clear that, in developing countries particularly, priority should be given to preventive measures rather than to the development of facilities to care for infants of low birth-weight.

Two principal preventive measures should be emphasized—namely, the improvement of nutrition in pregnancy either by means of suitable educational programmes or by the provision of dietary supplements, and the provision of family-planning aids to ensure that pregnancies are appropriately spaced.

These measures are closely inter-related in areas where a woman's fertility span is characterized by a continuous cycle of pregnancy and lactation, resulting in a serious drain on her nutritional reserves. The avoidance of pregnancy in early adolescence when the nutritional demands of growth have not yet been fulfilled, and planning for pregnancies to occur during the optimum period between the ages of 18 and 30 years can also contribute to improved fetal nutrition and development.

The additional amounts of nutrients required by a woman during a gestational period of 280 days and a lactation period of 180 days have been calculated and are shown in Table 3. Only a small proportion of these nutrients are required in the first 5 months of pregnancy; it is during the last trimester of pregnancy that the combination of an inadequate food intake and poor nutritional reserves begins to take a toll on the developing fetus. In those areas where diets are very low in calories it is possible that a simple supplementation to meet caloric demands in the last 3 months of pregnancy would contribute to a better outcome of the pregnancy. In other areas, calories may be adequate but the low protein intake of about 30 g per day should be improved. When attempts are made to improve the maternal diet, it is important that cultural beliefs, particularly those connected with pregnancy, should be known and sympathetically handled.

Other measures that may be helpful in correcting the maternal nutritional status, and correspondingly the birth-weight of the infant, include the manage-

TABLE 3

AMOUNTS OF NUTRIENTS REQUIRED BY A WOMAN DURING A GESTATIONAL PERIOD OF 280 DAYS AND A LACTATION PERIOD OF 180 DAYS

Nutritional factor	Quantity	Reference
Calories	219 200 kcal	Food and Agriculture Organization (1957)
Reference protein	3780 g	Joint FAO/WHO Expert Group on Protein Requirements (1965)
Calcium	230–368 g	Joint FAO/WHO Expert Group on Calcium Requirements (1962)
Ascorbic acid	7200 mg	Joint FAO/WHO Expert Group on Requirements of Ascorbic acid, Vitamin D, Vitamin B_{12}, Folate, and Iron (1970)
Folacin	74 mg	
Niacin equivalent	1440 mg	Joint FAO/WHO Expert Group on Requirements of Vitamin A, Thiamine, Riboflavine and Niacin (1967)
Riboflavine	118 mg	
Thiamine	100 mg	
Vitamin A	243 000 IU	

ment of anaemia and improvement in the folate intake. Measures against parasites, particularly malaria and intestinal parasites, are important adjuncts to nutritional improvement during pregnancy in some areas, while the avoidance of overwork in the later stages of pregnancy, particularly by those women whose diet is inadequate, can also contribute to better fetal development.

RÉSUMÉ

NUTRITION FŒTALE

A titre de contribution au programme de recherche de l'OMS sur la croissance et le développement de l'enfant, on a procédé à une revue d'ensemble des très nombreux travaux consacrés au problème de la nutrition pendant la grossesse. On a tenu compte des observations faites dans diverses régions du monde et concernant les essais contrôlés d'apport supplémentaire de nutriments aux femmes enceintes, l'influence des périodes de disette sur l'évolution des grossesses, le développement de l'enfant en fonction du poids à la naissance, de l'intervalle entre les grossesses, de la parité et des grossesses multiples. L'interprétation de ces données est entravée par l'impossibilité de dégager les aspects strictement nutritionnels de l'ensemble complexe des facteurs génétiques, infectieux, immunologiques et physiques qui influent sur l'issue de la grossesse.

L'un des principaux indices du développement fœtal est le poids à la naissance en relation avec la durée de la gestation. En 1960, une étude de l'OMS portant sur 23 000 observations montrait qu'une proportion élevée des nouveau-nés présentait un faible poids à la naissance par rapport à l'âge gestationnel. L'importance de ce phénomène n'a été reconnue que tout récemment. Si l'on analyse les résultats d'enquêtes périnatales longitudinales et d'études de jumeaux, on constate que la malnutrition fœtale n'entraîne pas seulement un retard du développement *in utero* mais aussi, à long terme, des déficiences physiques et mentales, qui se manifesteront après la naissance.

On note très généralement une étroite corrélation entre le poids de l'enfant à la naissance et le niveau socio-économique de la famille: les femmes des classes pauvres mettent au monde des enfants dont le poids est inférieur à celui des enfants nés de mères appartenant à des milieux plus favorisés. Le rapport est manifeste, que la comparaison soit établie à l'échelle internationale ou qu'elle porte sur différents groupes de population d'un même pays. La pauvreté engendre chez la mère un mauvais état de nutrition auquel on a imputé l'insuffisance de poids de l'enfant à la naissance. On a donc procédé à divers essais visant à fournir à la future mère un complément de nutriments, de façon à accroître le poids du nouveau-né et à éviter l'apparition de certaines complications au moment de l'accouchement. De l'étude critique de ces tentatives, il apparaît que leurs résultats sont peu concluants et qu'il importe d'effectuer de nouveaux essais dans des pays en développement.

En l'absence d'éléments permettant de définir des mesures spécifiques de prévention de la malnutrition

fœtale, les auteurs mettent l'accent sur la nécessité de pourvoir aux besoins nutritionnels de la femme pendant la grossesse et la lactation. Une planification familiale devrait permettre d'espacer les grossesses et de différer la première jusqu'à ce que la jeune fille ait achevé sa croissance et son développement. Dans certaines régions, la lutte contre les maladies infectieuses et les parasitoses doit être intensifiée. Enfin, il importe d'éviter à la femme enceinte tout travail pénible durant les dernières semaines de la gestation. On peut espérer, par ces mesures, améliorer la nutrition du fœtus et assurer une issue plus favorable à la grossesse.

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