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WORLD HEALTH ORGANIZATION

TECHNICAL REPORT SERIES

No. 302

NUTRITION IN PREGNANCY AND LACTATION

Report of a WHO Expert Committee

This report contains the collective views of an international group of experts and does not necessarily represent the decisions or the stated policy of the World Health Organization.

WORLD HEALTH ORGANIZATION

GENEVA

1965

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1965

WHO EXPERT COMMITTEE ON NUTRITION IN PREGNANCY AND LACTATION

Geneva, 6-12 October 1964

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NUTRITION IN PREGNANCY AND LACTATION

Report of a WHO Expert Committee

The WHO Expert Committee on Nutrition in Pregnancy and Lactation met in Geneva from 6 to 12 October 1964. Dr P. Dorolle, Deputy Director-General, opened the meeting on behalf of the Director-General. Professor W. J. Darby, Jr, was elected Chairman and Professor J. Sénécal Vice-Chairman.

INTRODUCTION

Reports from many parts of the world have illustrated a general association between low birth-weights, high foetal and infant mortality rates, and diets of poor nutritive value; and it seems reasonable to conclude that undernutrition and malnutrition among mothers, especially in the developing countries, contribute towards impaired maternal, foetal, and infant health and vitality.

With these considerations in mind, the Joint FAO/WHO Expert Committee on Nutrition (1962) noted that:

> Expectant and nursing mothers, infants and children constitute vulnerable groups of a population from the nutritional standpoint and merit special consideration. The usual diets of women in most of the developing countries have been found nutritionally inadequate, and the special needs of pregnancy and lactation seem to have received little consideration. Hence these states of physiological stress may aggravate chronic dietary inadequacy and thus adversely influence the course and outcome of pregnancy, foetal growth and the health and growth of the infant. It must be emphasized, therefore, that a high priority should be given to a study of maternal and infant malnutrition and of possible preventive measures.

After dealing with several specific topics that were thought to merit investigation, the Joint Committee recommended that an Expert Committee on Nutrition in Pregnancy and Lactation be convened to consider critically the different aspects of the problem, taking socio-economic, cultural, and environmental factors into account. The proposed Committee should also attempt to define nutritional requirements in pregnancy and lactation.

In fulfilling its assignment, the present Committee has considered the metabolic and physiological aspects of pregnancy and lactation that relate to changed nutritional needs during these periods. Despite the widespread convention of setting standards of dietary intakes to meet the estimated total dietary needs of the mother, the Committee considered that it should examine the basis of the increment in nutrient requirement occasioned by the changes occurring in pregnancy and lactation. Numerous aspects of the physiology of pregnancy and lactation, therefore, had to be considered.

The successive physiological adjustments that occur from conception to the end of lactation and the possible effects upon them of different nutritional states of the mother also underlie numerous other topics considered by the Committee : for example, changes in maternal body weight during pregnancy and lactation, the toxaemias and anaemias of pregnancy, the growth of the foetus and its vitality as expressed in statistics of "pregnancy wastage " and of " prematurity ", the accumulation or depletion of nutrients in the maternal and foetal organisms, and the yield and composition of breast milk and its relationship to the growth and health of the breast-fed infant.

Pregnancy and lactation have often been considered separately, but in the opinion of the Committee the whole reproductive process should be considered as a single physiological cycle. Their unity is also apparent in terms of their sociological, psychological and cultural impact upon the mother. In so far as pregnancy and lactation have been considered separately by the Committee, this has been for the sake of clarity and convenience only.

1. NUTRITION IN PREGNANCY

1.1 Physiological adjustments during pregnancy

From the standpoint of physiological function, pregnancy cannot be regarded as a process of foetal growth superimposed on the ordinary metabolism of the mother. Foetal development is accompanied by extensive changes in maternal body composition and metabolism.

The Committee prefers to use the term " adjustment " rather than " adaptation " to describe the physiological changes occurring during pregnancy. Adaptation implies adjustment to an essentially undesirable situation, whereas pregnancy is neither abnormal nor undesirable. Many of the adjustments begin in early pregnancy before foetal growth is appreciable and therefore cannot be interpreted as reactions to " stress ". Undoubtedly many of them are under hormonal control, although the precise mechanisms are poorly understood.

1.1.1 *General metabolism*

Basal metabolism increases during pregnancy, but the extent of the increase may have been over-estimated. Hytten & Leitch (1964) concluded that the increased cost of maintaining the product of conception and maternal tissues averages about 150 kcal per day during the last half of pregnancy. There are indications that general metabolism may be affected by alterations in hormonal balance in such a way as to favour anabolic processes (Beaton, 1961).

1.1.2 *Alimentary function*

The evidence for markedly altered gastric function during pregnancy is somewhat inconclusive. Nausea, heartburn and constipation are common, and there is evidence of reduced gastric tone, motility and secretion.

The efficiency of absorption of iron, vitamin B_{12} and certain other nutrients may increase, particularly in late pregnancy. Published calcium balance experiments suggest an increased efficiency of calcium absorption (Duckworth & Warnock, 1942), but most studies have been at high levels of intake and interpretation is difficult. Since adjustments in the efficiency of absorption of several nutrients are known to occur when dietary intake or body need is altered, such adjustments occurring during pregnancy may not be specific effects of pregnancy. Much more research is needed to establish the efficiency of absorption of nutrients during pregnancy, particularly at lower levels of intake and with diets of different characteristics.

1.1.3 *Renal function*

The glomerular filtration rate is considerably increased in pregnancy, as are the clearances of several substances (e.g., creatinine, urea, uric acid). The capacity to handle a water load changes, with unusually high rates of excretion in mid-pregnancy and very low rates in late pregnancy (Hytten & Klopper, 1963). Glycosuria is common. Amino acids are excreted in increased amounts and their pattern is altered. There are increased losses of inorganic iodine in the urine (Crooks et al., 1964). In contrast, calcium excretion in the urine has been found to decrease during pregnancy (Goss, 1962).

1.1.4 *Blood volume*

The plasma volume increases on average by about 50%, and the red cell mass by up to 20%. The concentration of haemoglobin and the packed-cell volume usually fall despite the absolute increase in total haemoglobin. The serum proteins also fall, but not all fractions change to the same extent. Many other changes in the composition of the plasma occur (see, for instance, Macy, 1958; McGanity et al., 1958). Some are well established in early pregnancy and appear to be anticipatory rather than reactions to established stress (Hytten & Thomson, 1964). Not all changes in concentration of the blood constituents are of the same magnitude or even in the same direction, and therefore haemodilution is not a sufficient explanation. The purpose of these many alterations in the composition and volume of maternal blood is presumably to facilitate the transport of nutrients to and removal of waste products from the foetus ; the controlling mechanisms are unknown.

It is clear that clinical standards considered " normal " for the non-pregnant woman cannot be used as standards for pregnant women. Biochemical indicators frequently used in nutritional studies so change during pregnancy and lactation that they may mislead the unwary who attempt to assess the nutritional status of the gravid woman by standards designed for the non-pregnant state. For example, there are progressive decreases in the haemoglobin concentration, erythrocyte count, packed-cell volume, total serum protein and certain fractions thereof (including albumin), and vitamin A and ascorbic acid, and decreased urinary excretion of thiamine and riboflavin. Simultaneously there occurs an increase in the serum concentration of carotene, tocopherols, cholesterol and N-methyl nicotinamide (Darby et al., 1953) ; the last is perhaps a result of increased conversion of tryptophan to niacin (Wertz et al., 1958). Failure to recognize such " normal " phenomena has led to many inaccurate appraisals of nutritional status and false claims concerning anaemia and deficiency states in pregnancy, and to misleading estimates of the requirements for certain nutrients. There is an immediate need for the establishment of biochemical standards in relation to healthy, pregnant, and lactating women, for use in appraising nutritional status during the reproductive cycle.

1.1.5 *Water metabolism*

The total body water may increase by as much as seven litres, and in late pregnancy the kidney may have some difficulty in disposing of the surplus water ingested. Hytten & Leitch (1964) have made theoretical estimates of the distribution of water in the various tissues associated with the reproductive process and have compared them with measurements of the actual total body water. As shown in Table 1, the measured average gain in total body water in their patients (gaining 12.5 kg in body weight) amounted to 7000 g, while only 5800 g could be accounted for on theoretical grounds. They postulated that the difference of 1 200 g, which appeared only in the last ten weeks of pregnancy, was attributable to an increase in extracellular fluid.

Little direct evidence is available at present on the partition of water in the various body compartments during pregnancy. It is recognized that the partition might be affected by nutritional status. More research is needed to define the distribution of water during pregnancy and its variations under different circumstances. It should be recognized, however, that the behaviour of certain compounds, such as antipyrine and urea,

TABLE 1. WATER COMPONENT OF WEIGHT GAINED IN NORMAL PREGNANCY *

	Estimated water content (g) of mother and foetus after following number of weeks of pregnancy [a]		
	20	30	40
Foetus	264	1185	2343
Placenta	153	366	540
Liquor amnii	247	594	792
Uterus	483	668	743
Mammary gland	135	270	304
Maternal blood	538	1156	1083
Total	1820	4239	5805
Measured increment of total body water	1500	3750	7000

* Adapted from Hytten & Leitch, 1964.
a Total weight gain = 12 500 g.

which are frequently used in such studies, may be altered during pregnancy thus providing misleading results.

The changes in other body constituents are discussed later in this report.

1.2 Diets of pregnant women

Data on the dietary intake of women during pregnancy and lactation should provide answers to the following questions:

What does a pregnant woman eat and how does she alter her diet as pregnancy progresses and during lactation?

Does her diet during this period differ quantitatively and qualitatively from that during the non-pregnant state?

Do socio-economic conditions, cultural patterns, beliefs, taboos, or advice from the midwife or obstetrician influence her diet, and if so how?

How does her diet compare with appropriate standards of recommended dietary intakes?

Such information would be useful in medical care and public health programmes and would aid in assessing the reasonableness of standards for varying conditions. Unfortunately, satisfactory published information is extremely scanty. Particularly is this true of data from developing countries.

The majority of the dietary surveys in developed countries have been made by keeping seven-day records of food consumption, either weighed or recorded in household measures. In some instances, dietary " recall " has been used, but this method has been found less precise and reliable. In developing countries the diets usually have been assessed by detailed questioning in the home concerning the foods used. Calibrated household containers have been employed as aids in assessing quantities. The difficulties and techniques of dietary surveys are considered at length in many reviews (Reh, 1962).

The appraisal of dietary data would be facilitated if reports included information on factors known to influence requirements — such as body size, physical activity, weight change during pregnancy, and time of pregnancy — or at least some circumstancial detail concerning the health and manner of life of the groups being investigated. Unfortunately, dietary survey reports rarely include such information. It appeared to the Committee that the average calorie values of some diets reported from developing countries are improbably low; as, for example, when the average barely exceeds the estimated basal metabolic requirements of individuals of similar body size. In such instances the records of dietary intake may have been incomplete, or the sample may have been grossly biased in some unrecognized way.

1.2.1 *Evidence concerning nutrient intakes*

Most of the recently reported information on the nutritive value of diets taken by pregnant women is summarized in Annex 1. Despite the limitations referred to above, a general appraisal of the data indicates that in developed countries the diets of pregnant women provide an average intake of more than 2000 kcal, usually 2400-2700 kcal, while in developing countries the average reported intakes are in the range of 1500-2000 kcal. In the latter countries, however, the surveys have been almost exclusively carried out among the poorest sections of the populations. The average kcal value of 2760 reported for well-to-do women in Calcutta (Bagchi & Bose, 1962) compares favourably with diets in the developed countries. Lower levels of 2000-2100 kcal reported from the USA probably reflect the effectiveness of the advice of physicians in an effort rigidly to control weight gain during the last trimester of pregnancy.

If the average intakes exceed some 2000 kcal, the values rise relatively little (100-200 kcal daily) from early to late pregnancy, and according to some reports there was a small decrement. Such decrements may reflect efforts to control the weight gained during pregnancy. This phenomenon requires further study, in order to reconcile it with the estimates of the calorie needs of the mother during gestation, taking into account varying levels of activity, gains in weight, body composition, and other parameters.

In a study of low-income women in Hyderabad, India (Shankar, 1962), the average kcal consumption was reported as 1390, 1520, and 1650 daily during the first, second, and third trimesters respectively. It might be inferred from this report that at the lower intake levels women do increase their calorie consumption by 200-300 kcal if this is possible. Additional data of this sort would be valuable.

The proportion of calories derived from protein is around 12% for most western-type diets. Despite values of similar magnitude from Egypt and Israel, the more usual range reported among the poor in developing countries is between 8% and 10% of calories from protein, mainly of vegetable origin. Extremely low values of 5%-8% are reported from poor diets based on sweet potato and sago (Oomen & Malcolm, 1958).

Intakes of calcium exhibit similar differences between the more and less abundant dietaries, usually clustering about 0.8-1.1 g daily in the developed countries (with lower intakes among the poor) and 0.3-0.5 g daily in the less wealthy countries (except among the economically well-to-do, for whom the reported levels are similar to those in the developed countries).

The data available on intakes of vitamins A and C, riboflavin, niacin, and thiamine are especially meagre for pregnant women in the developing countries. It would be logical to expect these nutrients to vary with socio-economic position as do other dietary components, modified perhaps by the ecological setting. On the other hand, there is little difference by socio-economic class or by country in the recorded dietary content of iron in most of the groups surveyed. In view of the importance of iron-deficiency anaemia, the iron content of diets and the physiological availability of iron in food merit more critical and intensive study.

Little information exists on the dietary intakes of several other important nutrients—iodine, vitamins B_6 and B_{12}, and folate. Unfortunately, the limitations of present methods for determining quantitatively these vitamins in foodstuffs, and the uncertainties about the utilization of several active forms and their availability from foodstuffs do not hold out much promise that this gap in knowledge will be quickly filled.

By comparison with recommended allowances, diets in developed countries seem likely to be deficient in calcium only, whereas diets in developing countries are likely also to be low in vitamin A, the B vitamins, and ascorbic acid. Clinical signs of frank nutritional deficiency are, however, infrequently reported even in developing countries. The assessment is complicated by the fact that investigators use different criteria to judge deficiencies.

1.2.2 *Alterations of diet during pregnancy*

In general, the diets of pregnant women are influenced by the same considerations as are important in determining diets in general. The evidence discussed above emphasizes the importance of the economic factor.

There are, however, influences that are peculiar to pregnancy, though not enough is known about them to assess their effect. Reference has already been made to the effect of obstetric advice aimed at limiting the amount of weight gained by pregnant women. Pregnant women may themselves alter their diets as a result of cravings for particular kinds or forms of food, or even for substances normally regarded as non-edible and non-nutritious (pica).

Cultural factors may be influential, particularly in some communities in the developing countries. Many beliefs regarding diet in pregnancy are of a prohibitory nature, the taboos and restrictions varying a great deal from place to place, even within a small area. They require further study, especially because knowledge of their nature and significance may suggest specific ways of improving the nutritive quality of diets taken by pregnant women.

1.3 Diet as a factor that may influence the course and outcome of pregnancy

The clinical course of pregnancy and childbirth depends on the combined influence of a host of genetic and environmental factors, and a thorough knowledge of the "natural history" and "epidemiology" of human reproduction is required before we can fully understand the effect of diet during pregnancy upon the outcome. The socio-economic gradient in the nutritive values of diets and a similar socio-economic gradient in clinical statistics are often taken as a *prima facie* reason for postulating an effect of diet. But mothers in differing socio-economic groups vary not only in terms of food eaten but also in age, parity, physique, general health, education, and conditions of living and working; and the standards of medical care available vary as well. It is, in fact, almost impossible to isolate groups that differ in diet but are similar in all other relevant respects.

1.4 The course and outcome of pregnancy

The Committee considered four topics thought to be of particular interest from the point of view of nutrition:

1.4.1 *Foetal and neonatal mortality*

Stillbirth and neonatal death rates usually show a socio-economic gradient. The rates are low where the standard of living is high, and high where the standard of living is low. There are exceptions: the rates among poor-class Chinese women in Hong Kong appear to be remarkably low by any standard (Thomson, Chun & Baird, 1963).

Not much reliable information exists about variations in causes of stillbirth and neonatal death according to socio-economic status. An analysis of the data of the United Kingdom Perinatal Mortality Survey

(Illsley & Kincaid, 1963) suggests that there is a distinct "poverty gradient" in nearly all causes of perinatal death. This might be expected if nutritional influences underlie the gradient. The undernourished or malnourished foetus or neonate would probably exhibit a general depression of vitality and thus an increased liability to succumb from a wide range of immediate causes of death.

Special mention may be made of congenital malformations, which have been produced in pregnant animals maintained on deficient diets (Warkany, 1958). There is as yet no proof of such effects in man, but some malformations, e.g., anencephaly, show well-marked geographical and socio-economic differentials, which might be partly of nutritional origin (Anderson, Baird & Thomson, 1958). The investigations of Robertson (1962) suggest that thalidomide might interfere with the metabolism of the B vitamins. Antimetabolites, such as those of the anti-folic-acid group, have a teratogenic effect in animals, and they may well have a similar effect in man.

Little is known about the causes of abortion, and there are great practical difficulties in determining the incidence even approximately. There seems to be no good evidence of a socio-economic gradient in abortion rates. Some authors have given figures relating to " total pregnancy wastage " — combining abortions with stillbirths — but such figures are impossible to interpret unless they are broken down into their component parts (WHO Expert Committee on Health Statistics, 1950).

First pregnancies have a relatively high risk of being complicated by pre-eclampsia and difficult labour, and are therefore associated with relatively high stillbirth and neonatal death rates. Youth is an advantage from the point of view of childbirth and foetal survival; the increased risks incurred by elderly primigravidae are well known to obstetricians. The rates of foetal mortality by age in primigravidae are complicated by the fact that in some areas the youngest primigravidae may come from the poorest strata of the community, and the advantages of youth may then be outweighed by the disadvantages of low socio-economic status.

Mortality rates are lower in second and third pregnancies than in first. As the number of pregnancies rises, the mortality begins to increase. A long succession of pregnancies results in an accelerated rate of physiological aging, which may be further accelerated if nutritional and environmental conditions are adverse; and in societies where the average family size is small, women having an unusually large number of children tend to be drawn selectively from the poorer socio-economic groups.

1.4.2 *Birth weight and "prematurity"*

There is a very large literature on birth weights in different communities, but interpretation of the data is complicated by the facts that most series are derived from births in hospital and are therefore more or less selected, and that many authors arbitrarily include or exclude " premature " babies. Table 2 gives some examples in which variations by socio-economic status have been investigated.

TABLE 2. MEAN BIRTH WEIGHTS ACCORDING TO SOCIO-ECONOMIC STATUS

Place	Population	Subjects	Mean birth weights (g)	Source
Madras	Indian	Well-to-do	2985	Achar & Yankauer (1962)
		"Mostly poor"	2736	
South India	Indian	Wealthy	3182	Venkatachalam (1962)
		Poor	2810	
Bombay	Indian	Upper class	3247	Udani (1963)
		Upper middle class	2945	
		Lower middle class	2796	
		Lower class	2578	
Calcutta	Indian	Paying patients	2851	Mukerjee & Biswas (1959)
		Poor class	2656	
Congo	Bantu	"Very well nourished"	3026	Janz (1959)
		"Well nourished"	2965	
		"Badly nourished"	2850	
	Pygmies		2635	
Ghana (Accra)	African	Prosperous	3188	Hollingsworth (1960)
		General population	2879	
Indonesia (Jogjakarta)	Javanese	Well-to-do	3022	Timmer (1961)
		Poor	2816	

Despite the difficulties of comparison, reports are remarkably consistent. In most European and American series the birth weight is of the order of 3300 g. In most other series mean birth weights are about 3000 g, with the exception of Indians, Ceylonese, and pygmies, where most means are about 2700 g.

There is clear evidence of a socio-economic gradient in birth weight within ethnic groups. In any given group the well-to-do mothers tend to have bigger babies than the poorer mothers. It is not clear whether differences in mean birth weight between ethnic groups are due mainly to environmental or to genetic differences.

It would be interesting if there were evidence of an upward secular trend in birth weights, paralleling the socio-economic and nutritional improvements that have undoubtedly occurred in some communities during recent decades. But the evidence is inadequate and what there is does not suggest any striking trend; it has been summarized by Hytten & Leitch (1964).

It is now increasingly realized that the term "prematurity" is misleading. The WHO Expert Committee on Maternal and Child Health (1961) has suggested instead the term "low birth weight", which is undoubtedly better but is probably still not sufficiently definitive, for the level of birth weight that is taken to be low may vary in different communities. Many different factors influence birth weight and hence the incidence of low birth weight, however defined. More scientific investigations of birth weight, within and between ethnic and national groups, are required, taking into account such factors as duration of pregnancy, parity, and maternal size, as well as socio-economic or nutritional status.

The difference in mean birth weights and in the so-called prematurity rates between ethnic groups is probably mainly due to differences in foetal growth rather than in duration of gestation, but it is difficult anywhere to obtain reliable information as to the duration of pregnancy and usually impossible in unsophisticated communities.

Birth weights tend to be higher and the incidence of low birth weight lower in multiparae than in primiparae. For this reason it is important to distinguish birth order in presenting data. Some of the difficulties of interpreting socio-economic differences in "prematurity" rates have been discussed by Thomson (1961).

Babies of low birth weight have relatively high mortality rates, as is shown by the data in Table 3, in which de Silva, Fernando & Gunaratne

TABLE 3. DISTRIBUTIONS OF LOW BIRTH WEIGHTS AND FIRST-WEEK DEATH RATES *

Birth weight (g)	United Kingdom		Ceylon		India	
	No.	% died	No.	% died	No.	% died
<1000	20	90	22	68	32	87.5
<1500	31	51.6	65	55	89	58.6
<2000	76	10.5	270	12	410	18.0
<2500	276	3.9	1123	2.7	1740	3.1
All under 2500	403	14.1	1480	7.7	2271	9.1

* From de Silva, Fernando & Gunaratne, 1962.

(1962) give low birth weights and first-week death rates derived from series in the United Kingdom (Sorrento Maternity Hospital, Birmingham), Ceylon (De Soysa Maternity Hospital, Colombo) and India (R.N.S.P. Hospital, Calcutta).

The death rates among all babies under 2500 g are considerably lower in the Ceylonese and Indian series than in the United Kingdom series ; but the weight-specific death rates are not greatly dissimilar. It is not known whether a similar standard of paediatric care can be assumed in all three series. The differences in the over-all death rates are apparently due to the fact that a much higher proportion of the Indian and Ceylonese babies were in the weight category 2000-2500 g with its relatively low mortality. But babies weighing 2500 g or less formed only 9% of all births in the United Kingdom series, as compared with 28% in the Ceylonese series, so that the contribution to total neonatal mortality from babies of low birth weight was much higher in Ceylon than in the United Kingdom, despite the lower mortality rate among such babies in the former.

1.4.3 *Pre-eclampsia and eclampsia*

The Joint FAO/WHO Expert Committee on Nutrition (1962) has observed that:

> A high incidence of pre-eclampsia and eclampsia has been reported among pregnant women of low socio-economic groups in some parts of the world. Conflicting views have been expressed as to the possible role of malnutrition . . .

The toxaemias of pregnancy are difficult to define with sufficient precision for epidemiological purposes. A very high standard of antenatal observation, and the adoption of agreed criteria, are certainly prerequisites for research into the incidence of pregnancy toxaemia and its variations. Even so, the difficulties of differentiating between pre-eclampsia and diseases such as chronic nephritis and essential hypertension would remain to be overcome. The United Kingdom Obstetric Medicine Research Unit at Aberdeen has found the working definition of pre-eclampsia suggested by Nelson (1955) to be of value for survey purposes: a rise of diastolic blood pressure to 90 mm of mercury or higher after the twenty-fourth week of pregnancy, without proteinuria (mild pre-eclampsia), or with definite proteinuria not attributable to infection (severe pre-eclampsia). Oedema is neglected in this definition. The Aberdeen workers have failed to find a " poverty gradient " in the incidence of pre-eclampsia, and Thomson (1959) has shown that women who developed pre-eclampsia took on the average diets of higher calorie value and nutrient content than those who did not. In the Vanderbilt survey (McGanity et al., 1954) the result was the reverse of Thomson's, i.e., women with pre-eclampsia took diets of lower calorie value than those without pre-eclampsia. This was interpreted as a result of the disorder, not as a cause. It may be observed that in some countries where undernourishment is common and where the average gain of weight during pregnancy is much less than that observed in the developed countries, the incidence of pre-eclampsia appears to be considerably higher than would be expected on the hypothesis that pre-eclampsia is favoured by overnutrition.

There is little doubt that eclampsia and the severer degrees of pre-eclampsia are more prevalent in communities where the standard of antenatal care is low and the milder manifestations are overlooked and allowed to progress to a severe degree. Most obstetricians believe that eclampsia is a preventable disease, the main method of prevention being the efficient management of pre-eclampsia. Similarly, most believe that restriction of the amount of weight gained during pregnancy forms a very important aspect of antenatal care, from the point of view of reducing the incidence of pre-eclampsia.

Though advice designed to restrict the food intake may incorporate suggestions for the improvement of dietary quality, there seems to be no scientific basis for believing that deficiency or excess of any essential nutrient predisposes to pre-eclampsia and eclampsia. A possible exception is sodium chloride. Many obstetricians prescribe low-salt diets during pregnancy, and these are certainly useful in the treatment, and perhaps in the prophylaxis, of oedema. More information is, however, needed on the role of sodium in pregnancy, and upon the possible adverse effects of severe sodium restriction.

The incidence of pre-eclampsia and eclampsia is so intimately affected by standards of antenatal care that it is difficult on the evidence available to define the precise role of nutrition in toxaemia, except to state that the nutritional status of the patient may possibly modify the course of the disease. Epidemiological surveys, using precise and objective definitions, may help further in the evaluation of the role of nutrition in the etiology or clinical course of the toxaemias of pregnancy.

1.4.4 *Anaemia*

The concentration of haemoglobin in the blood tends to be lower during pregnancy than at other times, because the plasma volume increases by about 50% on the average and the volume of circulating red cells by about 20%. The resulting fall in haemoglobin concentration may be about 2 g per 100 ml blood. It is not as a rule accompanied by hypochromia (low mean corpuscular haemoglobin concentration), and it must be emphasized that the fall in the blood haemoglobin concentration usually occurs despite an increase in the total amount of circulating haemoglobin.

Superficially, the physiological change resembles the manifestations of iron-deficiency anaemia and can often be reduced by giving iron in therapeutic quantities. In many antenatal clinics iron is therefore prescribed routinely. There is no sound clinical evidence that in a generally healthy population this benefits the normal mother or foetus. Sturgeon (1959) has shown in California that despite considerable " improvement " as judged by haematological criteria large doses of iron given during pregnancy conferred no apparent benefits. His treated and untreated mothers became haematologically indistinguishable six months after the birth, and at no time was there evidence of " improvement " in the babies.

A few pregnant women may show a greater fall in haemoglobin concentration than can reasonably be attributed to " haemodilution ". This may be due to some unknown defect of iron metabolism rather than to a primary shortage of dietary iron. If, therefore, the blood haemoglobin concentration appears to be low, the possible causes should be investigated and appropriate treatment instituted.

The WHO Study Group on Iron Deficiency Anaemia (1959) has suggested that " anaemia can be considered to exist " in the pregnant female when the haemoglobin concentration is below 10 g/100 ml, and the Committee agrees that this level may be accepted as a general indicator of the lower limit of physiological adjustment during pregnancy. In other words, women whose haemoglobin concentration becomes lower during pregnancy should be considered as potentially or actually anaemic and appropriate investigation and treatment instituted.

In most of the developing countries, this level may occur so commonly that the great majority of pregnant women would be considered as potentially or actually anaemic, and in practice it may be expedient to reserve detailed clinical investigation for women with a lower level. The practical implications of this will be discussed later (see section 3.4).

The consensus of the Committee is that in many areas of the world most anaemias in pregnancy have the characteristics of iron-deficiency anaemia. The causes may be several, among the most important being:

(*a*) increased blood loss due to systemic or intestinal parasitism;

(*b*) increased iron requirements for foetal growth, or impairment of iron metabolism during pregnancy;

(*c*) dietary iron deficiency, due either to insufficiency of iron in the diet or low physiological availability;

(*d*) inability, in women with initially depleted iron stores, to make up for blood losses during labour because pregnancies follow too rapidly on each other.

In a varying proportion of anaemic pregnant women the anaemia may be due to a deficiency of folate or vitamin B_{12} (more often the former) giving rise to megaloblastic anaemia. Frequently deficiencies of iron and folate exist simultaneously. This has been further substantiated by a prophylactic trial undertaken in Madras (Krishna Menon & Rajan, 1962).

Such anaemias are severe in that haemoglobin levels may fall to below 6.5 g per 100 ml, which may have serious consequences for the mother.

The reasons for folate deficiency in pregnancy are not obvious. They are probably dietary, but more information about them is needed.

1.5 Weight gain during pregnancy

The Committee was of the opinion that the question of weight gain in pregnancy should be considered in the wider context of energy exchange. As energy requirements obey the laws of thermodynamic equilibrium, any woman gaining a specified amount of new tissue during pregnancy while doing a given amount of physical work must be consuming sufficient food to permit such a gain. Different extremes are represented by wealthy, healthy, physically inactive women who have the opportunity to eat a good diet and others in rural and urban areas in developing countries who lack such opportunities and may have to continue heavy physical work up to the day of delivery.

The weight gain during pregnancy and its nature and significance must therefore be considered in relation to the widely differing ways in which women live in different regions of the world.

1.5.1 *Weight gain of pregnant women in communities considered to be well-nourished*

The published evidence is far from homogeneous, lacking consistency in the timing of measurements, including mixtures of normal and abnormal pregnancies, and being influenced by the amount of weight that obstetricians thought their patients ought to gain. Table 4 gives some examples of reported gain.

The variations are extremely large, the reasons sometimes being apparent, sometimes obscure. Most average gains reported from Europe and the USA are between 10 and 12 kg. It should be noted that the figures in Table 4 do not cover the whole of pregnancy. The Committee does not know of any measurements covering the whole of pregnancy from conception to the onset of labour.

1.5.2 *Weight gain in pregnant women of communities considered malnourished*

A limited amount of direct (Venkatachalam, Shankar & Gopalan, 1960) and indirect (Nicol, 1959; Hauck, 1963) evidence derived from India and West Africa indicates that the weight gain of pregnant women from rural communities is between 5 and 7 kg. Little published information exists on this matter, and the Committee recommends that more data be obtained to cover the different classes in both the developed and developing countries.

TABLE 4. AVERAGE GAIN IN BODY WEIGHT, MEASURED FROM FIRST TRIMESTER OF PREGNANCY

Author	Subjects	Average gain (kg)	Notes
Kerwin, 1926 (USA)	Mostly " labouring class "	7.5 (range 2.7 to 17.3)	Diets restricted
Plass & Yoakum, 1929 (USA)	Private patients, normal pregnancy	17.0	No information on diets
Lawson, 1934 (USA)	Normal private patients in " comfortable circumstances "	10.9 (range —5.4 to + 20.0)	Some dietary manipulation
Pugliatti, 1937 (Italy)	Abnormalities excluded	10.4	No information on diets
Stander & Pastore, 1940 (USA)	Normal healthy pregnancies	12.8	No information on diets
Kuo, 1941 (China)	Selected for normality	Primigravidae 10.6 Multigravidae 9.7	Diets not manipulated
Kerr, 1943 (USA)	Normal healthy pregnancies (women who lost weight excluded)	10.4	No information on diets
Tompkins & Wiehl, 1951 (USA)	Not stated	10.9	No information on diets
Humphreys, 1954 (UK)	Normal health pregnancies	Primigravidae 11.7 (S.D. 3.8) Multigravidae 10.7 (S.D. 3.8)	War-time rationing only
Thomson & Billewicz, 1957 (UK)	Primigravidae with normal blood pressure	11.4	Diets not manipulated
Ihrman, 1960 (Sweden)	Unselected hospital patients	10.2	No information on diets
Venkatachalam, Shankar & Gopalan, 1960 (India)	Poor-class women employed in tea plantation	Primigravidae 5.4 ± 0.76 Multigravidae 6.2 ± 0.44	Recognized to be taking diets of poor nutritive value

The Committee considered that the available evidence, although scanty, indicates that women living in developing countries do not on the average gain as much weight during pregnancy as most women living in developed countries. The weight gain involved appears to be only half as much. Nevertheless, the birth weight of the children of such women is on average not much below that of the babies of women in developed countries.

1.5.3 *The nature of the weight gain in pregnancy*

The components of the weight gain in average healthy well-fed Scottish women estimated to gain 12.5 kg during pregnancy are shown in Table 5 (Hytten & Leitch, 1964).

TABLE 5. COMPONENTS OF WEIGHT GAINED DURING NORMAL PREGNANCY *

	Increase in weight (g) up to:			
	10 weeks	20 weeks	30 weeks	40 weeks
Foetus	5	300	1500	3300
Placenta	20	170	430	650
Liquor amnii	30	250	600	800
Uterus	135	585	810	900
Mammary gland	34	180	360	405
Maternal blood	100	600	1300	1250
Not accounted for	326	1915	3500	5195
Observed total gain	650	4000	8500	12500

* Modified from Hytten & Leitch, 1964.

It is known that the weight of the placenta and the volume of the liquor amnii are related to the birth weight of the babies, and so presumably is the size of the uterus. The increase in the maternal plasma volume is related to foetal weight rather than to the plasma volume before pregnancy (Hytten & Paintin, 1963).

It should be noted that, after taking into account the growth of the product of conception, the enlargement of the organs of reproduction, and the expansion of the blood volume, about 5 kg of the overall weight gain remain unexplained. By determining the total body water at intervals during pregnancy, Hytten concluded that about 1 kg of the weight not accounted for at term may represent extracellular fluid (see section 1.1 and Table 1). The rest was considered almost certainly to be fat. This could well be so in well-nourished communities of good socio-economic level, the Committee felt, since mothers from such communities often report increased adiposity during pregnancy, especially around the lower trunk, hips, and thighs. Serial skinfold measurements have confirmed such an increase (Taggart, 1961).

In any event, it is clearly of the greatest importance that more information should be obtained in different environmental settings on the components of weight gain during pregnancy, its net amount, and its significance for health. The Committee considered that this applies to the conditions not only in developing countries but also in developed countries, where considerable doubt still exists about the extent to which weight gain is desirable.

1.6 Adult body size in relation to pregnancy

Considerable differences in average adult stature and body weight are known to exist between different populations. Adult stature is largely determined by genetic factors, and it is incorrect to hold that differences in average stature are entirely due to nurture rather than nature. Yet socio-economic gradients in adult stature have been demonstrated in some countries. The data of the United Kingdom Perinatal Mortality Survey show that the proportion of tall women (165 cm or more) falls from 41% among the wives of professional men to 26% among the wives of semi-skilled and unskilled manual workers (Illsley & Kincaid, 1963). In the USA, the average height of women aged 18 to 39 (in 1940) fell from 64.33 in (163.4 cm) when the family income was $3000 or more to 63.16 in (160.4 cm) when it was less than $1000 (O'Brien & Shelton, 1941).

TABLE 6. CORRELATION OF MATERNAL STATURE AND WEIGHT-FOR-HEIGHT WITH MEAN BIRTH WEIGHT *

Height of mothers	Mean birth weights (g) in relation to mothers' heights			
	Under 61 in (155 cm)	61–63 in (155–162 cm)	64 in & over (163 cm)	All heights
Weight-for-height [a]				
Underweight	2987	3110	3223	3114
Average	3114	3228	3396	3251
Overweight	3201	3351	3482	3355
Mean birth weight of all infants	3101	3228	3373	3242

* After Hytten & Leitch, 1964.

[a] "Underweight" mothers were in the lowest 25% of the distributions of weight according to height. "Overweight" mothers were in the upper quartile. "Average" mothers consisted of the remaining 50%.

The average height of women studied by Krishna Menon (to be published) in South India was 150 cm, with a probable non-pregnant body weight of 35 to 45 kg. His subjects came from the poorest segments of the population, and their average height was probably about 4 cm less than that of Indian women in general. It is probable that chronic subnutrition is one of the factors responsible for such socio-economic differences in average stature within ethnic groups.

There are hundreds of papers dealing with the physical measurements of children, and there seems little doubt that a socio-economic gradient in height and weight has been found wherever it has been looked for. Unfortunately, very little attention has been paid to the measurements of adults from this point of view, particularly in the developing countries. Most anthropometric surveys have sought morphological differences between ethnic groups and have not been concerned with socio-economic differences within such groups.

It would be expected that smaller women should have smaller babies and larger women larger babies. Table 6 gives the mean birth weights in a large series of Aberdeen primiparae (Hytten & Leitch, 1964). The short women had babies about 8% lighter on the average than the tall women, and the underweight women had babies about 8% lighter than the overweight. Tall *and* heavy women had babies about 14% heavier than short *and* light women. In the Vanderbilt study it was observed that within a given range of height heavier women had heavier babies, lighter women lighter babies. Somewhat similar observations have been made by Krishna Menon (to be published) in a study covering 300 women from the low socio-economic groups in Madras.

Baird (1945) showed that short women in a community have higher rates of stillbirth and difficult labour than tall women, and he and his colleagues have elaborated this theme in a number of publications. Table 7

TABLE 7. INCIDENCES OF LOW BIRTH WEIGHT, CAESAREAN SECTION AND PERINATAL MORTALITY IN SCOTTISH (ABERDEEN) AND CHINESE (HONG KONG) PRIMIPARAE, BY MATERNAL STATURE

<table>
<tr><th rowspan="2">Height (in)</th><th colspan="2">Birth weight under 2500 g (%)</th><th colspan="2">Caesarean section (%)</th><th colspan="2">Perinatal deaths per 1000</th></tr>
<tr><th>Aberdeen</th><th>Hong Kong</th><th>Aberdeen</th><th>Hong Kong</th><th>Aberdeen</th><th>Hong Kong</th></tr>
<tr><td>Under 57</td><td rowspan="2">16.3</td><td>19.3</td><td>25.8</td><td>20.5</td><td rowspan="2">41</td><td rowspan="2">19</td></tr>
<tr><td>57–58</td><td>11.6</td><td>12.5</td><td>5.0</td></tr>
<tr><td>59–60</td><td>10.3</td><td>6.6</td><td>5.3</td><td>3.1</td><td>29</td><td rowspan="2">17</td></tr>
<tr><td>61–62</td><td>6.9</td><td>6.7</td><td>3.3</td><td>2.3</td><td>26</td></tr>
<tr><td>63–64</td><td>6.2</td><td rowspan="2">5.7</td><td>2.7</td><td rowspan="2">1.8</td><td rowspan="2">24</td><td rowspan="2">14</td></tr>
<tr><td>65 & over</td><td>3.7</td><td>2.4</td></tr>
</table>

* From Thomson & Billewicz, 1963.

shows that the situation is similar in Chinese (Hong Kong) and in Scottish primiparae. This tendency may be explained, at least in part, on the hypothesis that many short women have been stunted during growth (Thomson, 1959a).[1]

Apart from its general significance as a possible indicator of nutritional status and its obstetric significance, maternal body size is of direct concern when estimating food requirements for pregnancy. The Committee felt, however, that not enough is known about differences of maternal body size (and of weight gain during pregnancy) between different populations to enable this factor to be taken into account in formulating estimates of the physiological cost of pregnancy (see section 3). More investigation is needed.

2. NUTRITION IN LACTATION

2.1 Physiological adjustments during lactation

Preparations for lactation begin during pregnancy. Apart from the growth and development of the mammary gland, maternal energy reserves (fat) are laid down during the earlier part of pregnancy in a well-nourished woman and may be available, in whole or in part, to subsidize lactation.

It has often been stated that metabolism during lactation enters a catabolic phase, but balance studies give little evidence to this effect. The few measurements available have mostly been made shortly after delivery, when the involution of the uterus would probably cause elimination of surplus nitrogen. It is probable that the general metabolic pathways and processes are not much different during lactation from what they are in a non-pregnant, non-lactating woman, except probably for the specialized processes involving the synthesis of milk protein, milk fat, and lactose. The processes of glandular secretion probably suffice for the excretion of other nutrients in milk. However, it seems that some physiological adjustments do take place in lactation; for instance, losses of calcium in milk are to some extent counterbalanced by the adjustment of renal function to reduce calcium excretion. According to Knapp & Stearns (1950), the excretion of calcium in the urine drops abruptly after parturition and remains below the mean normal value during the greater part of lactation. The extent and nature of other adjustments, if any, are not yet known.

Venkatachalam & Gopalan (1960) have suggested that poor Indian lactating women are in a greater state of hydration than non-pregnant, non-lactating women, but this has not been confirmed. Hytten & Paintin

[1] The association between maternal stature and, for example, birth weight is low when expressed as a correlation coefficient (Lesinski, 1962). It is important, when seeking to establish such interrelationships, to eliminate as many interfering variables as possible (e.g., parity and hospital emergency cases) and to use samples of adequate size.

(1963) found the maternal plasma volume to be back to its pre-pregnant size about two months after parturition, and maternal haematological characteristics are certainly back to " normal " then or soon afterwards.

With the possible exception of an increased trend towards calcium conservation, there thus seem at present to be no good grounds for assuming that maternal physiological characteristics during lactation differ in any general way from those of the non-pregnant state. The position during the earlier stages of lactation is, of course, complicated by the fact that the antecedent adjustments characteristic of pregnancy take some time to " wind down ". More information is needed on the nature and pace of the transition from the pregnant physiological state to that of lactation, and it has yet to be fully established whether there are any important differences between general physiological processes during mature lactation and in the non-pregnant, non-lactating state.

2.2 Efficiency of milk production

The energy in milk must be derived ultimately from the diet, but may at any time be subsidized by catabolizing maternal tissues. The energy exchanges of lactation, of course, form part of the total maternal energy metabolism, and may be represented in terms of the following equation :

$$L = e\ (D + S - M)$$

where L is energy output in milk

D is the energy available from diet

S is the energy contributed from (or to) maternal body stores

M is the cost of maintenance apart from lactation

e is a factor representing the efficiency of milk production.

L and D may be estimated directly or indirectly. The energy requirement of a healthy fully breast-fed baby may be taken as equivalent to L and may, under some conditions (e.g., where the milk output is inadequate or over-abundant), give a more representative figure than one derived from collection and analysis of the milk (Hytten & Thomson, 1961).

S cannot be measured directly and must as a rule be inferred from a knowledge of changes in maternal weight. M is assessed in terms of the energy needs of a non-pregnant, non-lactating woman of similar physique at a similar level of activity. The factor e must be determined from a knowledge of all the other terms.

The only published study that has attempted to deal with this equation as a whole is that of Hytten & Thomson (1961). They had data for the dietary intake, body size, change in body weight, and growth of the baby in a group of 11 primiparae who were breast-feeding successfully. The milk output was not measured directly, but a yield of 555 kcal daily was estimated on the assumption that the babies were receiving 120 kcal/kg (approximately equivalent to 800 ml milk at 70 kcal/100 ml). The women were losing 38 g daily on the average: taking the loss of 1 kg body weight as equivalent to the release of 6500 kcal, this represents a contribution from body stores of almost 250 kcal daily towards the energy exchanges. The average maintenance requirement was assessed as 2150 kcal daily. The average diets supplied 2580 kcal daily. The equation then became:

$$e = \frac{555}{2580 + 250 - 2150}$$

from which the value of *e* was calculated to be just over 80%.[1] Hytten & Thomson used this efficiency factor in conjunction with data in the literature and considered that it fitted the evidence better than the lower value of 60% previously accepted by the FAO Committee on Calorie Requirements (1957).

It may therefore tentatively be assumed that energy supplied in the diet may be used for milk production with an efficiency of at least 80%. Practically nothing is known about the efficiency of production of nutrients in milk.

2.3 Lactation in relation to the growth and health of infants

Mothers' milk in sufficient quantity is probably the best food for infants in the first months of life. Its chemical composition, particularly in terms of proteins, fats, and carbohydrates, seems the most appropriate for the needs of infants. Breast-feeding, bringing about a close relationship between mother and infant, seems also to be beneficial to the physical and mental development of the child; furthermore, by reducing the hazard of infection associated with artificial feeding, it protects the infants' health.

2.3.1 *Indicators of the adequacy of lactation*

Weight curves are the simplest indicators of the adequacy of lactation. Additional anthropometric measurements, such as total height or body segments, head and chest circumferences, and skinfolds are also useful, although more difficult to carry out. Comparison between weight and height always proves valuable. The health of the child may be assessed by the absence of disease and by clinical examination.

[1] An efficiency lower than 80% would, of course, be obtained if a lower calorie value for milk or a higher calorie value for the contribution from body stores were to be inserted in the equation. It is possible to elaborate and modify such calculations in many ways, but "Attempts at refinement are not likely to reduce, and may increase, the error. The real need is for more measurements." (Hytten & Thomson, 1961).

The age of eruption of deciduous teeth has not been shown to be a reliable indicator, as it does not seem to be affected by the child's nutrition. On the other hand, bone age is a sensitive indicator.

Psychological tests for mental development and biochemical investigations are used as tools for specific purposes. They are not necessary for simple evaluation of the adequacy of lactation.

Comparison of growth curves from different countries and communities is useful, particularly if based on longitudinal data (Falkner et al., 1958). It is difficult to define the ideal growth curve. However, for practical purposes, a gain of 800 g ± 20% per month during the first six months of life or the doubling of birth weight by about the end of the fourth month of life may be regarded as satisfactory.

2.3.2 *Measurement of milk yield*

Two techniques exist for measuring the milk yielded by the mother: (1) to weigh the child before and after each feed, or (2) to empty the breast by hand or mechanically.

Both techniques have their drawbacks. In the first, the quantity measured represents that taken by the child and not that secreted, which may be larger. This technique does not allow the taking of samples for determinations. In the second method, it is difficult to ensure that the breast is completely empty. Both methods suffer from the disadvantage that their application requires a set feeding schedule, the introduction of which may influence the milk yield, particularly if the mother is accustomed to feed the infant on demand. It appears necessary to make observations for at least a week to minimize the psychological effects of such procedures.

Many factors may influence the volume of milk production. They have been described by Janz, de Maeyer & Close (1957). They include the age and weight of the infant; age, parity, and the state of health of the mother; and individual variations.

2.3.3 *Composition of milk*

Study of the quality of milk is fraught with still more difficulties than that of its quantity. It is known that the composition of milk varies during a feed and over a 24-hour period, the amount of variation being most important in lipids. The variations during the feed and according to the time of day are more important than the variations from one day to the next. There also exist variations during the lactation period, colostrum differing from mature milk and the passage from one to the other happening progressively through "transitional milk" (production of which, according to the literature, may last from 15 days to two months).

There is less information on the composition of mature milk during substantially prolonged lactation, but work done in Africa in particular indicates that the milk composition remains practically unchanged, particularly for amino acids (Close, 1956). There may be modifications in the concentrations of casein, lactalbumin, and lactoglobulin.

Observations so far reported indicate that, even in countries where chronic malnutrition exists, human milk contains about one gram of protein per 100 ml, and the calcium content remains satisfactory even when the maternal diet is apparently poor in calcium. In general, our knowledge regarding the influence of maternal diet on the nutrient composition of milk is meagre, and this aspect deserves more study. Nutrients that are synthesized by the mammary gland may respond to dietary changes in a different manner from those merely transferred from maternal blood to the milk secreted.

2.3.4 *The role of lactation in western cultures*

The extent of lactation is different in different countries and cultures. In many affluent countries the proportion of women who breast-feed their infant does not exceed 20%, and lactation is often of short duration. Medical, social, cultural, and economic factors contribute to these variations in practice. Often there is an obvious lack of enthusiasm on the part of medical and para-medical personnel in encouraging women to breast-feed their infants. The availability of acceptable and convenient infant feeding formulations and their promotion through advertising has contributed greatly to this trend towards a decrease in lactation. Another factor in sophisticated communities is probably the embarrassment caused by exposure of the breast.

In countries where safe milk and other commercial products are available and the mothers are educated and medically supervised, this situation, although regretted by some, does not seem to have undesirable results.

2.3.5 *Lactation in the developing countries*

In the developing countries breast-feeding is still the rule, and lactation may be prolonged for considerable periods. Breast milk is usually the sole or main food of infants up to 3-4 months of age, and it is remarkably satisfactory.

The Committee wishes to point out that, even in areas where undernutrition and malnutrition are believed to be widespread, records of the growth and development of infants up to 3-4 months of age are in general extremely satisfactory. Average growth rates seem to differ little from those regarded as satisfactory in developed countries.

The position changes when the infants attain the age of about four months, for they are then outgrowing the breast milk supply and supplementation of the diet is essential. The Committee notes that during this later phase there is abundant evidence of faltering growth and impairment of health among infants and young children in the developing countries, but considers that the examination of the causes does not come within its terms of reference. It wishes, nevertheless, to point out that breast milk may continue to make a highly valuable contribution to the infant's diet, even when it is no longer sufficient as the sole or main food. There are a few reports from Africa and India which indicate that up to 750 ml breast milk may be secreted when the infant is 12-18 months of age (Sénécal, 1959; Someswara Rao et al., 1959).

Unfortunately there seems to be a trend towards shortening of the duration of lactation and more extensive use of breast milk substitutes in the developing countries. This trend should not be encouraged.

2.4 Effects of lactation on maternal health

A mature milk flow of 850 ml represents a net energy loss of about 600 kcal daily which must be balanced by the energy intake or subsidized from body stores. Primiparae studied in the United Kingdom eating self-chosen diets providing an average of 2580 kcal were losing weight slightly (Hytten & Thomson, 1961). Little or no information exists to permit an assessment of the manner in which mothers in developing countries (who often have to undertake hard physical work while lactating) meet the energy costs of lactation.

As shown above (section 1.5), well-fed women tend to lay down considerable quantities of body fat during the earlier part of pregnancy which, if not used up during late pregnancy, may be used to subsidize lactation. In the more poorly-fed communities in developing countries, where many women are in an almost continuous state of pregnancy or lactation, it seems doubtful that such reserves of fat can be accumulated. Yet, unless energy requirements during lactation are balanced by food intake such women must lose weight. Unfortunately, very few studies of the changes in maternal body weight in association with successive pregnancies and lactation have been reported, and the Committee considers that further research in this field is urgently needed.

If the evidence regarding maternal weight loss (energy deficiency) during lactation is equivocal and unsatisfactory, it is no better with regard to deficiencies of specific nutrients. The protein-calorie deficiency diseases are infrequent. It would be expected that women losing around 300 mg of calcium daily in breast milk while consuming diets low in calcium and undergoing a succession of pregnancies and periods of lactation would suffer from severe calcium depletion. This has not yet been demonstrated except in those regions where a deficiency of vitamin D is simultaneously induced by lack of exposure to sunlight. In certain parts of the world where women traditionally spend much time indoors and wear voluminous robes, osteomalacia in association with pregnancy and lactation is reported to have been comparatively common. It is the Committee's opinion that it is becoming rarer in these limited areas. Surprisingly, vitamin-deficiency diseases have rarely been reported as increasing in prevalence during lactation ; beriberi may be an exception.

The Committee urges that further research be undertaken in both developed and developing countries to solve the many problems still existing in relation to the effects of lactation on maternal health. These problems include :

(*a*) changes in body weight and the nature of these changes ;
(*b*) haematological changes ;
(*c*) levels of nutrients in the blood or plasma ; and
(*d*) clinical manifestations of impaired health.

All these should be considered in relation to the energy and nutrient composition of the diets eaten and the quantity and quality of the milk produced.

2.5 Diets of lactating women

Information concerning dietary intakes during lactation is even more unsatisfactory than that relating to pregnancy (Deem, 1931 ; Shukers et al., 1932 ; Kaucher et al., 1946 ; Bransby et al., 1950 ; Pasricha, 1958 ; Karmarkar et al., 1959 ; 1963 ; Hytten & Thomson, 1961). Data are scanty from both developing and developed areas, and those available are sometimes not accompanied by evidence enabling the adequacy of the intake or the lactational performance of the mother to be judged, and are seldom associated with data on intakes in pregnancy or in the non-pregnant, non-lactating state obtained in a similar way. The meagre information available does indicate a socio-economic gradient for dietary intake similar to that discussed for pregnancy. It suggests a slightly greater consumption of food during lactation than during pregnancy, but the information is not sufficient to permit generalization on the increment. There are taboos, beliefs, and customs concerning foods believed to induce or influence lactation, but they have received much less attention than have beliefs about foods during pregnancy. In the recent literature there is a notable lack of attention to this subject in Europe and America, which is most likely a reflection of the widely recognized trend towards the artificial feeding of infants in developed areas.

Lactation must involve a considerable increase in maternal water metabolism, but there is no evidence that it is readily impaired by restriction of water intake.

3. NUTRITIONAL REQUIREMENTS DURING PREGNANCY AND LACTATION

3.1 General introduction

There are few definitive data relating to nutritional requirements in pregnancy and lactation, and women may show little evidence of impairment of reproductive efficiency over a wide range of nutrient intakes. In these circumstances the Committee feels it would be the best in the first place to assess the physiological cost of pregnancy and lactation; and in the second place to consider what practical recommendations can be made.

"Physiological cost" is defined as the total amount of nutrients directly included in the product of conception or in the milk produced and in new maternal tissues produced as a necessary part of normal reproduction (see sections 1.1 and 1.5). This definition excludes losses incurred during the absorption of nutrients from the gut and during their utilization within the body. The physiological costs are, therefore, not the dietary requirements, which are necessarily greater and will be considered in section 3.4.

In respect of energy, where more definitive data for theoretical calculations are available, physiological cost involves estimates of the efficiency of conversion from energy in food.

As already mentioned (section 1.6), the Committee considers that the available information is insufficient to enable it to make estimates of the variation in physiological cost under different conditions, e.g., of maternal body weight and weight gain during pregnancy and of maternal activity. The estimates that follow are to be interpreted as reasonable averages for a healthy woman of average size who has a normal pregnancy and lactation, who has a sufficient supply of food of adequate nutritive value, and who is not forced to maintain a high output of physical work. This general definition of the " physiological " pregnant and lactating woman has been developed in greater detail by Hytten & Leitch (1964). In the physiological estimates and practical suggestions that follow, comment is made, where appropriate and where sufficient information exists, on the probable implications of some of the major variations that may exist in different parts of the world.

3.2 Physiological cost of pregnancy

3.2.1 *Calories*

Hytten & Leitch (1964) have estimated the average net changes in body composition occurring during pregnancy in normal women in Aberdeen. These changes are depicted in Table 8. The total calorie cost (which must be met sooner or later from the diet) of supplying and maintaining this new tissue approximates to the 80 000 kcal per pregnancy adopted in the report of the FAO Committee on Calorie Requirements (1957), of which more than 40 000 kcal is accounted for by fat storage. It is important to note that these calculations are referred to a weight gain of 12.5 kg.

It has already been recognized in this report that women in certain areas of the world may complete their pregnancies and deliver babies commensurate with their own body size with a weight gain of only about 6 kg. It is probable that women under these conditions would deposit much less fat. In the Aberdeen studies, fat was considered to be in large part a maternal store rather than an essential tissue component associated with the reproductive process (Hytten, 1964). If no maternal fat stores were accumulated, the physiological cost would be reduced by about 40 000 kcal. The composition of the weight gain under conditions of low gain requires experimental investigation.

It is also significant that the data of Hytten and co-workers suggest that fat deposition begins early in pregnancy and is presumably part of a physiological process laying down an energy reserve that may be needed at a later stage of pregnancy or during lactation, when the immediate needs of the baby are increasing rapidly. It is interesting that direct evidence of such an " anticipatory " deposition of energy reserves has been reported in rats (Beaton et al., 1954).

It should be noted that assessments of the energy cost of pregnancy in these terms depend upon the amount of weight that is considered to be desirable and upon the composition of that gain.

3.2.2 *Protein*

The Joint FAO/WHO Expert Group on Protein Requirements accepted evidence (similar to that summarized in Tables 8 and 9) that about 950 g of protein is accumulated during pregnancy in the product of conception and maternal tissues. The average daily increment is computed to be

TABLE 8. PROTEIN AND FAT GAINED IN NORMAL PREGNANCY *

	Weeks of pregnancy			
	10	20	30	40
Observed total weight gain (g)	650	4000	8500	12500
Protein deposited (g)	35	210	535	910
Fat deposited (g)	367	1930	3613	4464

* From Hytten & Leitch, 1964.

TABLE 9. THE COMPONENTS OF PROTEIN STORAGE IN NORMAL PREGNANCY BY WEIGHT

	Protein storage (g) after following number of weeks of pregnancy			
	10	20	30	40
Foetus	0.3	27	160	435
Placenta	2	16	60	100
Liquor	0	0.5	2	3
Uterus	23	100	139	154
Breasts	9	36	72	81
Blood	0	30	102	137
Total	35	210	535	910

about 5 g during the last six months of pregnancy. The Committee agrees with these assessments. In contrast with the energy cost, it is unlikely that this protein deposition would be materially affected by differences in total weight gain during pregnancy.

3.2.3 *Iron*

At term the foetus contains about 300 mg and the placenta about 70 mg of iron. The blood-free uterus and breasts probably contain negligible additional amounts. Most of this total of 370 mg must be supplied during the second half of pregnancy. Early in pregnancy the maternal red cell mass begins to increase. At term, this increase may represent on the average an increment of 290 mg of iron. Iron requirements for all these purposes are, in part, offset by the cessation of menstruation ; this economy would amount to about 120 mg through the whole of pregnancy (Hytten & Leitch, 1964). The additional physiological cost in terms of the iron requirements of pregnancy then amounts to approximately $300 + 70 + 290 - 120 = 540$ mg. A large part of this iron must be made available in the second half of pregnancy and would amount to 2-3 mg per day.

Some 50 mg of iron may be lost through haemorrhage at normal parturition. This would normally be provided for through the increase in maternal red cell mass and need not be added to the physiological cost of pregnancy.

3.2.4 *Calcium*

The Joint FAO/WHO Expert Group on Calcium Requirements (1962) accepted evidence that about 30 g of calcium was deposited in the foetus.

Most of this is deposited in the last half of pregnancy. The Committee accepts this amount as the physiological cost.

3.2.5 *Other nutrients*

The Committee feels that insufficient evidence is available to estimate physiological costs for other nutrients, although it recognizes that requirements may increase for several of them.

3.3 The physiological cost of lactation

3.3.1 *Calories*

Only limited evidence is available on the volume of milk secreted at various stages of lactation. The volume probably increases gradually for some months. The FAO Committee on Calorie Requirements (1957) based its estimate on a mature milk yield averaging 850 ml daily with a calorie value of 600. The present Committee accepts this yield as a realistic basis for estimating the physiological cost of milk production.

The FAO Committee used an efficiency coefficient of 60% and then computed the daily cost of milk production to be 1000 kcal. Using the higher coefficient, 80%, proposed by Hytten & Thomson (1961), the cost would be 750 kcal daily (see section 2.2). Further investigation is needed to define the calorie cost of lactation.

3.3.2 *Other nutrients*

A first approximation of the physiological cost of lactation is obtainable from the amounts of nutrients secreted in milk. Unfortunately, the available evidence on milk composition shows considerable variability, especially for some nutrients, probably as a result of sampling error and difference of method as well as of real variability in milk composition. The only nutrients that seem to vary widely in response to differences of diet are the water-soluble vitamins. Some nutrients, for example iron and calcium, seem to be very stable, regardless of the maternal diet.

The averages in Table 10 are abstracted from the literature ; they are not maxima and minima. In respect of the water-soluble vitamins, the population sampled, and hence the habitual nutrient intake, may have had a marked effect upon the recorded composition (e.g., in respect of ascorbic acid). In the particular case of iron, the two most frequently quoted values are cited ; it is almost certain that methodological differences explain their divergence, and the Committee is unable to select one value as the more reliable but is unwilling to continue to average them, as has been done so frequently.

TABLE 10. NUTRIENTS IN MATURE HUMAN MILK

Nutrients		No. of determinations	Conc./100 ml	Content in 850 ml [a]
Protein and free amino acids	(3)	583 (protein N) 157 (amino N)	1.2 g	10.2 g
Calcium	(3)	628	34 mg	290 mg
Iron [b]	(4) (5)	67 14	0.03 mg 0.36 mg	0.25 mg 3.1 mg
Vitamin A	(2)	1390	49 µg	420 µg
Ascorbic acid [c]	(1) (6) (3)	148 261 233	2.6 mg 3.7 mg 5.2 mg	22 mg 32 mg 44 mg
Niacin	(3)	268	183 µg	1.6 mg
Riboflavin	(3)	272	37.3 µg	0.32 mg
Thiamine	(3)	277	14 µg	0.12 mg

[a] Assumed average daily volume for whole of lactation.

[b] The difference between these two averages is probably a result of the methods used, and the common practice of quoting the average of the two is not justifiable.

[c] The first figure cited relates to poor Indian women, the third to women living in USA.

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The content of these nutrients per 850 ml, as shown in Table 10, then provides an estimate of the average physiological cost of lactation.

3.4 Practical considerations

Whereas for energy and for certain nutrients it is possible to make reasonably precise estimates of average physiological costs, the further step of translating them into dietary allowances is fraught with uncertainty. Indeed, the Committee felt that our present knowledge is not sufficiently extensive to lay down a schedule of requirements firmly based on physiological costs.

The requirements of pregnancy and lactation must, of course, be met ultimately from food, but not necessarily on a " current account " basis.

Immediate needs may be met from maternal tissues as well as directly from absorbed nutrients, and it has already been noted that special maternal reserves (e.g., of fat) may be laid down at a relatively early stage of pregnancy and utilized later when the requirements of the product of conception are increasing rapidly.

Losses are incurred during the digestion and absorption of nutrients from food. The coefficients used in the preparation of ordinary food tables make more or less accurate allowance for losses during the conversion from gross energy to metabolizable energy. Much less accurate assessments can be made for losses during absorption of most of the important nutrients (e.g., iron, calcium). The problems are further complicated because there are reasonable grounds for assuming that the efficiency of absorption of at least some nutrients is altered during pregnancy and (perhaps differently) during lactation.

Having been absorbed, nutrients from diet have to be transported and converted into new tissue. This process is termed utilization, and further losses are incurred during it. A few of these losses can be roughly estimated ; about many, however, we are ignorant.

Even greater ignorance pervades the field when nutrients required for new tissues and secretions come, not directly from absorbed nutrients, but from maternal tissues. As already indicated, additional maternal tissues are formed as an intrinsic part of the physiological adjustment of pregnancy, but the amount may vary widely according to circumstances. The relatively well-fed woman may lay down a large energy store in the form of fat, which may not be used up and may then be prejudicial to health ; whereas the poorly-fed woman in a developing country, who has to work hard during pregnancy, may lay down a much smaller reserve and use it all up before the end of pregnancy.

The conditions of pregnancy and lactation in large areas of the world are by no means " physiological ". Infections and parasitic diseases may deplete the non-pregnant maternal reserves, and in such circumstances a realistic schedule of dietary allowances should no doubt take account of the fact.

Finally, although it is customary and useful to base physiological requirements on an average or " reference " individual (see FAO Committee on Calorie Requirements, 1957, for example), individuals in real life show a very wide range of variation. It has been noted that maternal size varies in different areas of the world ; the weight gain during pregnancy may vary from about zero in one individual to more than 20 kg in another individual ; and the customary activities and obligations of pregnant and lactating women throughout the world show a kaleidoscopic variety.

Many other expert bodies have been confronted with these problems and have prepared requirement schedules or " recommended allowances " appropriate to the circumstances with which they were concerned. For convenience, some recent recommendations are tabulated in Annex 2. The Committee does not feel able to produce yet another set of recommendations on similar lines. The comments that follow may, however, assist governments and other authorities in deciding upon practical targets for themselves.

3.4.1 *Energy supply*

Observations upon the diets of healthy women fail to indicate that there is any considerable increase of energy intake during pregnancy and lactation over and above the intake in the non-pregnant, non-lactating state. While the available dietary evidence cannot be regarded as conclusive, there are indications from physiological studies that the additional costs of pregnancy and lactation are to some extent buffered by deposition of maternal stores before foetal needs become large. Reduction of activity may also reduce the need for a considerably increased food intake. The Committee, therefore, notes that there appears to be little justification, in terms of the ordinary dietary habits of healthy pregnant and lactating women, for recommending a sharp increase of calorie intake during the later part of pregnancy and a still greater increase during the whole course of lactation.

The framing of practical allowances should take into account the habitual patterns of activity of pregnant and lactating women and the level of weight gain during pregnancy that is considered to be desirable.

3.4.2 *Protein supply*

In general, the intake of protein will tend to change in proportion to any change in the calorie intake. In many areas of the world the ordinary protein supply is such that no particular provision need be made for the additional costs of pregnancy. In other areas, however, the protein supply may be limited and of low biological value. In such instances steps should be taken to cover at least the additional physiological costs of pregnancy and lactation specified above, taking into account the biological value of the customary dietary protein. Guiding principles have been discussed in detail by the Joint FAO/WHO Expert Group on Protein Requirements.

3.4.3 *Calcium supply*

The Committee agrees with the Joint FAO/WHO Expert Group on Calcium Requirements (1962) that 1000 to 1200 mg of calcium per day during pregnancy and lactation is a suitable amount. Although many women fail to achieve this in certain areas of the world, the Committee was unable to find evidence of harm to their general health. Attention is drawn to the possible buffering role of maternal stores. It may be more important to prevent undue depletion of such stores than to provide for the immediate physiological costs of pregnancy and lactation.

3.4.4 *Iron supply*

The recommendation of the WHO Study Group on Iron Deficiency Anaemia (1959) that 15 mg of iron daily be provided during pregnancy and lactation is acceptable to the Committee, at least so far as healthy populations living in generally favourable conditions are concerned. Such an allowance may be insufficient in countries where the availability of iron in food may be relatively low and the incidence of anaemia high. The Committee considers that practical nutritional recommendations for such unfavourable situations can scarcely be made without further research. Such research should seek to establish not only the feasibility of increasing the supply of available iron in diets, but also the degree of benefit which can be expected among pregnant and lactating women, as well as in the general population, from such a measure.

There are indications that the efficiency of absorption of dietary iron increases during pregnancy and, as has been noted above, the total physiological cost incurred by pregnancy and lactation is relatively small. Nevertheless, the Committee agrees that pregnant women are especially liable to develop anaemia of iron-deficiency type, the causes being obscure. The liability is greatly increased in areas where diseases such as ancylostomiasis and bilharziasis are common. A haemoglobin concentration of 10 g/100 ml blood or less may be taken as probably indicative of anaemia and warrants the institution of appropriate measures for investigation and treatment. Where full haematological investigation on an individual basis is difficult or impossible, it is justifiable to prescribe iron as a routine to " anaemic " women. This should be regarded as a therapeutic rather than a nutritional measure. The Committee feels that the indiscriminate issue of iron preparations as a routine to all pregnant women in situations where there is no obvious indication for them is to be deplored. It is not merely wasteful; it also impedes research upon the problem and a more rational approach to the prophylaxis and treatment of anaemia.

3.4.5 *Iodine supply*

While it has not been possible to estimate the physiological cost of pregnancy in terms of iodine, an increased requirement is recognized on the basis of an increased incidence of goitre during pregnancy. Special attention should be given to the needs of pregnant women in areas of endemic goitre. The problems in such areas have been considered in a WHO monograph by Clements et al. (1960).

3.4.6 *Vitamins*

As has already been indicated, it is not possible to give any precise indication of the physiological cost of pregnancy and lactation in terms of vitamins.

In general, the Committee agrees with the customary practice of relating the intakes of thiamine, riboflavin, and niacin to the calorie value of the diet.

Although there is seldom any need for concern about the supply of vitamin D to adults, the Committee feels that the increased needs for calcium during pregnancy and lactation make it desirable to assure an adequate supply of vitamin D so that there can be no risk of impairment of calcium absorption and utilization. In areas where women, for cultural or religious reasons or as a result of climatic conditions, may be insufficiently exposed to sunlight, the special provision of a dietary or pharmaceutical source of vitamin D should be considered.

The Committee felt that it did not have sufficient information to enable it to come to any practical conclusions in respect of the supply of vitamins A and C, beyond the obvious one that diets should provide for any additional physiological costs.

The Committee recognizes that deficiencies of folate and probably of vitamin B_{12} also are apparently more common during pregnancy than at other times. Unfortunately, no useful estimates of either the physiological cost or of the desirable dietary supply of these vitamins can be made at the present time. There is an urgent need for further investigation, particularly in areas where megaloblastic anaemias of pregnancy are relatively common.

The Committee wishes to draw attention to the fact that the indiscriminate use of vitamin preparations in high concentration is potentially dangerous. Hypervitaminosis may result, and in animals the administration of large quantities of vitamin A has had teratogenic effects. Vitamin concentrates should always be issued under careful medical supervision.

4. IMPLICATIONS FOR PUBLIC HEALTH PROGRAMMES

It is unrealistic to consider the nutrition of pregnant and lactating women in isolation. They are members of their family groups and of their social milieu. Their diets closely resemble the habitual diets of their families and show relatively little change in quality or quantity during pregnancy and lactation. Public health measures should therefore be directed in the first place towards the improvement of nutritional conditions in social and family groups as a whole.

The diets of pregnant and lactating women and of their infants, limited by the social and familial environment, may be further prejudiced by specific customs and taboos. Such customs and taboos may vary widely from place to place, and local health personnel can do much to ascertain and understand them, and to counteract them when desirable.

Pregnant and lactating women offer a useful focus for public health measures directed towards the whole family and the community, especially during the first pregnancy when women are usually more receptive of advice and assistance. The extent to which such measures are successful in improving their nutritional condition is a measure of success in improving that of the family as a whole, and thus that of the community.

The Committee wishes to emphasize that the areas of ignorance relating to nutrition in pregnancy and lactation are extremely large and it is impossible as a rule to state didactically that this or that particular form of dietary change will produce a specific clinical benefit. Nevertheless, it can scarcely be doubted that the diets of pregnant and lactating women in many areas of the world are capable of improvement, as are those of the families of such women.

Healthy, well-grown mothers are derived from healthy, well-grown children : children who have been permitted by their physical and social environment to realize their full biological potential. Probably the most important single aim of a nutrition policy is to safeguard the health and growth of children, from conception to adult life. The mother is the necessary link between any health service and the foetus and young child. For this reason, nutritional education directed towards the mother goes far beyond the immediate betterment of pregnancy and lactation. Such education should begin in antenatal and child welfare clinics, and should be reinforced by home visiting. Individual advice, group lectures, discussions, and demonstrations, with the participation of women themselves and perhaps, in some circumstances, the provision of nourishing meals at an attractive price may be helpful. Educational measures using radio, television, and the press may also be beneficial. Education in nutrition should form an important part of the primary and secondary education of girls in schools.

The effective planning of public health nutrition programmes directed towards pregnant and lactating mothers, particularly in the developing countries, depends upon the realization of the importance of nutrition. That this realization does not exist, or at best is faulty, is due to the fact that nutrition receives inadequate attention in the medical teaching of undergraduates and also of graduates qualifying as specialists. The Committee notes that the inclusion of the subject of nutrition in medical curricula has been previously discussed at several meetings of the Joint WHO/FAO Expert Committee on Nutrition and refrains from a fuller discussion of this aspect. Nevertheless, it wishes to emphasize the great importance it attaches to the concept of integrating nutrition teaching with teaching of all the different studies forming the undergraduate medical curriculum. In order to achieve this object, the Committee believes that nutritional orientation in postgraduate training of specialists should be given a high priority. Obstetricians, gynaecologists, and paediatricians are specifically mentioned here, for their training with this new orientation is pertinent to the subject matter of this report. The above measure in itself will partly, if not wholly, ensure that nutrition teaching finds its proper place in undergraduate medical training.

The same kind of considerations apply to the training of paramedical personnel : in this context, midwives, nurses, and other medical and nursing auxiliaries who are concerned in the provision of services for pregnant and lactating women and for infants and young children. Such paramedical personnel are likely to hold key positions in many of the developing countries, particularly in rural areas.

While nutritional propaganda directed towards the general public may awaken an interest in the subject in the better educated elements of communities, it often fails to make any impact on those families and groups whose nutritional standards are in most need of improvement. To be successful, such propaganda should be initiated by the authorities responsible for drawing up national programmes of food production and supply, and should be supported by nutrition education at community level, under the advice and guidance of health personnel. If such programmes of food production are to be soundly based, it is essential that governments, both central and local, should be well advised and interested in the nutritional problems involved. At the same time, one of the objects of nutrition education should be to promote the best possible use of the food available.

The provision of special nutrients such as vitamins and minerals, or even of free food supplements, undoubtedly has value in certain circumstances. It is, however, no substitute for a sound food and nutrition policy and should be undertaken under medical supervision only.

It would be unrealistic to refrain from all mention of the pressure of population upon food supplies and their utilization. The Committee calls attention to the high birth rates that still prevail in large areas of the world in the face of poor environmental conditions including shortages of food supplies. The third report of the WHO Expert Committee on Maternal and Child Health (1961) considered the effects of unfavourable environmental conditions and high birth rates in connexion with the problem of children of low birth weight, and stated : " Too frequent child-bearing, which occurs more often under poor environmental conditions, undoubtedly leads to maternal exhaustion and increases the incidence of small babies ". The Committee also calls attention to the fact that in many societies the maintenance of lactation for relatively long periods is of great value for the protection of the young child and may also be of value as a custom assisting the spacing of births.

Breast milk is inadequate as the sole food of a baby of more than about four months of age, and at this stage supplementary foods should be introduced. But lactation should be maintained for a year or more, particularly where the diets of older infants and young children are nutritionally inadequate.

The Committee deprecates the indiscriminate distribution of breast milk substitutes to communities without proper supervision. This is not only likely to encourage the abandonment of breast feeding but may also assist the spread of infantile gastro-enteritis and other infectious diseases in societies where the standards of hygiene are low.

The synergistic action of infection and malnutrition and undernutrition should always be recognized. Programmes for the improvement of hygiene and sanitation at community, family, and personal level and for immunization should always accompany programmes for the improvement of the nutrition of expectant and nursing mothers.

Finally, the Committee wishes to emphasize that public health programmes should be evaluated as well as implemented. This means, in the first place, the institution of suitable measures for the collection of vital statistics and the investigation at intervals of the general health, growth, and physique of the population. Since so much is unknown, it will often be desirable, in the first instance, to institute public health measures on a small scale and on a research basis. Those which prove to be practical and beneficial can then be expanded on a more general scale.

5. RECOMMENDATIONS FOR RESEARCH

Studies designed specifically to define the nutritional costs of pregnancy and lactation in terms of any nutrient have rarely been made in such manner as to quantify the costs precisely. Where data exist that seem reasonably satisfactory for the conditions in one area or population, the information necessary to transpose the conclusions to a quite different set of conditions does not exist. Much published work on nutrition in relation to pregnancy and lactation is of limited value because it is based on short-term investigations restricted to one particular facet. Thus, the nutritive value of diets has been reported on without reference to the clinical and metabolic context ; data on milk yields and composition are presented without reference to the growth and health of the babies or nutritional status of the mother ; studies of metabolism in pregnancy have been undertaken with scant attention to the implications of maternal body size and change in body weight. Examples could be multiplied, and it is not going too far to assert that more complete information is required on every aspect of the subject. Only when the isolated fragments of information build up into a comprehensive and internally consistent pattern can we begin to understand the patterns of human reproduction in all their complexity. Additional studies in three broad categories must, therefore, be made:

(*a*) quantitative physiological studies designed to provide information on the nature of the adjustments that occur during pregnancy and lactation and their variation under the usual conditions of life, with careful attention to the mother's pre-existing nutritional status, the development of the foetus and infant, and the amount and quality of lactation;

(*b*) broad descriptive studies of variations in nutritional status and maternal and infant health, coupled with systematic collection of data on the composition of diets and the nutrients in the foetus and the mother's milk;

(*c*) epidemiological investigations of pregnancy diseases, foetal waste, and infant health and disease that should *inter alia* include properly designed studies of possible nutritional factors.

In the latter two types of studies in particular, the Committee feels that WHO can effectively participate by assisting in planning, co-ordinating, and standardizing the methods employed by investigators in this field, so that the efforts expended are more productive and the results more comparable.

Examples of the specific information needed have been noted in this report. Some of the main needs may be summarized as follows:

(1) Investigations of the implications for health of maternal size and body composition during pregnancy and lactation. Such studies are especially necessary so that the energy, protein, and mineral requirements during pregnancy and lactation can be assessed better.

(2) Information on the energy metabolism of pregnant and lactating women is sorely needed. Research in this field should deal with such parameters as dietary intake, expenditure on physical work, change in body size and composition, the growth of the product of conception, and the amount and composition of breast milk.

(3) Alterations in the absorption and excretion of various nutrients during pregnancy and lactation need further study. For example, is the absorption of iron, calcium, folate, and vitamin B_{12} in fact increased or decreased during pregnancy and lactation? Does changed kidney function result in the greater excretion or decreased loss of nutrients? Are there increased dermal losses (of iron, for example)? Similarly, there is need to determine whether changes in the conversion of the precursors of some nutrients occur during pregnancy and lactation. Serum carotene levels

rise during pregnancy, the serum vitamin A concentration decreases. Is there any change in the efficiency of the conversion of carotene to vitamin A ? Similar questions might be asked regarding the interconversion of some other nutrients, such as the amino acids.

(4) The nutritional functions of the placenta — its permeability to nutrients, its synthesizing role and requirements—are likewise germane to an understanding of the physiological needs of the maternal organism. Again, the needs and efficiency of the mammary gland as a synthesizing and secretory organ require further investigation.

(5) Proper standards for both the biochemical and clinical assessment of the nutritional status of pregnant and lactating women must be evolved through data obtained from investigations of healthy women with satisfactory obstetric and lactational records.

(6) Additional and more precise longitudinal studies on food intakes, beliefs, and dietary habits of pre-pregnant, pregnant, and lactating women are needed in groups of differing (but well described) economic status and physique.

These studies need special organization and effort. The time scale in human reproduction is long. A single cycle of pregnancy and lactation may continue for two years or more, and the reproductive history of a woman may last for over 20 years. It is not sufficient to limit attention to reproduction itself. The growth and development of the children in a community help to determine the characteristics of the mothers.

For these reasons, much of the research is best undertaken by a team, led by senior scientists who have a wide range of interests and are prepared to devote many years to this field. Junior research workers who are appointed as members of a stable team representing several relevant scientific disciplines will receive a more profitable training than those who are allowed to work in isolation and on a narrowly planned technical basis.

The needs of the subjects of investigation must also be considered. A pregnant or lactating woman is unlikely to co-operate willingly and effectively unless she receives some " reward ". A high standard of clinical supervision and personal care is such a reward, and the scientific team must provide her with it. Research into the problems of human pregnancy and lactation should, therefore, be undertaken in co-operation with a good maternity and child welfare clinical unit.

All this involves teamwork of an unusually comprehensive and intimate nature. Teamwork is more than mere collaboration, and is difficult to achieve and to sustain. The administrative framework must permit the free co-operation of specialists in the various clinical and scientific disciplines required. The senior members of the team, if they are to continue working this field, need to be given a career structure and a status that will encourage them to persist rather than to turn to other and easier kinds of research. Accommodation, too, presents problems, since this is research upon patients and relatively few clinical units have enough space to take in relatively normal " research patients " in face of the need to deal with a flood of abnormal cases and emergencies. Nurses and other subordinate staff in a clinical research unit should be trained in research methods and to adopt a research outlook. Even in so simple a procedure as the measurement of body weight great accuracy is required. The clinical accommodation should, of course, be conveniently near the necessary laboratories.

Without well-organized and sustained teamwork, the problems of nutrition in relation to human pregnancy and lactation will continue to be elucidated in a piecemeal, erratic, and sometimes misleading fashion.

The Committee recommends that WHO assist in planning and co-ordinating a long-term, broad programme of study designed to obtain needed information in this field, and that WHO encourage and assist in the development of units of investigators, competent to undertake the required investigations.

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Annex 1

SUMMARY OF REPORTED DIETS

Country	Trimester	Calories	Protein (g)	Calories from protein %	Calcium (g)	Iron (mg)	Vitamin A (I.U.)
Scotland (Aberdeen)	III	2633	80	12.2	1.2	—	9900
		2521	78	12.4	1.1	—	8100
		2354	72	12.2	0.9	—	7500
Holland	"middle" of pregnancy	2770	81	12.0	0.9	14.5	—
Holland (Amsterdam)	I	2620	79	—	0.8	13.8	—
	II	2720	80	11.8	1.0	15.9	—
	III	2620	76		1.0	15.6	—
Australia (Adelaide)	II	2414	78		—	—	—
	III	2342	82	13.6	—	—	—
	prenatal	2422	85		—	—	—
United States of America (Tennessee)	I	2140	70		1.1	13.0	6500
	II	2200	75	13.5	1.1	14.0	6600
	III	2020	70		1.0	13.0	5900
United States of America (New England)	2-4 mth	1915	65		0.9	11.4	7254
	9 mth	1915	67	13.5	0.9	11.0	6766
	postnatal	1900	64		0.8	11.0	6189
Israel (Negev)	1/3 II 2/3 III	2064	71	13.8	0.7	11.0	3763
Egypt (Alexandria)	8th mth	2046	72	14.3	0.3	14.5	2636
		2124	78	14.3	0.9	14.6	2391
India (Calcutta)	?	2760	86	12.4	1.3	—	4600
		1920	48	10.0	0.5	—	2120

Annex 1

OF PREGNANT WOMEN

Thiamine (mg)	Riboflavin (mg)	Nicotinic acid (mg)	Ascorbic acid (mg)	Subjects		Source
				No.	Nature of sample	
1.22	2.05	12.0	79	101	white-collar class	Thomson (1958)
1.18	1.89	11.4	85	109	wives of skilled manual workers	
1.16	1.74	11.8	61	279	wives of unskilled manual workers	
1.4	1.7	—	114	270	from rural districts	den Hartog et al. (1953)
1.32	—	—	123	488	urban dwellers	Amsterdam Study (1962)
1.3	—	—	120	376		
1.3	—	—	122	300		
—	—	—	—	65	clinic attenders	Cellier & Hankin (1963)
—	—	—	—			
—	—	—	—			
1.5	2.5	12.0	66	278	white women; middle or lower income range	Darby et al. (1953)
1.5	2.3	12.0	62	1222		
1.4	2.3	11.0	65	1665		
1.09	1.72	12.8	83	48	the patients of one physician; various income groups	Murphy & Wertz (1954)
1.10	1.84	13.1	88	65		
1.07	1.60	13.0	86	65		
1.17	1.23	10.9	90	100	women of poor education	Guggenheim et al. (1960)
—	—	—	23	22	poor women	Sadek (unpublished thesis, 1960)
—	—	—	27	23	poor women	
2.6	2.4	—	72	50	well-to-do	Bagchi & Bose (1962)
0.74	0.33	—	21	150	poor	

Annex 1 *(continued)*

Country	Trimester	Calories	Protein (g)	Calories from protein %	Calcium (g)	Iron (mg)	Vitamin A (I.U.)
India (Calcutta)	weeks 20–24	1960	42	8.5	—	24	—
	25–28	1870	38	8.0	—	18	—
	29–32	1990	42	8.5	—	22	—
	33–36	2010	41	8.2	—	22	—
	37–term	1980	36	7.5	—	28	—
	non-preg.	1920	39	8.1	—	26	—
South India	14 in I; rest in II & III	1408	38	10.1	0.3	18.0	912
South India (Hyderabad)	I	1390					
	II	1520	40	10.5	0.3	16.8	911
	III	1650					
South India (Coonoor)	?	1815	44	9.0	0.4	18.2	—
New Guinea Chimbu		1490	19	5.1	0.4	11	—
Ajamaroe	?	1450	31	8.5	0.5	10	—
Waropen		1170	15	5.1	0.1	8	—

Annex 1 *(continued)*

Thiamine (mg)	Riboflavin (mg)	Nicotinic acid (mg)	Ascorbic acid (mg)	Subjects No.	Subjects Nature of sample	Source
—	—	—	23	36	low socio-economic status	Bagchi & Bose (1962 a)
—	—	—	21	42		
—	—	—	32	37		
—	—	—	31	52		
—	—	—	29	64		
—	—	—	30	50	non-pregnant women	
—	—	—	—	352	poor-class women	Venkatachalam (1962)
—	—	—	—	65	poor-class women	Shankar (1962)
—	—	—	—	100	poor-class women	Pasricha (1958)
—	—	—	—	9	in poor circumstances	Oomen & Malcolm (1958)
—	—	—	—	7		
—	—	—	—	10		

Annex 2

RECOMMENDED ALLOWANCES FOR PREGNANCY AND LACTATION *

Country	Weight	Calories	Protein (g)	Calcium (g)	Iron (mg)	Vitamin A (I.U.)	Vitamin D (I.U.)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Ascorbic Acid (mg)
1. United States, 1963						(a)				(b)	
Non-pregnant	128 lb	2100	58	0.8	15	5000	—	0.8	1.3	14	70
Pregnant 4–9 months		2300	78	1.3	20	6000	400	1.0	1.6	17	100
Lactating		3100	98	1.3	20	8000	400	1.2	1.9	21	100
(Food and Nutrition Board, 1963)											
2. Canada, 1963						(c)					
Non-pregnant	124 lb	2400	40	0.5	10	3700	—	0.7	1.2	7	30
Pregnant 7–9 months		2900	50	1.2	13	4200	400	0.9	1.5	8.5	40
Lactating		2900-3400	60–70	1.2	13	5200	400	1.0	1.7	10	50
(Canadian Council on Nutrition, 1963)											
3. Great Britain, 1950						(d)					
Non-pregnant		2250	66	0.8	12	5000	—	0.9	1.4	9	20
Pregnant 1–5 months		2500	93	0.8	12	6000	400	1.0	1.5	10	40
6–9 months		2750	102	1.5	15	6000	600	1.1	1.6	11	40
Lactating		3000	111	2.0	15	8000	800	1.4	2.1	14	50
(British Medical Association, 1950)											
4. Norway, 1957						(e)					
Non-pregnant	60 kg	2500	60	0.8	12	2500	400	1.3	1.5	13	30
Pregnant 7–9 months		2900	85	1.5	15	3000	400	1.6	2.1	16	50
Lactating		3500	100	2.0	15	4000	400	1.8	2.6	18	75
(Øgrim, 1958)											
5. Holland, 1961						(f) (g)					
Non-pregnant		2400	60	1.0	12	0.45 2.4		1.0	1.5	10	50
Pregnant 7–9 months		2700	80	1.5	15	0.55 2.5		1.2	2.0	12	75
Lactating		3100	100	2.0	15	0.60 2.5		1.4	2.5	14	100
(Commissie Voedingsnormen van de Voedingsraad, 1961)											

6. South Africa, 1956						(*h*)					
Non-pregnant	130 lb	2300	55	0.6	12	4000	—	0.8	1.4	12	40
Pregnant 7–9 months		2600	80	1.5	15	5000	400	0.9	2.0	14	55
Lactating		120/100 ml	80	0.12/ 100 ml	15	6000	400	0.4/1000 Addnl Cal	2.0	15	55
(National Nutrition Council, South Africa, 1956)											
7. Japan, 1961						(*i*)					
Non-pregnant		2100	60	0.6	10	2000	400	1.1	1.1	11	60
Pregnant 1–5 months		2400	75	0.7	12	2500	400	1.5	1.5	15	80
6–9 months		2700	90	1.4	15	2500	400	1.8	1.8	18	100
Lactating		3000	95	1.7	15	3500	400	2.0	2.0	20	150
(Ministry of Health & Welfare, Japan, 1961)											
8. Central America (INCAP) 1955						(*f*)					
Non-pregnant	50 kg	2000	50	0.7	10	1.3 mg		1.0	1.2	10	45
Pregnant 7–9 months		2500	75	1.3	14	1.6		1.2	1.8	12	65
Lactating		3000	90	1.8	14	2.1		1.5	2.2	15	95
(INCAP, 1955)											
9. USSR, 1961											
Non-pregnant						5000		2.	2.5	15	70
Pregnant						6600	500	2.5	3.	20	100
Lactating						6600	500	3.0	3.5	25	120
(Yarusova, 1961)											
10. India, 1958											
Non-pregnant	45 kg	2300	45								
Pregnant 5–9 months		2300	100								
Lactating		2700	110								
(Patwardhan, 1960)											

* Recommended intakes have been taken from Young, E. G. *Dietary standards*. In: Beaton, G. H. & McHenery, E. W., ed., *Nutrition: a comprehensive treatise*, New York and London, Academic Press (in press).

(*a*) 1/3 vitamin A; vitamin A: carotene = 2:1
(*b*) Expressed as "niacin equivalents"
(*c*) 1/2 vitamin A; vitamin A: carotene activity = 3:1
(*d*) 1/3 vitamin A; vitamin A: carotene activity = 3:1
(*e*) 2/3 vitamin A
(*f*) mg vitamin A
(*g*) mg carotene
(*h*) 1/3 vitamin A
(*i*) all as vitamin A

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