AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 52

1. SUBJECT CLASSIFICATION
A. PRIMARY: TEMPORARY
B. SECONDARY:

2. TITLE AND SUBTITLE
Contribution of family planning to health and nutrition

3. AUTHOR(S)
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4. DOCUMENT DATE: 1974
5. NUMBER OF PAGES: 68p.
6. ARC NUMBER: ARC 613.2.M466

7. REFERENCE ORGANIZATION NAME AND ADDRESS
AID/PHA

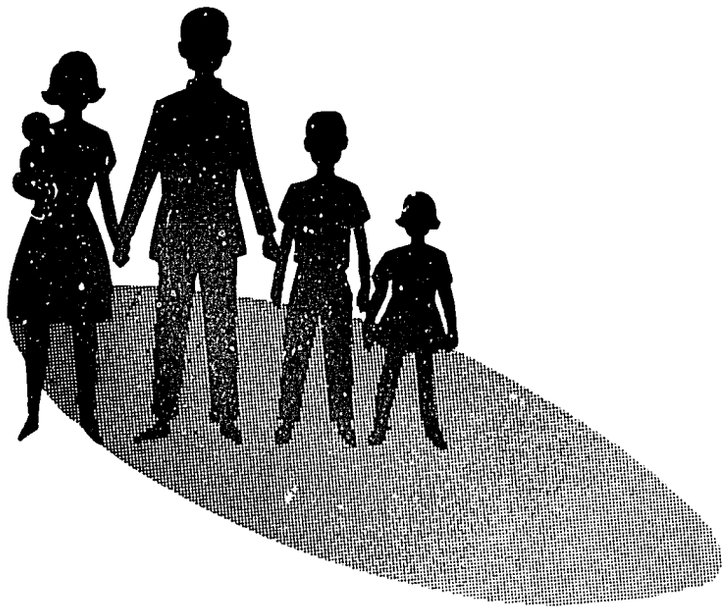
8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT
(Health R&D)
Major research on the nutrient requirements of women during pregnancy and lactation is reviewed. The consequences of unfulfilled requirements on maternal and child health are summarized, including high death rates for mothers and children and poor mental and physical development in children who survive. All the parameters of infant mortality are relevant to the problem of spacing pregnancies. Economic status and nutrition are interrelated factors which significantly influence mortality. Studies in developing countries suggest that larger families are more prone to contain malnourished children. It appears that the solution to problems of malnutrition among children must move beyond programs that are designed to educate the mother about nutritional needs and providing feeding programs for malnourished children. Education is required regarding the need to provide adequate spacing between the births of children and to limit family size. When evidence indicates that high fertility in the mother is associated with nutritional difficulties that spell mental and physical development impairments and higher morbidity in the child, the case for family planning and spacing of pregnancies becomes strong. There is a need to base family planning on the concept of family health.

10. CONTROL NUMBER: PN-AAD-304
11. PRICE OF DOCUMENT:
12. DESCRIPTORS:
13. PROJECT NUMBER:
14. CONTRACT NUMBER: AID/PHA
15. TYPE OF DOCUMENT:

AID 590-1 (4-74)

CONTRIBUTION
OF
FAMILY PLANNING
TO
HEALTH AND NUTRITION



OFFICE OF POPULATION
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

CONTRIBUTION
OF
FAMILY PLANNING
TO
HEALTH AND NUTRITION

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Publication of this compilation of research by others and the collection of data on nutritional and child spacing requirements was made possible by a grant from the *Office of Population, Agency for International Development.*

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Published November 1974

Library of Congress Card No. 74-600171

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INTRODUCTION

Malnutrition in the developing countries takes its most grievous toll on pregnant women and on children. Many millions of pregnant women in the poor countries fail to obtain the protein, fat, calories, minerals, and vitamins required for their own health and the well-being of their unborn babies. More than that, an estimated 300 million children are seriously malnourished. Nutritional impairment on such a vast scale calls for renewed efforts to increase per capita food availability efforts involving not only the expansion of food production but also the slowing, through family planning, of population growth rates. This dual approach is imperative if more catastrophes, such as the recent famine in the Sahel region of Africa, are to be avoided.

This paper reviews major research on the nutrient requirements of women during pregnancy and through the lactation period. It covers studies pointing to the need for recuperation between pregnancies a period that will allow a woman who has given birth time to readjust to the nonpregnant status. Finally, the paper summarizes the consequences of unfulfilled requirements on maternal and child health. The consequences include high death rates for mothers and children and poor physical and mental development for children who survive.

The unfavorable nutritional status of pregnant women and children in the developing countries exists despite the fact that in these areas there has been some progress in expanding total food output. The U. S. Department of Agriculture has reported that since 1955 the poorer countries boosted *total* food output almost in step with the developed world. But *per capita* food production in the less developed areas shows only a slight and uneven upward trend over this period. It is obvious from these facts that gains in total food production are being cancelled by rapidly expanding populations. With so many people eating out of the larder, there is not enough for each.

Therefore, a solution of the nutrition problem in the developing countries will depend in substantial degree on a slowdown in the rate of population increase. Today the mere requirements of pregnancy and the following period of child dependency are considerable when compared to available food resources. The essential requirements for the health and welfare of pregnant women and of children cannot be met in the future any more than they have been in the past unless a strong brake is applied to population growth through family planning.

I.
THE REQUIREMENTS OF PREGNANCY

Summary

1. Growth Requirements of Pregnant Women

Water	from	7.7 l	to	8.5 l
Protein (mother-placenta-fetus should add to mother's weight)				925 g
Fat (mother-placenta-fetus should add to mother's weight)				3,600 g
Calories				3,500-4,000 per day
Calcium (storage needed during pregnancy)				29.66 g
Sodium				22 g
Potassium				12 g

2. Growth Requirements of the Fetus

Water	from	2,100 g	to	2,450 g
Fat		340 g		480 g
Protein		450 g		480 g
Calcium			about	28 g
Iron (variable)				200 mg
Niacin				947 mg
Potassium				320 mg

3. Requirements of the Placenta at Term

Water	82-84 % of weight
Protein	15 g
Fat	0.5 % of weight
Glycogen	100 mg
Ash	1 %
Calcium	100 mg/100 g

Practically all of the above requirements for mother, fetus, and placenta must be supplied by the mother's diet.

* * * * * *

A. The Mother's Nutrient Requirements

During the first period of the pregnancy-lactation-recuperation complex, the mother and the placenta are the environment of the fetus, hence their characteristics and changes control the development of the fetus.

The first organ to change in the maternal body is the uterus, whose weight in non-pregnant women varies from 50 grams in the nullipara to 100 grams in the multipara. During pregnancy, the gross weight of the uterus increases from 50 to 1,100 grams at the 40th week, 8 percent of which is the weight of blood. The breasts also increase in volume by about 40 percent, or from the equivalent of 565 milliliters of water displacement at the outset to 775 milliliters at term. The blood volume of the pregnant woman is increased by about 1.3 liters at the end of the 34th week.

Total body water increases continuously during pregnancy. Because there are wide individual differences in the amount of body water, isolated measurements have little meaning and changes during pregnancy can be evaluated only when serial estimates are made. According to Hytten, Thomson and Taggart (75), the increment of total body water in pregnancy is about 800 grams or the difference between 7.7 liters and 8.5 liters.

1. Proteins

It is now believed that at the end of 9 months of pregnancy 483.9 grams of nitrogen have been put into storage in the mother's body after giving a number of organs their requirements in protein. During the first 10 weeks of pregnancy, a woman should add to her normal diet a minimum of 0.64 grams of protein daily. During the second 10 weeks this increment should rise to 1.84 grams, during the third 10 weeks to 4.76 grams, and during the last 10 weeks to 6.10 grams. At term, the mother-placenta-fetus complex must have added 925

grams of protein to its original weight, all of which must have come from the diet.

Taking into account the increments needed, the recommended daily protein allowance for pregnant women doing light work is 64 grams (see Table No. 1). Yet, according to the Food and Agriculture Organization of the United Nations (FAO), the average daily per capita availability of protein is only 56 grams in Africa, 57 grams in Asia, and 60 grams in Latin America. In specific countries the averages are much lower.

The biological value of the protein is dependent upon the quality of its amino acids. In developing countries, where the diet is usually based on poor quality protein like that of manioc, the amount of food consumed must be greater to obtain the proper value of protein. Yet, there is a limit to the amount of poor starchy food that a person can eat. The result is that on a manioc-based diet the increment of protein is inadequate to provide mother and fetus with the amount they need, and the chances of death of the child and short life expectancy for the mother are compounded. In practice, the value of the protein or protein mixture depends not only on its amino acid composition but also on the conditions under which it is eaten. For example, utilization of protein for the construction of new tissue will be diminished if the energy supplied by the diet is so low that protein must be used as fuel. Under ordinary conditions, protein is required for *structural purposes only* and not for energy activities. Yet, energy requirements being essential for survivial, they "steal" fuel wherever they find it, regardless of other requirements.

Many devices and conventions have been adopted in order to express the usefulness of dietary protein mixtures in practice. The point of reference is a protein which can be utilized completely, such as that of whole egg or human milk. The value of their proteins can then be expressed in percentages of the reference protein.

The term most commonly used at present to describe the value of a certain protein is "net protein utilization" (NPU). This expresses in a single factor both the digestibility of the protein and the biological value of the amino acid mixture absorbed through the intestine. Obviously, reference protein has an NPU value of 100. The protein in an ordinary British or American diet has an NPU value of about 70. In many developing countries, NPU value of the dietary protein is about 60-70 and where the protein of the staple is notably poor, as with diets where manioc predominates, it may be as low as 50.

The required increments of protein during pregnancy discussed above are, of course, proteins that are assumed to have been fully assimilated. The amounts, therefore, correspond to a dietary protein with an NPU value of 100. If the protein in the diet has an NPU value of 70 and if the mean daily increment of stored protein during the final weeks of pregnancy has to be about 6 grams, then the protein consumed during these final days must amount to 8.5 grams of dietary protein. In countries where the NPU value is smaller, the daily addition would have to be proportionately increased unless one can assume that, the mother being smaller and the baby being a little smaller (see Table 3, which gives

birth weights for babies in different regions), the increments of new tissue during pregnancy are less than those reported herein.

2. Fat

Most women should gain about 3.6 kilograms of fat during the course of their pregnancy. This additional fat is required for tissue building (small amounts), for energy (greater amounts) and for the solubilization of fat soluble vitamins (small amounts). Fat increments in the diet should occur at the rate of 5.85 grams daily during the first 10 weeks of pregnancy, 24.8 grams daily during the second 10 weeks, 21.85 grams daily during the third 10 weeks, and 3.3 grams daily during the fourth 10 weeks. It is during the middle of the pregnancy that the need for fuel is greatest in order to stock up the "fat bank" to be used during the last weeks when the body ceases to store.

3. Calories

During the third quarter of pregnancy, an additional 325 calories daily are required on the average to meet the demands of both mother and fetus for energy and oxygen, and during the fourth quarter the increment needed amounts to 250 calories per day. The average daily increment throughout the course of pregnancy is about 143 calories. These additional amounts are needed above and beyond the daily recommended allowance for non-pregnant women, which ranges from 2,000 to 2,300 calories per day (see Table No. 1). Thus, the average daily requirement in calories during pregnancy ranges from 2,143 to 2,443. Most women of Asia and Africa do not consume their requirements.

If the basic diet were adequate, one might assume that the relatively few extra calories needed during the final weeks of pregnancy could be compensated by reducing activity and hence energy requirements, but this is a luxury denied most women in developing countries.

Carbohydrates provide fuel and are required by the maternal brain which uses glucose, and by the fetus since it burns carbohydrates almost exclusively. Apart from that, only extremely small amounts of carbohydrates are required as structural material in the brain, cartilage, and connective tissue, and only limited amounts combined with deaminated protein are needed to prevent ketosis.

Apart from carbohydrates, additional stores of which during pregnancy are negligible, the additional requirement for energy specific to pregnancy comes from the demand on the protein and fat accumulated by the fetus and the mother, and from the addition to metabolism which the new tissues incur.

4. Minerals

Calcium. The specific increments of calcium compared with content of basal maternal body before pregnancy is estimated by Hytten and Leitch at 2.5 percent of the calcium in the maternal skeleton (74). If the amount of calcium

needed to build up the tissues of the fetus is not provided by the diet, then the requirement, being so small, can be drawn from the maternal skeleton.

However, the requirement of the fetus will be met with increasing difficulty in a succession of pregnancies which may result in osteomalacia in the mother. This underlines the importance of leaving a satisfactory space of time between two pregnancies to permit recuperation of possible losses. If calcium drain were to occur in two consecutive pregnancies separated by only a few months, the results obviously would be disastrous for mother and child. In such a case, an adequate supply of calcium would have to be added to the diet of the mother to avoid depletion. However, one must not forget that excessive calcium intake at that time could also lead to the calcification of the fetal skeleton, which could in turn create a considerable danger at the time of delivery.

Requirements for calcium become greater at the time of breast feeding and it is acceptable to add a small amount of calcium to the mother's diet at that time. However, this should be computed carefully so as not to fall into the other extreme.

Phosphorus. Since 85 percent or more of the phosphorus in the body is combined with calcium in the bone, what has just been said about calcium may also be said of phosphorus. However, whatever phosphorus is not in the skeleton is concerned with the enzyme reactions of energy metabolism and varies independently of bone content of phosphorus. The total specific need of this mineral is about 3.4 percent of the total in the maternal skeleton. The amount of phosphorus required daily during the fourth quarter of pregnancy is evaluated at 200 milligrams.

Iron. The iron requirement specific to pregnancy in a healthy woman is approximately equivalent to the loss she will incur at delivery, that is the iron in the fetus, in the placenta, and in the blood lost in childbirth. It is estimated by Hytten and Leitch that 150 milligrams of iron, corresponding to 500 grams of blood, plus the iron content in the fetus and placenta, amount to 600 milligrams of iron lost to the mother as the result of delivery (74). They estimate that the increase of red cell mass, which occurs normally during pregnancy, corresponds to an increase of 290 milligrams of iron which the mother can afford to provide, since she saves what she would ordinarly lose in menstruation.

It is well known that populations living at high altitude, as occurs in Latin America where substantial segments of the populations of Bolivia, Peru, Ecuador, Chile, and Colombia live way above 2,500 meters and some even at 4,000 meters, the requirements in iron, closely linked as they are with the production of hemoglobin, are proportionally increased in relation to the number of red cells per milliliter of blood. An amount of 14 grams of hemoglobin, which is considered ample at sea level, is low and even deficient when one reaches altitudes above 3,000 meters.

Sodium and Potassium. The specific increment requirements for sodium and potassium are assessed at 22 grams and 12 grams, respectively. The supply of potassium causes no problem since it is abundant in diets predominantly based on plant foods, which are common in developing countries. But plant foods provide less sodium than do animal foods and there is a natural urge to balance the two by adding salt to food. So long as there is unrestricted access to sodium chloride, there will not be any shortage. Many experts believe that more salt is taken with food than is required or desirable and many pregnant women have a craving for salty food.

5. Vitamins

Much has been written about requirements of vitamins during pregnancy, chiefly to show that it is easier to induce deficiency in the pregnant than in the nonpregnant woman, the difference being attributed to the demands of the fetus. There is little or no information about specific requirements and, as Hytten and Leitch point out, the picture is obscured by the indiscriminate use of them in clinical practice.

The B Complex. Of the water soluble vitamins, it is probably safe to assume that during pregnancy, as in non-preganancy, requirements of thiamine, riboflavin, and pyridoxine are related to the energy required. Since the energy intake must be greater because of a greater energy need, it is safe to assume that a slight undefined increase of the B vitamin group can safely be prescribed to the diet of the pregnant woman. These B complex vitamins are frequently in short supply in the diet in tropical diets, especially riboflavin, and a notable deficit is frequently observed in pregnancy.

Vitamin A. Of the fat soluble vitamins, of which vitamin A is the most important, an FAO/WHO expert group did not consider the requirement of vitamin A in the preformed state to arise during pregnancy (191). The recommendations of the National Research Council of the U.S. National Academy of Science are based on the assumption that approximately half the apparent vitamin A intake in ordinary diets is in the form of provitamin, with lower availability than the preformed vitamin in the diets (194). An additional 1,000 international units per day are, therefore, recommended during the latter two-thirds of pregnancy since the nutritional well-being of the rapidly growing fetus is dependent entirely on the mother's intake of this vitamin.

Table No. 1 gives the daily recommended allowances for nonpregnant and pregnant women doing light work. The table provides figures given by the United Nations, the United States, and the United Kingdom. It is quite obvious that the figures could be a little smaller for women in climates and areas where the average weight of the nonpregnant woman is less than 55 kilos, but this should be computed in each case by the local physicians equipped with the necessary background information on the subject.

Practical dietary allowances of pregnant women should make provisions for incomplete absorption. Malabsorption at the gut level is quite frequent in the tropics. The subject is now under review but it is safe to say that in a number of areas, such as India and Pakistan, the Middle East, western South Asia, and possibly the Caribbean area, some lack of absorption has been evidenced which would require that practical dietary allowances take this factor into account.

6. The Effects of Food Taboos

Given the short average supply of protein intake in developing countries (60 grams protein in Latin America, 56 grams in Africa, 57 grams in Asia), food taboos are quite significant because they involve essentially protein sources such as fish, eggs, and certain animals.

The diets of a high proportion of the world's population are very frequently subject to a variety of restrictive food taboos, including prohibitions against meat, eggs, beans, and certain fish which deprive the pregnant woman of the most important foods she could avail herself of. These taboos are mostly found in Africa, although in one form or other they exist everywhere in the world. Sometimes they are the result of religious beliefs. For example, certain virtues or curses are associated with the consumption of the meat of certain animals. In other instances the taboos reflect the male chauvinism existing in many cultures, according to which certain rich foods are "bad for women," expecially when pregnant, but all right for men.

The Tanzania Nutrition Committee has published a short table summarizing the food taboos of Tanzania. Pregnant and lactating women are prohibited from eating eggs, pork, chicken, catfish, intestines of any animal, twin bananas, pumpkins, and alcohol (100). The last taboo is certainly most reasonable, but the other restrictions, when added to natural scarcity or poor distribution of foods, create very serious problems which frequently result in increased maternal and child mortality.

B. Nutrient Requirements of the Fetus

The fetus, like its mother, gains weight by storing various chemicals as well as water. It has been computed that at term the water content of the fetus is around 70 percent for weights of 3,000-3,500 grams.

The fetus has to acquire protein, which at term represents 15-16 percent of its total body weight. The amount of fat acquired and stored is variable, and only an approximation can be given. For a group of four fetuses weighing between 3,048 grams and 3,105 grams reported by Hytten and Leitch, the amount of fat varied from 341 grams to 479 grams (74). The amount of calcium in the term fetus is estimated at 28 grams. The sodium and potassium content of the fetus rises progressively to about 6 or 7 grams at term.

Great variations are found by various scientists concerning the iron composition of the fetus. An acceptable estimate is 200 milligrams in a fetus

weighing nearly 4,000 grams or 0.5 percent. It has been suggested by Hytten and Leitch (74) that 450 milligrams of iron is a safe estimate of the iron content of the fetus and placenta. Yet, a joint FAO expert group estimates it at 315 milligrams (56) and Pritchard and Scott at 265 milligrams (195). Most of this iron is incorporated in the fetus during the second half of pregnancy when the average daily requirement is approximately 3 milligrams.

C. Nutrient Requirements of the Placenta

The placenta also must be built up. It contains water, protein, fats, glycogen, and ash, as well as minerals. The water content of the placenta is between 82 and 84 percent of its weight and the ash content, which is extremely variable, averages 1 percent at term. Other components per 100 grams of placenta include: 2.3 grams of nitrogen; 0.5-0.7 grams of fat; 100 milligrams of calcium; 200-250 milligrams of sodium; 120-190 grams of potassium; and 415 milligrams of iron, apart from the iron in the blood.

D. The Transfer of Nutrients from Mother to Fetus

Summary

The level of amino acids is higher in the fetus blood than in the mother's blood, indicating a loss of the valuable fraction of the dietary proteins from the mother's diet to benefit the child, and spelling the deterioration of the mother's health and further ability to bear a healthy child if the diet does not replace these losses. The fetus also absorbs the mother's glucose for its own energy and depletes the mother's glucose account. All water soluble vitamins are in higher concentration in the fetal blood than in the mother's

* * * * * *

The transfer of nutrients from the mother to the fetus is an important but little-known mechanism. It has been researched mainly be following radioactive isotopes of the molecules being investigated. Many studies have shown that most proteins do not pass from the mother to the fetus, although a few do. The most important of those that are transferred is the maternal immune globulin, especially immune globulin G, which provides the structure of antibodies. As a result, the fetus possesses almost all the immunological defenses of its mother. While the fetus does not receive the majority of the other proteins owned by the mother, it does receive the important breakdown products of these proteins – their amino acids. Thus, the concentration of the amino acids which are the core of protein nutrition are in higher concentration in the fetal blood than in maternal blood.

The mother transfers no fats to the fetus, but the placenta synthesizes them and the fetus takes them from the placenta. The fetus, to meet its energy needs,

absorbs glucose circulating in the placenta and thus constantly depletes the mother's glucose capital. She is then placed in the position of having to increase her carbohydrate consumption so as to provide for her own needs as well as those of the fetus.

The water soluble vitamins like thiamine, pyridoxine, riboflavin, vitamin B_{12}, folic acid, and ascorbic acid, are all in higher concentration in fetal than in maternal blood, implying again a great drain on maternal resources. Minerals pass to the fetus in different ways that can be studied by tagging molecules of these substances. Iron, one of the most important, is stored in the placenta and released to the fetus at rates that keep the iron saturation of the fetus high. While the present nutrition of the mother during pregnancy is, as just indicated, of considerable importance for the nutrition of the fetus, past nutrition is equally important since in order to provide the fetus with its needs, the mother must have in her body sufficient reserves to supplement deficient nutrition. This explains why starving or near-starving mothers may still give birth to normal children, at the cost of their future health, of course.

This shows also that mothers receiving customarily inadequate diets are not capable of producing many healthy children. They do not have the resources on which to drain when pregnant. When it comes to repeated pregnancies, they do not have time to replenish their stores between pregnancies and the rate of infantile mortality increases during their reproductive age while they themselves eventually die prematurely, like their children.

From the previous discussion, it follows that the egg is not just a parasite to which the mother reacts as she would to an ordinary parasite. It seems more acceptable to consider that a new biological unit has been created after conception which needs a special physiology to be able to function and perform what is expected of it. Adjustments to a large variety of substances and chemicals, therefore, has to be made and new metabolisms have to take place. Several hormones and biochemical systems are concerned with the regulation of the new metabolic mixture of nutrients in the body and in particular with the control of glucose concentration in the blood. The same can be said of the metabolism of lipids, the composition of blood and tissue fluids, the levels of amino acid in plasma, etc.

Dietary requirements and dietary intakes during pregnancy are governed by two sets of needs: the usual basic needs of healthy people and the added needs created by the presence of the fetus. These, however, do not necessarily add up arithmetically.

II.
THE NUTRIENT REQUIREMENTS OF LACTATION

Summary

For the production of satisfactory mother's milk, a 60-kilo lactating woman should consume 2,800 calories a day, 85 grams of protein, almost 3 grams of calcium, 21 milligrams of iron, and 7,000 international units of vitamin A. Very few such diets are available in the developing world. The close repetition of pregnancies prevents the mother from recuperating her losses. The successive children suffer and often die.

* * * * * *

Nursing the child is part of the whole pregnancy experience no less than the growth of the fetus into an infant. Hytten and Leitch give the estimated average increase in maternal body fat at about 9 pounds, representing a storage of energy of 35,000 calories (74). This should be enough to support lactation for 4 months at a rate of 300 calories a day. Among animals it is known that calcium is also stored during pregnancy and available for milk secretion. Among human females it is likely that the same process takes place, provided adequate calcium is available in the diet. Protein for milk, however, is probably not stored but required from the diet in addition to the basic requirements of the non-pregnant mother.

A. The Requirements for the Production of Milk

The production of milk in the mother is initiated through the secretion of the luteotrophic hormone by the anterior lobe of the pituitary gland which assists the development of the mammary glands. The amount of milk produced is influenced primarily by the diet of the mother and by the frequency of the newborn's nursing. It has been estimated that the minimum recommended allowances for a small woman during lactation should be 2,800 calories, 85 grams of protein, 3 grams of calcium, 21 milligrams of iron, 7,000 international units of vitamin A (although some experts believe this could be somewhat reduced) 2 milligrams of thiamine, 150 milligrams of ascorbic acid, 2.1 milligrams of riboflavin, and 20 milligrams of niacin. The milk produced should include the components listed on Table No. 2, especially 9 grams of nitrogenous

substances per 100 milliliters, 27 milligrams of fats, and adequate amounts of vitamins as shown.

An average mother produces between 850 milliliters and 1,000 milliliters of breast milk a day. The caloric requirement for this production has been estimated at 120 calories per 100 milliliters of milk for the secretory function and the caloric value of the milk.

Human milk is by far the best way of feeding an infant, avoiding the many troublesome consequences of bottle feeding. Except for iron and vitamin D, mother's milk contains adequate amounts of all nutritional factors needed by the newborn infant. Moreover, maternal milk also contains some of the immune bodies acquired and developed by the mother during her life which make the child more resistant to diseases. As the infant grows, mother's milk should be supplemented and gradually replaced by a diet appropriate to the infant's needs.

During infancy the child should consume foods providing him with about 50-55 calories per pound of his weight. About two-thirds of these calories should come from milk and the rest from carbohydrates supplied first by the milk and then by supplementary foods. Protein should be within 1.5-2.0 grams per pound of weight. This level is easily supplied by adequate milk intakes. Because of their essential fatty acids, fats should amount to 2 percent of the total caloric needs. Water requirements (also supplied by milk) should amount to about 140 grams per kilogram of baby weight daily. Mineral needs are usually met during the first 3 months from mother's milk.

Growth in weight and stature is the proper criterion for adequate nutrition and it must be remembered again that all these requirements for survival and health have to be provided by the available diet for both mother and child. It is significant that, according to the World Health Organization (WHO), death rates among preschool children in the developing countries are 10 times higher than in developed nations.

B. The Consequences of Inadequate Breast Feeding

Little information is available on child feeding practices in developing countries. From a review of the literature made throughout the *Ecology of Malnutrition* series (100), a general pattern emerges, but specific details by country and culture are not sufficiently available. The general pattern indicates that throughout the developing world, the trend is to shorten breast feeding more and more, either because women want to work for economic reasons or because of the desire to imitate practices in developed countries. The consequences of this trend work against the infant in three ways: a) clean, nutritious mother's milk is replaced by frequently over-diluted powdered or canned milk prepared with polluted water, often in dirty receptacles; b) starchy weaning foods are substituted for the natural protein of mother's milk; and c) the absence of lactation shortens the mother's period of amenorrhea, thus increasing the risk of a new pregnancy which, in turn, threatens the survival of the second child as well as the first. This is, of course, the story of kwashiorkor,

the "disease of the second child." (More often than not, it is the disease of all children in the family.)

Prolonged breast feeding can have adverse effects if continued after new conception takes place. Cantrelle and Leridon have made some interesting observations on this subject in a rural area of Senegal, 150 kilometers from Dakar (31). They found that the period of breast feeding varies from 12 to 36 months but averages 24 months. An examination of the curve by month shows that there is a marked peak at 24 months due to the custom of weaning a child at his second birthday. In 30 percent of the cases studied, conception occurred while the previous child was still being breast-fed. Ten percent of the mothers were still nursing when 4 months pregnant and 1.5 percent during the last month of pregnancy. The study revealed an infant mortality rate of 202 per 1,000 live births. Out of 1,000 births there are only 510 survivors by age 5. Since there was no voluntary limitation of family size, small families were rare. According to other results, mortality was found to be at a minimum for intermediate parities, that is, not below two and not above three or four.

These investigators found that if a series of pregnancies comes too close together, this may have consequences for the mortality of the first child in each interval who, as we have seen, risks being suddenly weaned. It may also affect the second child. Moreover, the mother's health may suffer from successive pregnancies and, as a consequence, that of the developing child as well. The investigators finally conclude that mortality in the first year of life is high and that mortality between the first and the third years is even higher.

Cantrelle and Leridon's study of the relationship between fertility, breast feeding, and infant mortality has shown that there is a direct negative effect of breast feeding on fertility. The interval between live births is 9 months greater for an increase of 1 year in age at weaning when weaning occurs between 12 and 36 months. They also found that the relationship between weaning and infant mortality is particularly clear when the child is weaned during the following pregnancy. The probability of death within 1 year of weaning then increases from 50 to 150 percent. They found the effect of mortality on fertility to be of the same sort and the same importance as the effect of weaning on fertility. It plays its role through the intermediary of weaning.

In the city of Kingston, Jamaica, Grantham-McGregor and Back (100) have studied a representative sample of 300 infants of working mothers and found that most children are breast-fed to age 6 weeks, following which some bottle feeding is added up to 5 months, when the switch to complete bottle feeding occurs and the child is weaned. Among nonworking mothers, breast feeding is extended for a longer period. Weights of the infants were found to be higher during the breast feeding period than during the bottle feeding period when gastroenteritis is also more frequent and increases as breast feeding diminishes.

McKenzie and Lovell compared 204 Jamaican children who had died between the ages of 6 months and 3 years, pairing them with living children of the same ages (100). They were able to establish that 70 of the deaths had been caused by malnutrition and that malnutrition had been a contributory cause of death in

132 cases. The investigators established to their satisfaction that the standard of child care, as measured by attendance at antenatal and postnatal clinics, was lower among the mothers of those who died than among the mothers of the living children. They also determined that the children who died were breast-fed for shorter terms and received less protein food supplements than those who survived.

The significance of these various explorations seems to be that when a child survives the early dangers of malnutrition, he develops within normal limits, but that there exist in Jamaica a number of areas where lack of education, restricted financial resources, and the structure of society are conducive to serious levels of malnutrition.

In rural areas of Haiti, practically all mothers breast feed their babies for at least 6 months. This is not the case in cities where more sophistication causes more bottle feeding and hence more diarrheas. According to Beghin et al. (100). a number of taboos for the mother and the child are still observed. White beans, tomatoes, and fish are generally taboo for nursing mothers and in certain places lard, eggplant, pork, and fruit are also forbidden. Infants are not allowed any kind of beans, meat, or eggs and, as in many developing countries, they are weaned on a light porridge of cornmeal and sweet water, and later receive a bread soup which may contain some fresh or reconstituted milk. Infant mortality is very high and stands at 146.5 deaths per 1,000 live births. Malnutrition is deemed by many investigators to be one of the first three causes of admissions and deaths of infants in the hospitals. Only infants with diarrhea and tetanus (through the umbilical cord) are as numerous.

In Gambia, Scottish investigators have found that Gambian babies weigh 2.2 kilograms to 2.6 kilograms at birth compared to 3.2 kilograms for Scottish children, reflecting possible undernutrition of the mother, especially during the rainy season. Yet these babies develop faster than their Scottish counterparts, regaining their birth weight in 10 days and gaining up to 800 grams in 14 days (100). This rapid development reflects the value of demand breast feeding, which is the custom in Gambia.

Gambian infants are left at home during working hours as soon as they are too heavy to be carried on their mothers' backs, which may occur as soon as the baby reaches 5 to 6 months of age. The child's diet, under these circumstances, is a breakfast of breast milk before the mother leaves for the field, then a few spoonfuls of pap fed to him by a grandmother or an older child at various times during the day until such time as the mother comes home and gives him another breast-feed. Under such a regimen, the mother loses her milk very soon, and no other milk being available, the child has to be put on an adult diet. Only modern mothers in towns purchase baby food, if they have the money. As a result of these conditions, infant mortality is high, especially in the least-accessible parts of the country. While malaria is certainly responsible for some of these early deaths, malnutrition is estimated to play an important role. McGregor, Billewicz, and Thompson found that 43 percent of 187 children they observed died before reaching the age of 7 years. The peak of infant mortality occurs between 9 and 15 months (104).

In Sierra Leone, babies are breast-fed for the first 18 to 24 months. When weaned, the infants are first fed on a starchy gruel, then eventually share the family's meal which includes very little fish or meat and sometimes none at all. Between 1950 and 1960 the rate of infant mortality in Freetown was ca.130 per 1,000 live births, while during the same years 350 of 1,000 deaths occurred in children (100). Malnutrition is a major cause, direct or indirect, of these high rates.

The growth of children in Sierra Leone follows a pattern not uncommon in developing countries. Until the child reaches 4 months of age, infant development parallels that of West European children. From the sixth to the twelfth month, the drop in growth is marked and corresponds to the weaning period. During a survey made in 1964, Blankhart found that up to the age of 5 and based on growth and comparison of weight increases, malnutrition in small children was a widespread problem (100). In his sample, 25 percent of the children at risk were undernourished, and of these 5.7 percent were severe cases. Extrapolated for the infant population of the whole country, this might mean that 12,000 children were to die within a month or two of the survey.

III.
THE RECUPERATIVE PERIOD

Summary

The reproductive cycle is not terminated with delivery: it includes lactation and recuperation. This latter period is the time required for the physiology of the woman to readjust to the non-pregnant status. What the length of the recuperative period should be is not known. That a healthy, well-fed woman living in a stress-free environment can recuperate in 1 year is possible but not certain. All studies, however, prove that the optimum space between two births is 3 years. Shorter as well as longer intervals mean increased risk of mortality for mother and child.

This little talked about period may play a very important role in family health and in child spacing. If a new pregnancy is imposed on a malnourished woman before she has recuperated from the previous one, the new burden, combined with the unhealed scars of the old one, may spell disaster for her and her child–a fate that planned parenthood helps to prevent. In the light of these observations, the acceptance of wide intervals between pregnancies seems inescapable. To reduce infant mortality, mothers need food and time.

* * * * * *

In the preceding pages we discussed the increments in dietary intake the pregnant woman must procure for herself to do justice to her pregnancy and to the consecutive and inseparable lactating period that follows. Besides the fact that taboos may deprive her of certain valuable foods, the additional proteins, fats and calories she needs may not be available in sufficient amounts in the environment in which she lives and under the stress she has to support in an improverished situation.

The two first periods of the reproductive cycle–pregnancy and lactation–are followed by a recuperative period during which the organism of the woman readjusts to the non-pregnant state. Wishik and Stern (177) remark that this readjustment may occur without damage if the woman is healthy and does not live in a stressful environment. But under certain unfavorable circumstances, such as those that exist in developing countries, changes akin to depletion do occur which modify the normal safety of the interval between births.

Even early in pregnancy, before the massive needs of the products of conception arise, hormonal controls begin to prepare the woman's body for the future needs of the pregnancy, delivery, and subsequent lactation. "The

situation is one of anticipation raither than response. In addition to readiness for enlarged tissue mass, the heightened metabolism seems to be attuned to a state of growth rather than to mere body maintenance. New capacities arise to handle materials that will be utilized at and beyond the placenta" (177). During the transition phase, that is, the first few months of gestation when changes precede actual need, it is believed that the woman's physiology may be less efficient than in the nongravid state. For example, the dilution of the blood means more heart action, and a higher metabolic rate burns more calories, both of which tax the kidney function. Wishik and Stern state that "while mere inefficiency would be no basis for concern - even extravagance is tolerable if the woman has reserves to waste - inefficiency superimposed upon deprivation can be a serious threat."

In relation to child health, there is some suggestion that birth interval may be as important, if not more important than, the number of children in a family. In a Colombian study (187), children were grouped according to interval between births and the prevalance of malnutrition. The data indicated that only among children who were over 3 years of age at the birth of the next sibling was there as appreciable decline in the prevalence of malnutrition. These findings were consistent with those reported in Bangkok where a statistically significant difference was reported in the proportion of malnourished children in families where the birth interval between siblings was over 24 months when compared with families where the interval was under 24 months (140). The investigators concluded that the advent of each additional child to a family acts as a check on the growth of all previous siblings.

Findings in the Philippines indicated that in families with three preschool children, the youngest of the three was found to be more nutritionally stunted than either of the two older siblings (94). In Haiti, it was found that the birth interval between children of normal weight and those who were slightly malnourished was consistently greater than the corresponding interval for children who displayed serious or severe malnutrition (173).

It is difficult, if not impossible, to find a report that suggests that there is an advantage to either the mother or her offspring as a consequence of an abbreviated interval between births. Rather, incidence of abortions and maternal deaths appear to be the result of short intervals. In a Zulu sample, it was reported that incidence of hypertension among mothers increased with the number of children. (152).

The demands of pregnancy in terms of food (two pounds per pregnant woman of proteins for each child bearing period in addition to the regular health protecting demands of the body) are so great that a shortage of nutrients poses a threat of tragedy to mother and child a threat so great as to make a recuperative period between pregnancies almost imperative.

IV.
THE CONSEQUENCES OF UNFULFILLED REQUIREMENTS

Summary

There is an abundant literature on the subject of reproduction and nutrition. Briefly, poor nutrition may cause the mother to experience serious complications of pregnancy and delivery during the puerperium, making her incapable of properly breast feeding her child or of serving the needs of a new fetus if she becomes pregnant too soon.

On the child's side, proper nutrition is needed for survival and, if this is assured, for mental and physical development. Brain development cannot catch up with infancy retardation and a child's future in this respect is probably sealed between the ages of 2 and 3. Poor infant nutrition goes hand in hand with large families. The children of small families score higher on achievement than children from large families and intelligence test scores drop as size of sibship rises (57). The risk of mental deficiency increases with increasing birth order, yet the presence of a retardate in a family does not lead to voluntary limitation of the number of children.

As we shall see hereunder, most researchers support the point of view that if the pregnancy requirements outlined earlier are not met, dire consequences can occur affecting the newborn, the mother, and eventually the entire family.

* * * * * *

A. Consequences Affecting the Mother

The disastrous consequences of haphazard pregnancies affect the mother profoundly. Maternal mortality increases with parity and maternal morbidity also increases, especially with diabetes and anemia. All of the mother's biochemical handicaps are eventually reflected in future fetuses and infants.

Eastman reviewed all maternal deaths at Johns Hopkins Hospital between 1896 and 1939 and found that for women of low parity (first to fifth births), maternal mortality ranged from 3.55 to 3.78 deaths per 1,000 live births, averaged more than four per 1,000 for sixth or eighth births and rose to 11.73 per 1,000 for ninth and later births (49). He found that more than half the deaths of women who had previously had five or more children were attributed, in order of importance, to rupture of the uterus, chronic hypertensive vascular disease, chronic nephritis, and placenta praevia.

Jaffe and Polgar have shown that for 348,393 live births in the United States between 1951 and 1961, maternal mortality generally increased with both age and parity (76). Furthermore, a comparison of maternal mortality for second to fourth births with that for fifth and later births within each of four maternal age groups revealed higher maternal mortality for the women of higher parities, in some cases more than twice as high as the mortality for low parity. (Similar results have been obtained by researchers in Finland (171), in Washington, D.C. (118), and in Kentucky (134).

In addition to obstetric complications, other health problems have been associated with multiparity. One of these is diabetes. Pyke in England concluded that a woman who has had five children appears to have about three times as great a chance of developing diabetes as a woman who has had none (138). Middleton and Caird confirmed these findings (109). Examining the records of 543 newly-diagnosed diabetic women and 413 men between the ages of 40 and 80 who represented virtually all newly-diagnosed diabetics in a population whose age and sex structure was known, they found among the diabetics an excess of women with four or more children. They also found that, while the likelihood of diabetes increased with age within each age group, the rates also increased with fair regularity with increasing parity. For men, the risk of diabetes was approximately that of women who had borne two children.

In order to compare their data with those from earlier studies, including Pyke's, Middleton and Caird calculated the excess risk of diabetes for women of each parity level over that of the risk of nulliparous women. The result of their study was in close agreement with others and showed that between the ages of 50 and 80 years, the excess risk above that of a nullipara is 20 percent after one child, 45 percent after two children, 100 percent after three, 200 percent after four or five, and 400 percent after six or more children

Many investigators have found that the risk of maternal and infant death increases when the mother is below the age of 18 or above the age of 35. Hence, proper child spacing will undoubtedly save life and health of mothers and children. Among many other risks, that of Down's syndrome (mongolism) in the child is real as the mother advances in age.

It has been observed that the spacing of pregnancy improves maternal health in areas where the woman's fertility span is characterized by a continuous cycle of pregnancy and lactation, resulting in a serious drain on her nutritional reserves. In addition to diabetes, close repeated pregnancies aggravate a large number of other ailments in the mother, such as cardiovascular diseases, renal insufficiency, anemia, hypertensive disease, and Rh incompatibility.

A study by Naeye and Blanc, reported in the May 1, 1972 issue of the *Hospital Tribune*, covered 1,044 newborns and confirmed that mothers under 17 and over 36 years of age have twice the number of toxemias of pregnancy than controls.

B. Consequences Affecting the Child

Summary

For the child, the most important consequence of failure to meet the nutritional requirements of pregnancy and lactation is infant mortality. High infant mortality rates are more specifically correlated with low birth weight, parity, faulty infant and preschool feeding, daily caloric intake of the mother (inversely), daily animal protein intake of the mother (inversely), per capita national income (inversely). These correlations have been demonstrated to hold true in 41 countries of the world.

According to the Pan American Health Organization (PAHO), in 35,095 cases of infant mortality studied, nutritional deficiency in mother and child contributed to infant mortality as the underlying or associated cause in 57 percent of the cases (136). Everywhere a study was made, it was seen that stillbirths increased with the number of deliveries. Infant mortality increases with short intervals between births and is at its maximum when the interval is less than 1 year. It also increases with too-long intervals. Fetal and neonatal mortality are at their lowest when the interval between births is around 3-3½ years.

* * * * * *

Morbidity and mortality are known to be associated with a multitude of factors of diverse origin. Indeed, there appears to be a complex interplay between the various social and economic factors and the morbidity and mortality of young children within a given community. All the parameters of infant mortality are relevant to the problem of spacing pregnancies. Economic status and nutrition are inter-related factors which significantly influence the mortality during the first year of life. Conversely, morbidity and mortality within the family affect the productive capacity of its members and their drive towards social and economic advancement, thus completing the vicious circle.

Srivastava and Maheshwari made a study of the national statistics of 41 countries (161). A positive correlation was observed between the infant mortality rate, the general death rate (0.73), and the birth rate (0.84). An inverse relationship was noted between the infant mortality rate and the daily per capita intake of calories (-0.49) to total proteins (-0.41), and animal proteins (-0.64) and per capita national income (-0.71). In all instances, the relationship was found to be highly significant. This study was based on the national statistics of Burundi, Gambia, Madagascar, Mauritius, South Africa, United Arab Republic, Barbados, Guatemala, Canada, Mexico, Puerto Rico, United States, Argentina, Brazil, Colombia, Guyana, Peru, Ceylon, Burma, India, Israel, Japan, Jordan, Malaysia, Pakistan, Philippines, Syria, Belgium, Czechoslovakia, Denmark, France, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom, the USSR, Yugoslavia, Australia, and New Zealand.

1. The Importance of Birth Weight

If the diet supplies the needed requirements in a regular fashion, the healthy development of the pregnancy has its culmination in the weight of the fetus at delivery. One of the intriguing findings of the PAHO investigation of neonatal mortality was the high proportion of deaths of infants of low birth weights. The importance of birth weight in reflecting a host of perinatal environmental and cultural factors, as well as nutritional factors, can hardly be overemphasized and the people in charge of family spacing programs should be well aware of the importance of this notion. A study of the distribution of birth weights among newborns in a given country can be a pointer as to what the important factors are that determine a certain pattern of infant mortality and hence can point to the direction to follow to improve the situation (see Table 3).

The results of a community study carried out in Aberdeen, Scotland (153), and a similar study in Kauai, Hawaii (190), suggest that the influence of low birth weight on mental ability at school age may be much less marked in the more affluent and well-educated sections of the community than in the poorer and worse-educated. Is it possible that the determining factor here is the quality of postnatal nutrition? It is essential to conduct more community-wide followup studies in an attempt to differentiate and separate as many factors as possible.

While the birth weight of the child is essentially governed by the diet of the mother, genetic differences do exert an influence and cannot be ruled out. Little can be done about them, however, once conception has occurred, while something can be done about the environmental factors, which include the nutrition of the mother.

Based on information in the literature, Robers (145) has computed norms or near-norms for birth weights among seven ethnic groups, as follows (also see Table 3):

Normal Birth Weights for Seven Ethnic Groups

Ethnic Group	Grams
Amerindians	3,568
Caucasians (Europeans)	3,222
East Asians	3,147
Southwest Asians	3,145
Indonesians (South Mongoloids)	3,052
Africans (Negroids)	2,993
Indians	2,886

This might indicates, assuming that the genetic factors remain more or less constant for the ethnic group considered, that the variations observed within the group are of environmental origin. The result of such factors as maternal size seem to play an important role in determining the size of the fetus, while the

paternal size does not seem to play any. The mother's size again reflects a genetic and environmental factor.

The reciprocal influence of genetic versus environment may be gauged by the fact that in 114 different species of mammals from bats to whales, including man, the correlation between fetus and parental size is always between fetus and mother, not father. This points to a dominant influence of environment of the mother in determining, together with the other factors, the size of the fetus at birth. Many other studies confirm this point. The question may be asked: Through what mechanism does the mother's environment reach the fetus? As we have already shown, the answer is obviously through the placenta.

McLaren and Michie write: "It can be supposed that the supply of blood and of its dissolved nutrients conditions the rate of fetal growth, both directly and also indirectly by determining in the earlier part of pregnancy the size attained by the placenta. Since the human fetus, contrary to what happens in many other mammals, is born at an advanced stage of development, the last demands made upon the mother's nutrition are likely to be large, increasing still further the importance of maternal diet in the condition of the fetus at birth." (106)

The importance of this diet is further proved by the finding of Thomson, Billewicz, and Hytten (167), who found a significant difference in birth weight of babies born to professional and managerial class families on the one hand and those of semiskilled and unskilled workers on the other. Moreover, the influence of maternal nutrition on the weight of the child was shown to be related to caloric intake rather than to quantities of any specific nutrient. It is also proved that the birth weight of babies born to nonsmokers is higher than that of babies born to smokers. There is a correlation between the number of cigarettes smoked and the birth weight. The more of the first, the smaller the second. This could be the result of both vasoconstrictive action of nicotine, which would reduce the blood flow to the placenta, and the tendency of the smoking habit to curb appetite and reduce diet.

It has been found in a number of studies from Britain, the United States, Africa, Italy and India, that the birth weight of the child has a tendency to increase with the number of parities. However, this birth weight advantage of later-born infants does not seem to persist through childhood. Douglas and Simpson investigated the inter-relationship of family size, social class and puberty among 3,000 British schoolchildren at ages 7, 11 and 15 (45). The investigators suggest that social class effects, such as poor diet, frequent infection and inadequate care common to large families may explain in part the association between family size and slow physical development.

It is also interesting to note that there is an optimum birth weight for each ethnic group at which infant mortality is at a minimum or at least a coincidence. Curves made by various researchers, such as Hollingsworth in Ghana (72), Jayant in India (80), Butler and Albeman in the United Kingdom (28) and Erhardt et al. in the United States (55), show that after a certain weight, infant mortality increases with the weight of the fetus.

Roberts found a significant inverse correlation between mean birth weight and mean environmental temperature (145). He remarks that this correlation must be indirect as the fetus grows in a constant placental temperature of about 39°C. Perhaps it is not so much the temperature of the surrounding air that is responsible for the low birth weight as the poor diet or possibly the diseased condition of mothers who must live under tropical or sub-tropical environmental conditions.

In a biennially variable multiple regression analysis of matched births and neonatal factors and the neonatal and postnatal death records for Baltimore City between 1960 and 1964, the following factors were considered by Shah and Abbey (156): birth weight, race, socioeconomic status, prenatal care, maternal age, and live birth order. The investigators concluded that birth weight was the single most important factor in neonatal mortality and that it was among the important factors in the postneonatal period as well. The authors pointed out that race, socioeconomic status, and maternal age were important because they were all related to birth weight. In regard to live birth order, it was found that mortality increased with birth order (with the exception of forced births).

Altitude seems to be directly correlated with birth weight as babies born at 4,500 meters in the Andes weigh less than infants born in Lima at 150 meters, while the placentas are heavier at high altitude than at nearby sea level (192). Several explanations can be suggested: the rarified oxygen at the high altitude may be correlated with the oxygenation of the fetal blood and with the size of the placenta whose growth may be stimulated by the increased mass of blood demanded to accommodate the increased erythrocytes. Yet, the increase may not be quite sufficient to bring to the fetus the oxygen it needs for development. Once more, the nutrition of the mother influences the birth weight which, under normal conditions, is a bench mark in estimating the health of the baby. Together with the lower birth weight observed at high altitudes, an increase in infant mortality also occurs.

2. Infant Mortality and Parity

Almost uniformly, studies from both industrialized and developing nations indicate that the risk of stillbirth is relatively high for first births, then the rate of increase varies (125). However, the available evidence indicates that after the third or fourth birth a sharp increase occurs which becomes more accentuated after the fifth or sixth birth. Infant mortality, expecially in the postneonatal period, increases steadily with parity, as does early child mortality. In general, studies from industrial nations, particularly studies from Britain, indicate that the relationship between infant mortality and parity is maintained even after there has been an overall decline in infant mortality rates. Some of these studies also indicate the strong inverse relationship of social class with perinatal and infant mortality.

Yerushalmy analyzed records of all births and stillbirths in the United States in the period 1937-1941 (180). He found that stillbirth rates increased with parity more dramatically for young women than for older women. Even

when the effect of maternal age was eliminated to produce a theoretical curve of the association of parity with stillbirth, stillbirth increased with parity most notably at very high birth orders of 10 and above. In his excellent paper, Omran reports many more studies which tend to prove the positive correlation existing between number of births and fetus, infant and child mortality. (125).

Yerushalmy in Kauai, Hawaii, showed that such deaths increase significantly after the third birth (190). Chase, analyzing 500,000 births in the State of New York (excluding New York City), found that childhood mortality rises after the second birth (33). Leob confirms these findings (91). His research shows the lowest number of deaths for the second parity and the highest for the fifth. In England, Morris and Heady found that perinatal death is directly associated with parity and mother's age and inversely to mother's class level (114). Spicer and Lipworth report similar findings (160).

In Lucknow, India, Bajpai et al. found a ratio of perinatal mortality of 114 per 1,000 live births and observed that the rate of death begins to increase when the mother is 25 years old and accelerates when the mother is over 35 (14). Perinatal mortality was lowest for the second birth, but rose thereafter. Mehdi et al. in Hyderabad also found that perinatal deaths were related to mother's age and parity (107).

In Ghana, Radovic reports that stillbirths rise from 1.81 percent in primipara to 6.45 percent in women experiencing their second to fourth deliveries and reach 11.36 percent thereafter (139). Roberts and Tanner in Tanganyika (now Tanzania) also found perinatal losses to be high in women with parities greater than five (146).

All these findings convey the notion that the chances of wasting pregnancies increase significantly after the third parity.

3. Infant Mortality and Closely Occuring Births

An occasional interval between births is generally accepted as beneficial to the health of mother and child. Too short intervals and occasionally too long intervals are believed to be a health hazard. However, an optimum interval between births is thought to be around 3 years. As with other variables considered in this paper, it is hard to completely separate the effects of birth interval from other variables, such as maternal age, family size and prenatal care. Early studies conducted by Woodbury in eight American cities during the period 1916-1920 showed that the infant mortality rate was high when the interval between births was short and was at a minimum for intervals of about 3 years (179). In an analysis of data from Johns Hopkins Hospital based on 5,158 births which occurred consecutively on the obstetrics services of the hospital during the period 1936-1943, Eastman demonstrated relatively high rates of stillbirth, neonatal mortality, prematurity, and certain complications of pregnancy and delivery when the interval between births was under 12 months, but he found no increase for these rates following birth intervals of any other length (48).

In 1945, Yerushalmy considered the problem in a study based on a tabulation of more than 7 million births and stillbirths that occurred in the United States in the 5-year period 1937-1941 classified according to maternal age and order of birth (189). The overall stillbirth rate was 29.5 per 1,000 total births. Using an indirect method for assessing the influence of the birth interval, he demonstrated that relatively short intervals and relatively long intervals were associated with higher stillbirth rates, while moderate intervals led to the lowest rates. Yerushalmy admitted, however, that the method did not yield a quantitative expression of the exact optimal interval for each parity and age group.

In another study already mentioned, on the island of Kauai, Hawaii, Yerushalmy proved that both late fetal and neonatal mortality rates were lowest when the interval from the termination of one pregnancy to the beginning of the next was between 2 and 3 years, which is equivalent to an optimum interval between births of about 3-3½ years (190). The mortality rates increased following a shorter interval, especially less than 4 months and following intervals of 3 or more years. In the case of late fetal mortality, the lowest rate was found for an interval of 1-2 years. As to postneonatal deaths and childhood mortality, a pregnancy interval of 3 or more years was the most favorable for survival through childhood and mortality increased progressively as the interval between pregnancies decreased.

In a nationwide British study including more than 13,000 births during a 1-week period, Douglas reported that the percent of premature infants was lowest for those born following an interval of at least 2 but less than 6 years since the preceding birth (44). Bishop reported in 1964 on a study in Philadelphia based on 16,000 consecutive deliveries (24). The incidence of premature births there was found to increase significantly when the interval between pregnancies was less than 1 year.

4. The Influence of Malnutrition on Mental Development

There is a great deal of concern today over the effects of malnutrition on mental development. Workers like Cravioto in Mexico, Coursin in the United States and Monckeberg in Chile have explored and demonstrated the strong probability that malnutrition in the two first years of life may frequently result in subliminal levels of mental development. Individuals thus affected are not only the victims of the imbalance in their environment between food supply and food requirements, but in addition, their deficiency places them in a position of such inferiority as to make it impossible for them to improve the environment in which they were born.

New techniques for measuring cellular structure and composition are now being used to study growth and development during intrauterine life. Information on cell size, numbers, and chemical content of the placenta is accumulating. It indicates that there is a marked reduction in certain components of placentas from malnourished pregnancies compared with those

with adequate nutrition. Therefore, the baby may already have been deprived *in utero* of nutrients necessary for the normal development (differentiation and integrity) of its rapidly growing brain. This may well cause irreversible changes in mental ability.

Today, tissue growth can be measured indirectly by determining the number of cells within a given organ. Since the amount of desoxyribonucleic acid (DNA) within the nucleus of a cell is constant for any given species, the total number of cells can be calculated by measuring the total amount of DNA within an organ. In humans, the greatest growth spurt for the brain occurs during the fetal period. By the end of the firt year of life, the brain has assumed approximately 70 percent of its adult weight, and by the end of the second year its growth is almost complete.

Studies of the human brain have shown a very rapid increase of DNA content toward the end of the period of gestation; the increase slows down after birth but continues until the child is 5 or 6 months of age. These findings suggest that cell division in the brain normally occurs during gestation and the early part of the first year of life. Markedly fewer cells (less DNA) were found in the brains of a small sample of children who died of malnutrition during the first year of life than in the brains of a sample of well-nourished children who died in accidents. It is not known whether this represents irreversible change or how severe the nutritional deprivation must be to show these effects. However, the studies demonstrate the importance of gestation and early infancy in nervous system development.

Monckeberg studied the intellectual performance of three groups of preschool children in Chile: those in the first were well-fed offspring of middle class parents; those in the second were children from lower class families who were well-fed, thanks to a food supplementation program; and those in the third were poorly-fed children from the same socioeconomic class as the second group (193). In the first two groups the rate of intellectual subnormality (IQ of less than 80) was the same at 3 percent, but in the third group the rate rose to 40 percent. Monckeberg concluded that when studying groups of low socioeconomic conditions and low intellectual performance, a significant relationship can be observed between growth retardation and low intellectual capacity. A similar correlation can be seen between animal protein intake and intelligence quotient, so that those children consuming a smaller proportion of animal protein present a significantly lower intelligence quotient. This correlation is not observed when analyzing the total amount of calorie intake.

A child's physical growth and emotional and intellectual development are particularly crucial aspects of the overall family health picture. The consequences of childhood experience not only affect an individual throughout his entire life, but may affect his progeny as well. Evidence that large family size may be detrimental to children's growth and development has been collected from a variety of cultural settings. Because of the many competing variables (genetic and environmental) and the lack of precise cultural independent measurements of physical and mental development, however, this data must be interpreted cautiously.

Rosen found that boys from smaller families scored higher on achievement motivation than boys from larger families and that there is evidence that both family size and birth order are important factors in shaping personality development (147).

The relationship between intelligence and mental deficiency and parity and family size has been studied in various parts of the world. According to Omran, among the better studies one was conducted by Gille in France in 1943 to 1954 and included approximately 2 percent of schoolchildren between the ages of 6 and 12 (57). The total number was 95,237 and was representative of 20 regions of the country. The mean test scores on Gille's intelligence tests dropped consistently as size of sibship increased. The mental age of children with no siblings was 1 and 2 years higher than those with seven or more siblings. The association was more apparent among the children of farmers, manual laborers, and clerical workers. It was barely discernible in the children of professionals.

Another early study was the Scottish Council Survey of 1947 in which a series of IQ tests was administered to virtually the total population of 11-year-old children in Scotland, totaling 70,805 (153). It was found that children's IQ levels decreased with an increase of sibship size of the total sample and when a Stanford-Binet Test was individually administered to a sub-sample of 1,258 children, the trend of this association was maintained.

In a more recent study, Record et al. investigated 50,172 Birmingham children and found a decrease in verbal reasoning test scores with increase in family size (141). When the social class effect was considered, it was apparent that the higher social class children had higher scores than lower social class children. However, within each social class there was a parity effect. That is, the higher birth order children in all social classes consistently scored lower on the verbal reasoning tests. Another recent study was reported by Reed and Reed (142). The part of the study with which we are concerned involved a sub-sample of 1,016 families, totaling 4,017 individuals for whom IQ scores were available for both parents and at least one child. It was found that the mean IQ's for the children for sibship sizes of one to five were similar, but that mean IQ dropped significantly for children of sibship sizes of six to ten. In India, a study by Chopra of urban and rural high school students in the Lucknow district showed a gradual decline in mean intelligence test performance and school grades as family size increased (35).

As to manifest mental deficiency, according to Omran (125), a relationship to family size has been reported in a few studies. Pasamanick and Lilienfeld compared the birth certificates and hospital records of mentally defective children born in Baltimore between 1935 and 1952 with a matched control (128). Their data suggest that the risk of mental deficiency increases with increasing birth order. Although lacking the advantage of a matched control, an earlier study of retarded children in Massachusetts by Dayton reported a significant relationship between retarded children's mean sibship size and the degree of retardation (39). Dayton concluded that families having a

retardate are larger than the average family in the general population and families having a mental defective are still larger. Regarding the possible deterrent effect of a child's retardation on the parents' reproductive behavior, Dayton suggests that except in cases of extreme retardation, such as mongolism, the presence of a defective child did not generally lead to voluntary limitation of family size by the parents.

Omran also feels that malnutrition is one of the most widespread and important health problems, for the quality of a family's nutrition can be decisive in determining the quality of each member's health, affecting children's growth and development, dental health, and resistance to infection (125).

In a study which sought to examine demographic and social factors which contribute to malnutrition, Wray and Aguirre n. ' a survey of protein-calorie malnutrition among the preschool children of Candelaria in Colombia (187). They collected complete socioeconomic data as well as measurements of malnutrition among a random sample of 354 families with 721 preschool children. They found that the differences in the prevalence of malnutrition in children from families with four living children are fewer compared with those from families with five or more was statistically significant. The first group had 38 percent malnourished among 642 children and the second 44 percent malnourished among 426. It was found that the pesos per person per week spent on food decreased steadily with increasing family size.

A number of studies have been conducted to try to determine the effect of family size and child spacing on family relationships and emotional adjustment. It has been shown that there is frequently some decline in successful marital adjustment with increasing family size and in many cases this is attributed to lack of success in controlling fertility in accord with a couple's choice of not only how many children to have but when to have them.

Webb, Ballweg, and Fougére report that after a 5-year nutritional education program in a rural Haitian community, involving the feeding of severely malnourished children and a nutrition education program for mothers, nutritional deficiencies containued to appear (173). A comparison of family size with the prevalence of malnutrition suggested that larger families were more prone to contain malnourished children. It appeared that success in the rehabilitation of one child through a feeding program was blunted when the size of the family increased to the point that resources were overextended and subsequent children also required rehabilitation.

Thus it appears that the solution to problems of malnutrition among children must move beyond programs that are designed to educate the mother concerning nutritional needs of her children and providing feeding programs for malnourished children. A further dimension that appears to be required is education regarding the need to provide adequate spacing between the births of children and to limit family size.

The link between family planning and family health is frequently verbalized but seldom put in operation. Presented with evidence indicating that high fertility in the mother is associated with nutritional difficulties that spell

mental and physical development impairments and higher morbidity in the child, the case for family planning and spacing of pregnancies becomes stronger.

While good health may be the desire of individuals it is not yet an essential concern of policy makers. Exposing convincingly the dangers inherent in increasing the number of guests when the larder is empty, might force recognition of the concept of pursuing family health.

V.
CONCLUSIONS

It is possible to say that short intervals between births increase morbidity and mortality in child and mother. This effect is accentuated when the mother is too young, or too old, or is a multipara.

Given the positive correlation between the increased number of pregnancies and increased deaths during the first year of life, the morbid status of child and mother is continued during the second year of the child's life when the weakened condition of both opens the door even wider to infections and diseases. In many countries, a positive association between shorter inter-pregnancy intervals and infant and child mortality has also been described. Short birth intervals have been associated with increased fetal loss and prematurity. There is little data relating child mortality to birth spacing, but it is reasonable to assume that the mortality differences associated with birth spacing reflects underlying differences in morbidity.

Increasing maternal age is positively associated with higher stillbirth rates and infant mortality and an increased risk of congenital abnormalities such as mongolism. Thus continued childbearing in the older groups may contribute to child morbidity.

Parity, birth spacing, and maternal age are inter-related variables, but each exerts a separate effect on child mortality which may be observed if any two of the three variables are held constant. The strength and consistency of these associations and their probable independence from disturbing variables suggests a causal relationship between maternal fertility behavior and child morbidity. As stated previously, evidence for causal relationships must be supplemented with plausible mechanisms and in the case of effects of maternal fertility on child health, there are probably at least three relevant mechanisms in operation. Short birth intervals due to the occurrence of a new pregnancy will interrupt lactation and cause premature weaning. This, in turn, may lead to infantile malnutrition and gastrointestinal infection. In larger families, the older children introduce communicable diseases into the home and infect younger, non-immune siblings. Also, the pressures of large families and closely spaced births may impair the standards of maternal care and add to social and economic burdens such as the cost of availability of food and medical services.

High fertility may also influence maternal health.

Obstetrical complications and maternal mortality are associated with increasing parity and age of mothers. Also, the prevalence of maturity-onset diabetes is related to high parity. In poorer countries, the cycle of recurrent pregnancy and lactation constitutes a substantial drain on maternal nutritional reserves, especially in situations where the normal diet is inadequate.

A state of chronic and cumulative undernutrition termed the Maternal Depletion Syndrome has been described in women who have suffered nutritional depletion from excessive childbearing. Even nutritional edema has been observed among such mothers. The high prevalence of clinical and sub-clinical iron deficiency anemias among women is, in part, the result of the depletion of iron stores due to recurrent pregnancies and lactations. Folic acid deficiencies, anemia, vitamin A deficiency, and osteomalacia due to calcium deficiency are also related to the burden of childbearing. The depletion of maternal mutritional reserves associated with excess fertility may lead to low birth weight of premature infants who suffer from increased perinatal and neonatal morbidity and mortality.

The effects of high fertility on maternal and child health are relevant in the context of family planning and it appears reasonable to assume that the reduction of family size and the better spacing of births may lead to substantial improvement in morbidity. The existing knowledge of the relationship between health and family planning is largely derived from fragmentary studies and circumstantial evidence, however, and further experimental research is needed. In considering the health benefits that may accure from family planning, attention must be given to both the positive and negative effects of contraceptive use.

In many countries of the developing world, a positive correlation between increasing numbers of pregnancies and prematurity has also been noted. This, of course, raises the rate of morbidity in the child, whose chances of an early death are increased. If this happens, then the mother's chance of becoming pregnant too soon are highly increased for two sets of reasons: the relative protection afforded by her amenorrhea or rather by its cause, ceases with the death of the premature baby and her anxiety to replace the dead child induces her psyche to seek another pregnancy. There is no doubt that the increased number of pregnancies increases greatly the state of malnutrition of the family as a whole and promotes its inception, if it was not yet there.

A positive association is also observed between shorter inter-pregnancy intervals and infant and child mortality in a number of contrasting societies. The prevalence of mongolism increases in parallel fashion with the age of the mother. Number of pregnancies, maternal age and the spacing of children are closely inter-related, but each has a separate effect. When operating together, three mechanisms combine to produce the following: short birth intervals will interrupt lactation; this may lead to infantile malnutrition which will be compounded by gastro-intestinal infections created by the use of unclean water in the preparation of formulas; moreover, this will be made more likely because of the unavoidable impairment of the maternal care of all children. The economic burden will be serious as the food budget will increase accordingly (183).

This review of the literature has attempted to show:

1. The considerable physiological effort involved in human reproduction.

2. The demands made upon the pregnant woman, the family and the environment by the pregnancy, lactation and recuperative periods.
3. The magnitude of the amount of nutrients of all kinds mobilized from the environment through the reproductive cycle.
4. The consecutive depletion of food reserves..
5. The health consequences of the failure to meet these nutrient requirements.
6. The cycle of wastage resulting from the parents vain efforts to produce a healthy child while by this very action they increase the adverse circumstances in which they operate.
7. The relationship between parity and child mortality.
8. The correlation between underdevelopment and child mortality.
9. The correlation between child mortality and underdevelopment.
10. The correlation between close births and child and maternal mortality.
11. The need to base our approach to child spacing on the concept of family health.

TABLES

Table No. 1

Daily Recommended Allowances for Non-pregnant and Pregnant Women Doing Light Work

	United Nations		U.S.A.		United Kingdom	
	Non-Pregnant	Pregnant	Non-Pregnant	Pregnant	Non-Pregnant	Pregnant
Weight, kg	55		58		55	
Weight gain, kg		10 ± 2		11		12.5
Energy, kcal	2300	40,000 per pregnancy	2000	2200	2200	2400
Protein, g	56	64	55	65	55	60
Calcium, g	0.4 - 0.5	1.0 - 1.2	0.8	1.2	0.5	1.2
Iron, mg	14 - 28	14 - 28*	18	18	12	15
Vitamin A, iu	2500	2500	5000	6000	2500	2500
Vitamin D, iu	100	400	None	400	100	400
Thiamin, iu	0.9	1.0	1.0	1.1	0.9	1.0
Riboflavin, mg	1.3	1.4	1.5	1.8	1.3	1.6
Nicotinic acid, mg equiv.	15.2	16.5	13	15	15	18
Vitamin B_6, mg			2.0	2.5		
Folate, μg	200	400	400	800		
Vitamin B_{12} μg	2.0	3.0	5.0	8.0		
Ascorbic acid, mg	30	50	55	60	30	60
Sources	Energy: FAO 1957 Protein: FAO/WHO 1965 Calcium: FAO/WHO 1962 Iron: FAO/WHO 1970 Vitamins: FAO/WHO 1967, FAO/WHO 1970		N.R.C. 1968		D.H.S.S. 1969	

*Assuming previous iron intake has been satisfactory.

Lower level is the recommendation where over 25 percent of calories are from animal foods.

Upper level is the recommendation where under 10 percent of calories are from animal foods.

Table 2

Properties and Constituents of Mature Human Milk

Values in parentheses are ranges			
	Property or Constituent (A)	No. of Observations (B)	Value (C)
	Physical Properties		
1	Fat melting point		(26.0-26.5)°C
2			(33.5-38.9)°C
3	Refraction index at 40°C		(1.4556-1.4583)
4	Specific gravity	94	1.031(1.024-1.043)
	General Chemical Components		
5	Ash	26	0.20(0.16-0.24) g/100 ml
6		94	0.20(0.09-0.50) g/100 ml
7	Salts		0.313 g/100 ml
8	Solids, total	27	12.2(9.8-15.6) g/100 ml
9		610	12.9(10.3-17.5) g/100 ml
10	Water		87.6 g/100 ml
		Electrolytes	Electrolytes
11	Aluminum		Trace
12	Barium		Trace
13	Boron		Trace
14	Bromine	17	912(327-1502) μg/100 ml
15	Calcium	55	28(15-40) mg/100 ml
16		31	40(20-60) mg/100 ml
17		628	34(17-61) mg/100 ml
18	Chlorine	216	38(9-73) mg/100 ml
19		10	34(30-40) mg/100 ml
20		44	50(16-158) mg/100 ml
21	Chromium	5	Trace
22	Copper	67	0.03(0.01-0.07) mg/100 ml
23	Iodine		(4.5-9.0) μg/100 ml
24	Iron	14	0.36(0.29-0.45) mg/100 ml
25		67	0.03(0.02-0.09) mg/100 ml
26	Lead	30	Trace
27		4	0.016(0.005-0.032) mg/100 ml
28		52	(0.001-0.018) mg/100 ml
29	Lithium		Trace
30	Magnesium	302	4(2-6) mg/100 ml
31	Manganese	30	Trace
32	Molybdenum		Trace

Table 2 (Continued)

	Property or Constituent (A)	No. of Observations (B)	Value (C)
	Electrolytes (Continued)		
	Phosphorus		
33	Total P	7	16(12-19) mg/100 ml
34		55	17(10-35) mg/100 ml
35		628	14(7-27) mg/100 ml
36	Inorganic P	51	5.13(1.5-8.77) mg/100 ml
37	Lipid P	11	3(2-4) mg/100 ml
38	Potassium	26	48(30-66) mg/100 ml
39		45	55(42-70) mg/100 ml
40		54	52(27-81) mg/100 ml
41	Rubidium	30	Trace
42	Silver	6	Trace
43	Sodium	26	13(2-25) mg/100 ml
44		302	17(6-44) mg/100 ml
45	Strontium		Trace
46	Sulfur	116	14(5-30) mg/100 ml
47	Titanium	6	Trace
48	Vanadium	6	Trace
49	Zinc	2	0.26(0.12-0.39) mg/100 ml
50		58	0.118(0.017-0.302) mg/100 ml
	Nitrogenous Substances		
	Protein		
51	Total	27	0.9(0.8-1.0) g/100 ml
52		94	1.5(0.8-5.6) g/100 ml
53		583	1.1(0.7-2.0) g/100 ml
54	Casein	166	0.37(0.14-0.68) g/100 ml
55	Lactalbumin	163	0.36(0.14-0.60) g/100 ml
56	Lactoglobulin		0.172 g/100 ml
57	Whey	31	0.7(0.4-1.0) g/100 ml
	Amino acids		
58	Alanine		35 mg/100 ml
59	Arginine	147	45(28-64) mg/100 ml
60	Aspartic acid		116 mg/100 ml
61	Cystine		20 mg/100 ml
62			41 mg/100 ml
63	Glutamic acid		230 mg/100 ml
64	Glycine		0 mg/100 ml
65	Histidine	147	23(16-34) mg/100 ml
66	Isoleucine	147	68(46-102) mg/100 ml
67	Leucine	147	108(72-159) mg/100 ml
68	Lysine	147	76(53-104) mg/100 ml
69	Methionine	146	14(9-21) mg/100 ml

Table 2 (Continued)

	Property or Constituent (A)	No. of Observations (B)	Value (C)
	Nitrogenous Substances (Continued)		
70	Phenylalanine	147	41(30-58) mg/100 ml
71	Proline		80 mg/100 ml
72	Serine		69 mg/100 ml
73	Threonine	147	54(40-76) mg/100 ml
74	Trypotophan	144	18(13-26) mg/100 ml
75	Tyrosine		50 mg/100 ml
76			78 mg/100 ml
77	Valine	147	71(48-114) mg/100 ml
78	Creatine	3	3.5(3.2-3.9) mg/100 ml
79		41	3.1(0-12.4) mg/100 ml
80	Creatinine	3	1.5(1.1-1.8) mg/100 ml
81		44	3.0(2.0-5.1) mg/100 ml
82	Urea	3	26.5(25.2-29.0) mg/100 ml
83		52	37.8(26.7-49.4) mg/100 ml
84	Uric acid	3	2.5(2.2-2.7) mg/100 ml
85		56	6.6(3.9-12.3) mg/100 ml
	Nitrogen		
86	Protein N		188 mg/100 ml
87	Casein N		63 mg/100 ml
88	Lactalbumin N		47 mg/100 ml
89	Lactoglobulin N		31 mg/100 ml
90	Whey N		94 mg/100 ml
91	Non-protein N	31	47(37-68) mg/100 ml
92		151	32(17-60) mg/100 ml
93	Amino acid N	3	7.2(4.6-8.6) mg/100 ml
94		157	5.0(2.8-11.3) mg/100 ml
	Lipids, Carbohydrates, Miscellaneous Organic Acids		
95	Cholesterol	27	13(7-19) mg/100 ml
96		7	27(13-47) mg/100 ml
97	Fat	37	3.9(0.7-8.0) g/100 ml
98		10	3.3(2.1-5.4) g/100 ml
99		94	3.3(0.5-9.0) g/100 ml
100	Lecithin	1	78 mg/100 ml
101	Lactose	55	7.1(5.8-8.4) g/100 ml
102	Citric acid		(35-125) mg/100 ml
	Vitamins		
103	A	264	61(15-226) μg/100 ml
104		1390	49 μg/100 ml
105	Carotenoids	265	25(2-77) μg/100 ml

Table 2 (Continued)

Property of Constituent (A)	No. of Observations (B)	Value (C)
Lipids, Carbohydrates, Miscellaneous Organic Acids		
B_1 (thiamine)		
106 Total	277	14(8-23) μg/100 ml
107	44	18(6-31) μg/100 ml
108 Free	258	5.3(1.2-15.8) μg/100 ml
109	61	4.3(1.3-12.4) μg/100 ml
B_2 (riboflavin)		
110 Total	272	37.3(19.8-79.0) μg/100 ml
111	43	52.4(12.6-100.0) μg/100 ml
112 Free	256	24.2(10.5-61.8) μg/100 ml
113 B_6(pyridoxine)	3	18(10-22) μg/100 ml
114	9	4(2-9) μg/100 ml
115 B_{12} (cyanocobalamine)	3	Trace
116 B_c (folic acid)	22	0.22(0.14-0.36) μg/100 ml
117	3	0.14(0.09-0.18) μg/100 ml
118 C (ascorbic acid)	233	5.2(0.0-11.2) mg/100 ml
119	261	3.7(0.4-7.7) mg/100 ml
120 D		(0.4-10) U.S.P. units/100 ml
121 E (tocopherol)	5	0.90(0.78-1.14) mg/100 ml
122	10	0.24(0.10-0.48) mg/100 ml
123 H (biotin)	10	0.2(0.1-0.3) μg/100 ml
124 K		50(0-200) Dam-Glavind units/100 ml
Choline		
125 Total	29	9(5-14) mg/100 ml
126 Free	3	2 mg/100 ml
Inositol		
127 Total	7	45(39-56) mg/100 ml
128 Free	5	44(39-52) mg/100 ml
129 Niacin (nicotinic acid)	268	183(66-330) μg/100 ml
130	9	160(120-220) μg/100 ml
131 Pantothenic acid	269	246(86-584) μg/100 ml
132	9	160(80-300) μg/100 ml

Source: D. S. Dittmer, Ed., Blood and Other Body Fluids. Federation of American Societies for Experimental Biology, Washington, D.C., 1961.

Table No. 3

Mean Birth Weight by Geographic Area

(Reprinted, with special permission, from *The Physiology of Human Pregnancy*, 2nd. Ed., by F. E. Hytten and I. Leitch, Blackwell Scientific Publications, Oxford, 1971.)

Author	Date of investigation	Place	Ethnic group	Socio-economic group	Total		Type of sample
					Number	Mean weight g	
EUROPE							
CZECHOSLOVAKIA							
Graitenberg (1942)	1880–1940	Prague	Caucasian	No data	25214	3298	Hospital deliveries. 'Mature' with minimum length of 48 cm and maximum of 54 cm. Stillbirths and multiple births excluded.
Fraccaro (1958)	1955	National	Caucasian	No data	167676	3338	Hospital deliveries. Still and live births of more than 28 weeks gestation and above 1000 g, + all survivors for 24 hours outside these limits.
GERMANY							
Hosemann (1949a)	1926–45	Göttingen	Caucasian	No data	11974	3359 (median)	All hospital deliveries where mother's last menstrual period definitely known.
Solth (1950)	1913–47	Berlin	Caucasian	No data	41239	3239	Hospital deliveries. All single births including fresh stillbirths of over 1000 g and born 'from the 8th month'.
	1900–48	Würzburg	Caucasian	No data	44675	3189	
	1900–49	Marburg	Caucasian	No data	29954	3274	
ITALY							
Fraccaro (1955–56)	1942–51	Pavia	Mediterranean	No data	5486	3180	Hospital deliveries. Abortions, malformations and twins excluded.
Aicardi and Rugiati (1965)	1933–36	Sassari, Sardinia	Italian	Sample of population of Province	1081	3119	Born at term in the Obstet. Clin. Univ. Sassari. Excluded were those born before the 260th day or after the 290th day of pregnancy; also stillbirths and twins and the obviously abnormal. Increase in numbers due to movement of the Clinic to new site with more beds. The birth rate for the Province showed little change.
	1937–40				1646	3154	
	1941–44				1407	3140	
	1945–48				1568	3221	
	1949–52				1757	3274	
	1953–56				1394	3326	
	1957–60				1977	3379	
	1961–63				2832	3400	

Table 3 (Continued)

Author	Date of investigation	Place	Ethnic group	Socio-economic group	Total		Type of sample
					Number	Mean weight g	
EUROPE (Continued)							
ITALY (Continued)							
Ancardi and Depperu (1966)	1960 65	Sassari, Sardinia	Natives only of the Province	Diverse socio-economic levels having in common attendance at mother and child welfare clinics	200	3363	Random sample of 200 born in the Clin. Ost. Ginecol. of the University of Sassari.
Piglia (1967)	1932 36	Camerino	Natives of		310	3245	Born at the Scuola Autonoma di Ostetrica at Camerino. All excluded with doubt about duration of pregnancy.
	1937 41	Marche	Marche		575	3270	
	1942 46	Province	Province		496	3337	
	1947 51				733	3327	
	1952 56				842	3405	
	1957 61				937	3400	
	1962 66				973	3436	
MALTA							
Camilleri and Cremona (1970)	1965	Whole island		Diverse groups from both Government and private hospitals	2358	3404	44 per cent of all Maltese births, 1965 excluding stillbirths and multiple births.
				Welfare service Present day	2000	3306	Extracts from records of comparable samples.
SPAIN							
Valtuena Borque (1966)	1944 and 1945 compared with 'the present'	Madrid	Spanish	Welfare service After the Civil War	2000	3151	
				Private patients Present day	334	3410	
				Private patients Post War	334	3085	
UNITED KINGDOM							
Duncan (1864 65)	No data	Edinburgh	Caucasian	No data	2053	3284	Hospital deliveries. All 'mature' babies.
British Association Anthropometric Committee (1879)				Artisan classes	917	3173	'Mature' babies.
" (1884)	No data	London and Edinburgh	Caucasian				" "
Pearson (1899 1900)	No data	Lambeth	Caucasian	No data	2000	3267	Hospital deliveries. Born at the 'normal' period. Twins excluded.
Robertson (1915)	No data	Birmingham	Caucasian	No data	200	3238	Hospital deliveries. 'Normal' 'Full-time'.

Table 3 (Continued)

Author	Date of investigation	Place	Ethnic group	Socio-economic group	Total		Type of sample
					Number	Mean weight F	
EUROPE (Continued)							
UNITED KINGDOM (Continued)							
McKeown and Gibson (1951)	1947	Birmingham	No data	All births	22527	3387	96.8 per cent of all births in Birmingham in 1947. Stillbirths excluded.
Karn and Penrose (1951-52)	1935-46	London	Caucasian	No data	13730	3258	Hospital deliveries. 'Normal' excluding twins, weights range down to 1 lb.
Ministry of Health (1959)	1947-50	11 Localities in England and Wales	Caucasian	Deficit of S.C. I and II and excess of III compared to national sample	19616	3350	Infants attending health clinics before before age of 2 months. 5 per cent premature by birth weight, national average of 6 per cent.
Unpublished	1950-57	Aberdeen	Caucasian	Similar to total population	25634	3302	Total hospital deliveries of live single infants.
Barron and Vessey (1966)	1958-60	London	British	I and II	290	3361	Infants born at Lambeth Hospital.
				III	1780	3239	
				IV	606	3261	
				V	722	3248	
				Other	258	3216	
			Irish	I and II	26	3375	
				III	242	3320	
				IV	96	3366	
				V	248	3316	
				Other	24	3134	
			Jamaican	I and II	29	3103	
				III	166	3211	
				IV	104	3148	
				V	404	3157	
				Other	60	3143	
			Barbadian	No data	70	3275	
			Cypriot	No data	158	3121	
Aykroyd and Hussain (1967)	1965	Bradford, England	Pakistani	Wives of men employed in woollen mills, wages of order of £ 15 a week	219	2975	Nearly all delivered in maternity hospital.
			English	No information	205	3260	Maternity hospital records.

Table 3 (Continued)

Author	Date of investigation	Place	Ethnic group	Socio-economic group	Total		Type of sample
					Number	Mean weight g	
THE AMERICAS							
U.S.A.							
Meredith (1952)	1896–1949	National	Caucasian Negro	(See type of sample)	121801 39656	3350 3230	A collection from fifteen publications. Wide variety of social status but on the whole Negroes of poorer economic level than whites. Dead infants and twins excluded from most studies. Premature infants excluded from some.
Crump *et al.* (1957)	1951–56	Tennessee	Negro	'Low socio-economic status'	1821	3179	Hospital deliveries. Premature infants excluded. Twins included.
Adams and Niswander (1968)	1965–66	U.S. excluding Alaska	American Indians, 18 tribes	Iroquoian			Between 1 July 1964 and 30 June 1966, a total of 18,811 births were recorded. Any tribe with less than 50 births of each sex was omitted from the analysis as were also multiple births, stillbirths, infants with major malformations, neonatal deaths and children of unknown tribe. The resultant sample was 14,376 infants in 18 tribes. It is thought to represent about one-half of all American Indian births. They were recorded by the U.S. Public Health Service, Division of Indian Health
				Cherokee	1085	3720	
				Algonquain			
				Cheyenne	228	3830	
				Chippewa	866	3755	
				Athapascan			
				Apache	931	3508	
				Navajo	5848	3510	
				Kiowan			
				Kiowa	151	3794	
				Siouan			
				Assiniboine	373	3604	
				Crow	201	3722	
				Sioux	1971	3725	
				Muskhogean			
				Choctaw	594	3768	
				Creek	289	3713	
				Uto-Aztecan			
				Comanche	106	3735	
				Hopi	302	3414	
				Paiute	125	3602	
				Papago	387	3626	
				Pima	271	3725	
				Pueblo			
				Tanoan	271	3489	
				Zunian			
				Zuni	377	3493	

Table 3 (Continued)

Author	Date of investigation	Place	Ethnic group	Socio-economic group	Total		Type of sample
					Number	Mean weight g	
THE AMERICAS (Continued)							
COLOMBIA							
Oberndorfer *et al.* (1965)	Feb.–Dec. 1960	Medellin, Colombia	Mixed: White, Negro and Indian ancestors	Lowest level, including 'married women, unmarried women and prisoners'	1650	2898	Hospital deliveries, free service. Excluded were 17 infants with birth weights between 4000 and 4300 g. All were 'apparently in good physical condition'.
DUTCH GUYANA (SURINAM)							
Doornbos *et al.* (1968)	1954–64	Dutch Guyana	Isolated group, descendants of West African Negroes	Primitive crop production, fishing, hunting	646	2988	Born in hospital.
GUATEMALA							
Cravioto *et al.* (1967)	Aug. 1963 Mar. 1964	Guatemala Village of Santa Catarina Barahona	American Indian Cakachiquel Group	Small farmers. About 25 per cent of men and women work at coffee harvest as wage earners.	78	3050 ±560	Births at home. There were 84 of which 78 survived for 6 m. All birth weights were between 1680 and 4750 g.
PERU							
Mazude Gustin and Ytahashi Cordova (1966)	1 July 31 Dec. 1964	Lima, Peru	Not stated	Lower class, ill-housed, ill-fed	12355	3400 (2550–5550)	Hospital deliveries. About half the total births in Lima are in hospital.
URUGUAY							
Caillabet (1965)	1937–39	Uruguay	No information	Middle and lower class	1010	3328	Hospital 'Pereira-Rossell'. No exclusion.
	1943–49			High social class	255	3487	All healthy infants over 2500 g.
	1952–53			Middle and lower class	1001	3379	Hospital 'Pereira-Rossell'. Single births of weight > 2500 g.
WEST INDIES							
BARBADOS							
Wells (1963)	1953–57	Barbados Maternity Hospital	Population per cent African 77.2 Mixed 17.6 European 5.1 Asiatic 0.1	Lower	2511	2891	Consecutive deliveries. Admission free to hospitals. At the Maternity Hospital diet supplements are prescribed, but must be purchased; at the District Hospital they are given free. At both, severe toxaemias, caesarean section and gross abnormalities are referred to Barbados General Hospital. In the Nursing Home the births were the first 100 consecutive births in each of the 4 years.
	1958–62	"		Lower	2763	2954	
	1961–62	District Hospital		Lower	720	3048	
	1958–62	Nursing Home		Higher	400	3411	

Table 3 (Continued)

Author	Date of investigation	Place	Ethnic group	Socio-economic group		Total		Type of sample
						Number	Mean weight g	
WEST INDIES (Continued)								
ST. KITTS, NEVIS, ANGUILLA								
Ashcroft *et al.* (1966)	1966	West Indies 1957 and 1958 St. Kitts	'Preponderantly negro' of West African origin	Labouring or peasant		550	3379	Most deliveries were at home 80 per cent in St. Kitts, 55 per cent in Nevis and 85 per cent in Anguilla. Multiple births and infants of low birth weight included.
MIDDLE EAST								
IRAN								
Sarram and Saadatnejadi (1967)	1963	Iran Shiraz	Irano-Afghan	1. University employees and urban high economic status		557	3104	Normal live-born, over 1000 g at birth. Private ward of Department Obstetrics, Pahlavi University.
				2. Low socio-economic status		1802	2983	Ward used by indigent patients, same department.
ISRAEL								
Epstein (1968)	1 Jan 1957 31 Dec 1961	Jerusalem	Not stated parents Israel born (I) or Morocco born (M) M_1 = 5 years or less in Israel M_2 10 years or more in Israel	Class III in a social class grading of 5 classes treated separately	I	63	3250	All babies born alive between the stated dates.
					M_1	5[illegible]	3350	
					M_2	58	3490	
					I III	85	3242	
					M III	122	3370	
UNITED ARAB REPUBLIC								
El-Abd and El-Sherbini (1963)		Alexandria	Egyptian	Poorer classes of Alexandria		1791	3200 ±600	Patients of Shatby Hospital, a free hospital which takes the poorer class mothers and 'being a University Hospital, it drains most of the complicated cases'.

Table 3 (Continued)

Author	Date of investigation	Place	Ethnic group	Socio-economic group	Total		Type of sample
					Number	Mean weight g	
FAR EAST							
CEYLON							
De Silva, Fernando and Gunasantne (1962)	1956 58	Colombo	Ceylonese	No data	10273	2500	From nine maternity homes run by the Municipality for normal cases living within the city. No detail.
CHINA							
Uttley (1940)	1934 39	Kowloon	Chinese (Cantonese)	No data	5437	3018	No data.
Lee (1948)	1945 48	Chengtu	Chinese	No data	3550	3038	No data, but title of paper indicates 'full term' infants.
Shan-Yah Gin (1948)	1940 - 41	Shanghai	Chinese	No data	228	3206	Selected from clinics as 'clinically healthy' or only 'moderately flabby' out of 4 categories of which the fourth was 'malnourished'.
INDIA							
Rajoo and Naidu (1944)	Not stated	Secunderabad	Indian	No data	10000	2897	Hospital deliveries. Infants of less than 4 lb and multiple pregnancies omitted.
Namboodiri and Balakrishnan (1958 59a)	1956 57	Trivandrum	Indian	No data	12640	2868	Hospital deliveries. Stillbirths, neonatal deaths and twins excluded from about 16,000 births.
Mukherjee and Biswas (1959)	1957	Calcutta	Indian	Poor class	878	2656	Consecutive hospital deliveries.
				'Paying patients'	160	2851	
Achar and Yankauer (1962)	1954 55	Madras	Tamil and Telugu Indian	'Mostly poor'	5176	2736	'Mothers relatively free from pregnancy complications'.
				"Well-to-do paying patients"	512	2985	
Venkatachalam (1962a)	Not stated	South India	Indian	Poor	2777	2810	Born in hospitals, alive and 'at term'.
				'Wealthy'	1753	3182	
Arora *et al.* (1963)	1957 59	Bombay	Indian Majority Maharashtrian, some Gujarati, Punjabi, South Indian and Muslim	Lower middle class	1129	2678	Single live births only. *'Prematures' excluded* but 37 per cent of births were below 2500 g. Maternity Hospital, the biggest in the city. The sample was of non-paying patients or patients paying a small fee.

Table 3 (Continued)

Author	Date of investigation	Place	Ethnic group	Socio-economic group	Total		Type of sample
					Number	Mean weight g	
FAR EAST (Continued)							
INDIA (Continued)							
Udani (1963)	Not stated	Bombay	Mixed	Slum area, cosmopolitan	1000	2578	From free general hospital.
			Mixed	Superior to above in housing and diet	1000	2796	Paying hospital; births from general ward.
			Mixed	Upper class	1000	2945	Semi-private hospital.
			Mixed	Best socio-economic group	270	3247	Private nursing home.
Paret and Liebrecht (1964)	1962	Pondicherry	Indian	Poor	90	2750	Hospital deliveries. Excluded were: 2 stillborn, 1 of obese diabetic mother, birth weight 5100 g, and 1 of 4500 g, and 6 of 1750 g or below.
Jayant (1964)	1947–61	Bombay	Indian Hindu	Upper social stratum			
				Total	3822	2912	Consecutive single births in a private maternity hospital.
				Survivors	3656	2951	
			Gujarati	Low social stratum			
				Total	2279	2530	Unselected single births in (BYL) Charitable Hospital.
				Survivors	2080	2604	
Nirmala *et al.* (1966)		Coimbatore		Low income group	16	2560	Hospital deliveries.
Banik *et al.* (1967)	Aug. 1962 June 1966	Delhi	Indian	Income range 600–2400 RS	72	2690	
				1. Monthly income RS 501 and over	65	3338	Single births. Delivery in hospital or at home, not distinguished
				2. Monthly income RS 201–500	259	2875	
				3. Monthly income RS 101–200	508	2774	
				4. Monthly income RS up to 100	638	2739	

Table 3 (Continued)

Author	Date of investigation	Place	Ethnic group	Socio-economic group	Total		Type of sample
					Number	Mean weight g	
FAR EAST (Continued)							
INDIA (Continued)							
Sakar (1968)	1 Jan. to 31 Dec. 1960	Ootacomund	Not classified	All classes	1470 1338	2806 2953	Hospital deliveries, live births: 33 stillbirths and 768 abortions excluded.
JAPAN							
Sagara (1961)	1949 1955	Nara	Japanese	No data	4002 2345	3143 3212	No data.
MALAYA							
Llewellyn-Jones (1955)	1951–52	Kuala Lumpur	Malay	No data	322	2747	Hospital deliveries. Hospital takes all abnormalities from a population of 500,000 and no normal case is ever 'refused admission.'
	1951–53		Chinese	No data	4005	2886	
	1951–53		Indian	No data	4696	2644	
Millis (1858–59a)	1950–53	Singapore	Chinese	Poor	46750	3024	Hospital deliveries. Mothers in '3rd class wards' with free attention.
			Indian		5166	2824	
SUMATRA							
Gamondi and Santos Reis (1960)	1957–58	Sawah Lunto	'Melano-asiatics'	No data	443	3114	A hospital group. Apparently no exclusions on weight basis.
Shattock (1968)	1960–64	Whigfoot Estate, North Sumatra	Javanese	Lower socio-economic, immigrant contract estate labourers.	13418	2958	Three-quarters of births in Estate Hospital. Free clinics.
			Indonesian	Estate assistants, middle socio-economic	113	3039	
THAILAND							
Stahlie (1959)	1956–57	9 regions of Thailand	Thai and Chinese	No data	7261	3028	Reports from midwives, stationed mostly in market towns. May under-represent the poorer rural areas. Thought to be no exclusions.

Table 3 (Continued)

Author	Date of investigation	Place	Ethnic group	Socio-economic group	Total		Type of sample
					Number	Mean weight g	
AUSTRALASIA							
AUSTRALIA							
Parsons (1965)	1965	Australia South West of Northern Territory, North West of South Australia and part of W. Australia	Pitjantjatjara Tribe of Aborigines	Tribal; some semi-nomadic	94	3008	Hospital records of Ernabella Mission.
Kitchen (1968)	2 years Not stated	Melbourne	Anglo-Saxon, 60 per cent: Italian, Greek and neighbouring countries, 40 per cent	Lower; 20 per cent recent immigrants			Consecutive deliveries over a 2 year period. Legitimate births excluding toxmia, diabetes, erythroblastosis, hypertension and multiple pregnancy, stillbirths and malformations, i.e. representing normal pregnancy.
				Gestational age: 'Dates verified'			
				38	214	3160	
				39	387	3260	
				40	390	3430	
				41	27[illegible]	3470	
				42	139	3570	
Propert *et al.* (1968)	Not stated	Australia Mornington Island	Aborigines	Low socio-economic status	62	3189	Collected by N. B. Tindale of South Australia Museum.
		Santa Teresa			69	3017	Collected by D. Propert; Santa Teresa Mission.
		Western Australia	Full blood		173	2980	Collected by Infant Health Sisters Department of Public Health, W. A. These figures given in a footnote without further information.
			Mixed blood		272	3223	
		Not stated	Full blood		384	2968	
			Mixed blood		351	3148	
NEW GUINEA							
Jansen (1962)	1957	Biak Island	Papuan	Poor: grow most of their food	298	2882	Hospital records: children 'born in villages near Biak-town'.
		Seroei		As above	452	2876	
		Hollandia		Similar to above	364	2817	Partly hospital deliveries.

Table 3 (Continued)

Author	Date of investigation	Place	Ethnic group	Socio-economic group		Total		Type of sample
						Number	Mean weight g	
AUSTRALASIA (Continued)								
NEW GUINEA (Continued)								
		Sorong		New Guinea Oil Company labourers of above and other groups living and working in the compound		130	2827	Excellent medical care: no malaria.
		Biak				76	3062	
		Seroei				379	2945	
		Indonesia				765	3041	
			Chinese	Shopkeepers		199	3154	
			Dutch	Birth No.	1	24	3084	
					2-5	72	3286	
					6-8	5	3730	
			Indonesian and Chinese		1	104	2777	
					2-5	405	3109	
					6-8	150	3106	
					9-12	39	3308	
		Sorong	Papuan		1	73	2719	
					2-5	197	2997	
					6-8	30	2967	
Barnes (1963)	Jan. 1959 July 1962	Chimbu sub-district	Natives	Bush or village natives on almost exclusively vegetarian diet chiefly sweet potato and a small group of 'station' natives who have a sweet potato, rice, wheat, tinned meat issue.				Hospital deliveries. The parents are 'quite reasonable physical specimens, as a rule' The average Chimbu male measures roughly 63 and female 59 in. in height. The village mother works in the garden to the start of labour.
				Village:		456	2990	
				Station:		45	3283	

Table 3 (Continued)

Author	Date of investigation	Place	Ethnic group	Socio-economic group	Total		Type of sample
					Number	Mean weight g	
AUSTRALASIA (Continued)							
NEW GUINEA (Continued)							
Wark and Malcolm (1969)	1962–67	Lumi	Wapi (Language group)	Small villages: subsistence food-gatherers	63	2400 ±500	Infants born in Lumi Hospital.
AFRICA							
CONGO							
Jans (1959)	Not stated	Ituri forest area	Pygmies	No data	40	2635	Born in hospital.
			Bantu	'Very well nourished'	No data	3026	No exclusions for weight.
			Bantu	'Well nourished'	No data	2965	
			Bantu	'Badly nourished'	No data	2850	
SENEGAL							
Dupin, Masse and Correa (1962)	1949	Dakar	African	No data	4103	2997	Born in hospital. Twins excluded.
	1954				5757	3072	
	1959				8409	3117	
ETHIÒPIA							
Young (1967)	30 June 1966–22 March 1967	Addis Ababa	Mostly Amhara and Galla: a few Tigre and Gurage	All classes of society but less than true proportion of poorest	500	3115	500 consecutive live single births in Princess Tsahai Memorial Hospital in Addis Ababa. Stillbirths and multiple births omitted. A selected group in that most women are delivered at home.
		Gondar	Almost all Amhara and Tigre	Poorer than Addis Ababa sample	500	3047	Sample of 500 from Hospital records, Gondar.
GHANA							
Hollingsworth (1960)	No data	Accra	African	General population	917	2879	Born in hospital.
				Prosperous	201	3188	
KENYA							
Shaw (1933)	No data	Nairobi	African	No data	750	3153	Hospital deliveries. Twins excluded together with infants 'born prematurely, with the exception of children born following induction of labour in the later weeks of pregnancy . . . for minor degrees of disproportion'.
			Indian		207	2830	

Table 3 (Continued)

Author	Date of investigation	Place	Ethnic group	Socio-economic group	Total		Type of sample
					Number	Mean weight g	
AFRICA (Continued)							
PORTUGUESE GUINEA							
Janz *et al.* (1959)	1954 - 56	Guinea	African	No data	332	3486	Born in a maternity hospital.
REPUBLIC OF SOUTH AFRICA							
Salber and Bradshaw (1957)	No data	Durban Pietermaritsburg Capetown	Caucasian Coloured Bantu Indian	No data	1757 931 7608 1737	3388 3107 3071 2930	Hospital deliveries; Europeans from private nursing homes. Abortions and multiple births excluded.
Malan *et al.* (1967)	1 Mar. 1964 - 28 Feb. 1965	Capetown	White, descendants from immigrants from Europe (incl. Britain)	Middle and low income groups: fairly good cross-section.	2045	3299	Hospital deliveries, 4 hospitals. Live births. Rejected were records of 316 infants: records incomplete. The Cape Coloured were admitted as primigravida or with some complication or from 'unsuitable homes'.
			Cape Coloured	Lower levels than White	4657	3050	Percentage primigravidae: White 38.6; Cape Coloured 35.5 and Bantu 26.1.
			Bantu from Central Africa	Only older and established families since few live in Capetown	982	3208	
SUDAN							
Ahmed and Abdalla (1967)	Jan. 1965 - Oct. 1966	Omdurman and Khartoum	Eastern Hamite	A selected group that could afford hospital delivery	525	3103 ±367	Single births. Babies of mothers with serious illnesses, diabetes, toxaemia, severe anaemia, excluded.
TANZANIA							
Latham and Robson (1966)	1959 - 60	Nzega	Negro	Peasant Farmers	2007	2900	Hospital deliveries: single live births. Not a random sample of births; only 12 per cent of births are in institutions and many of those are in hospital because of difficulties; recorded here were normal births.
	1960 - 63	Moshi	Negro, Chagga tribe	Small holdings: highest per caput income in Tanzania	2166	3040	
	1955 - 60	Tanga	Negro	Farmers and fisherman	3355	2970	
UGANDA							
Simpkiss (1968)	1956 - 57	Uganda	Bantu Non-Bantu	No data	1828 837	3003 2899	Data from 2068 consecutive African births in maternity wards of Mulago Hospital, Kampala.

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