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Maternal Nutrition and the Course of Pregnancy

SUMMARY REPORT

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Health Services and Mental Health Administration

Maternal Nutrition and the Course of Pregnancy: Summary Report

Committee on Maternal Nutrition / Food and Nutrition Board

National Research Council

National Academy of Sciences

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Preface

This summary report presents the principal findings, conclusions, and recommendations of a more comprehensive volume* that synthesizes and documents the role of nutrition in human reproduction. The larger work contains the full reports of several working groups and an assembly of invited review papers. An annotated bibliography has been prepared and is available separately from the Maternal and Child Health Service of the Department of Health, Education, and Welfare.

Chapter 2 of this summary report reflects in its six subsections the highlights of comparably titled sections in the main document. The last two chapters comment on the implications of the substance of the major volume for dietary management during pregnancy and summarize in somewhat different form and sequence the recommendations contained in that work.

The study here summarized grew out of concern about the relatively high neonatal and infant mortality rates in the United States, rates that have persisted at levels well above those of many countries of the western world. It was organized by the Food and Nutrition Board of the National Research Council through a Committee on Maternal Nutrition in order to provide an authoritative review of available information and practical guidelines that would assist professionals in the health field, professional associations, educational institutions, and health agencies in their efforts to improve nutrition services for pregnant women and their families. It sought also to identify areas and problems requiring further study and evaluation and to develop

*Committee on Maternal Nutrition, Food and Nutrition Board, National Research Council. 1970. *Maternal Nutrition and the Course of Pregnancy*, National Academy of Sciences, Washington, D.C.

practical recommendations for improving the education of professionals participating in prenatal and child care.

The Committee hopes that the information summarized here, and detailed in the full report, will be found appropriate to the concept of maternal care as described by the World Health Organization:

> The object of maternity care is to ensure that every expectant and nursing mother maintains good health, learns the art of child care, has a normal delivery, and bears healthy children. Maternity care in the narrower sense consists in the care of the pregnant woman, her safe delivery, her postnatal care and examination, the care of her newly born infant, and the maintenance of lactation. In the wider sense, it begins much earlier in measures aimed to promote the health and well-being of the young people who are potential parents, and to help them to develop the right approach to family life and to the place of the family in the community. It should also include guidance in parentcraft and in problems associated with infertility and family planning.*

*World Health Organization. 1969. *The Organization and Administration of Maternal and Child Health Services*, Fifth Report of the World Health Organization Expert Committee on Maternal and Child Care, WHO Tech. Rep. Ser. No. 428, Geneva.

Contents

1 *Introduction*

Over most of recorded history, special attention has been given to the diets of pregnant women. Some kinds of food have been restricted or prohibited. Other kinds have been regarded as necessary to ward off catastrophe for the mothers or their infants. Restrictions seem to have had strong appeal in ancient times, and they have had parallels in modern times, both in primitive and in highly developed societies. Even today, some of the views concerning maternal nutrition have little more scientific basis than did the views of the ancients.

During the past 40 years, several excellent reviews of the literature relating to nutrition in pregnancy have appeared. Garry and Stiven (1936) reviewed over 300 animal and human studies, mostly performed during the 1920's and early 1930's. In this paper they considered the evidence relating to the roles of individual nutrients, and compared it with accepted standards for nonpregnant women.

A decade later, Garry and Wood (1946) evaluated some 400 contributions to the literature that had been published since the earlier review and noted that "in spite of the voluminous literature, the additions to scientific factual knowledge are somewhat meager." In *Biology of Human Starvation*, Keys *et al.* (1950) reviewed the evidence then available concerning relation of nutrition to various aspects of pregnancy. A central conclusion was that when there is substantial caloric restriction in maternal diet, the size of the newborn is affected.

The NRC bulletin *Maternal Nutrition and Child Health* (Toverud *et al.*, 1950) contained a complete review of the literature. More recently, the 1965 report of the World Health Organization, *Nutrition in Pregnancy and Lactation*, provided a comprehensive review of evidence from epidemiological and laboratory sources.

The 1940's, a decade of enthusiasm about the importance of nutrition in bringing about improvements in pregnancy outcome, were followed by a period of disillusionment and disinterest after the publication of a series of reports during the 1950's whose chief conclusions appeared to contradict earlier concepts. It was not until the late 1960's that interest was reawakened and a period of reappraisal began. Attention is now being given not only to the immediate effects of nutritional deficits on the outcome of pregnancy but also to the long-term effects on the subsequent physical and mental development of the child. An appreciation of the complexities of these relationships and the application of improved techniques to the study of nutrition both in populations and in the laboratory give promise of providing fuller answers to these important questions.

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2 *Highlights of the Study*

EPIDEMIOLOGY OF HUMAN REPRODUCTIVE CASUALTIES

The fertility rate in the United States has been declining in recent years: In 1967, it stood at 87.8 per 1,000 women 15 to 44 years of age, as compared with 122.9 in 1957. The decline has been similar for white and nonwhite women, although the rate for nonwhite women has remained above the rate for white women in each age group. The declining fertility rates have meant a decreasing number of live births in recent years. Nevertheless, the total numbers of pregnancies and live births will almost certainly rise in the near future as the large number of persons born after World War II themselves enter the childbearing age group.

The maternal mortality rate has also declined sharply, reaching a figure of 28 per 100,000 live births in 1967. Rates for whites are lower than for nonwhites. Proportionately more nonwhite women bear children at less favorable ages and parities, but this fact does not completely account for the observed differences in mortality rates. In areas where mothers of both races receive equally good maternity care, the difference is minimized.

When maternal mortality rates fall, fetal and infant mortality becomes a more sensitive indicator of reproductive efficiency. In addition to infant mortality, the proportion of low-birth-weight infants, the prevalence of perinatal handicaps and injuries, and the number of infants who fail to grow and develop normally are important measures of unfavorable outcomes of pregnancy. Although by 1967 infant mortality in the United States reached a record low of 22.4 per 1,000 live births, this figure is higher than that prevailing in many countries. Among the 40 countries selected according to the criteria proposed by Chase (1969), the United States ranked 13th in infant

mortality in 1966 and in the provisional ranking for 1967. The proportion of infants of low birth weight remains high; in 1965 it accounted for 8.3 percent of all live births, and this proportion seems to be increasing.

The incidence of low-birth-weight infants, and the closely related neonatal mortality rates, is affected by the socioeconomic status of the mother and by other factors, including biological immaturity (under 17 years of age), high parity, short stature, low prepregnancy weight for height, low gain in weight during pregnancy, poor nutritional status, smoking, certain infectious agents, chronic disease, complications of pregnancy, and a history of unsuccessful pregnancies.

Research designed to assess the relative importance of individual factors, including poor nutrition, in pregnancy outcome has been difficult to carry out, and the results have been difficult to interpret. This situation arises because a number of factors tend to affect the same woman or groups of women. The most vulnerable individuals are likely to have been born and brought up in poor homes and in large families having inadequate access to good medical care, food, and education for their children. Poor-quality crowded housing tends to favor the spread of infectious diseases, which are then too often not properly treated. Immunizations and other preventive health services are not available, or are not utilized. Children in these environments often grow up with poor health and food habits. Under circumstances such as these, girls tend to bear children early and must ordinarily rear them in similar surroundings. They often have not grown and developed in childhood to their full genetic potential and thus enter pregnancy with suboptimal health and nutritional status.

While poverty appears to be central to the chain of circumstances just described, there are also women with adequate incomes who for other reasons, including the current fashion for slimness, arrive at childbearing age with poor health and nutritional status and inappropriate health habits.

MATERNAL PHYSIOLOGICAL ADJUSTMENTS

Much of what is known about the physiology of human pregnancy has been acquired recently. Many features typical of normal pregnancy resemble those characteristic of certain pathological states, e.g., reduced concentrations of hemoglobin in blood and of albumin in plasma, enlargement of the thyroid gland, changes in cardiac function, spillage of amino acids in urine, and the frequent appearance of edema. Thus, clinical standards considered "normal" for the nonpregnant woman cannot be applied to pregnant women. A more appropriate concept is that of an integrated maternal-fetal synergism

undergoing progressive physiological change to assure the growth of the fetus, even under conditions of stress.

Particular attention may be drawn to weight gain as it reflects the physiological consequences of pregnancy. Thomson and Billewicz (1957) found an average gain in total weight of healthy pregnant women in Aberdeen, Scotland, of 12.5 kg (27.5 lb) and a gain of approximately one pound per week during the second half of pregnancy. This rate of gain was associated with the lowest overall incidence of pre-eclampsia and low birth weight in infants and with a relatively low perinatal mortality. By contrast, Tompkins (1955), in Philadelphia, found the average total weight gain in healthy pregnant women to be 24 pounds.

A conspicuous feature of weight gain in pregnancy is its variability. Young women tend to gain slightly more weight than older women, primigravidas slightly more than multigravidas, and thin women slightly more than fat women. In western societies, housewives tend to be relatively sedentary; for them, the total "energy cost" of pregnancy for a healthy woman approximates 40,000 kcal, representing an additional daily requirement of about 200 kcal. This is commensurate with a total weight gain of 25 lb.

ANEMIAS COMPLICATING PREGNANCY AND THE PUERPERIUM

Normal hematopoiesis requires a nutritionally adequate diet. For the production of hemoglobin, a complex molecule of protein and iron, there must be an ample supply of protein to furnish essential amino acids; sufficient calories to protect the protein from catabolic degradation; iron and other minerals, including copper and zinc; and folic acid and vitamin B_{12}, as well as several other vitamins that serve as cofactors in the synthesis of heme and globin. During pregnancy, increased maternal erythropoiesis occurs at the very time that appreciable nutritional demands are being created by the growing fetus. Anemia during pregnancy may thus be due to many factors, both acquired and hereditary. Attention here is focused primarily on iron-deficiency anemia and on megaloblastic anemia due to folate deficiency. Iron-deficiency anemia and anemia due to acute blood loss are the most common anemias of pregnancy, and the two are often intimately related.

Anemia is usually defined in terms of a significant reduction in the concentration of hemoglobin per 100 ml of blood, in the number of erythrocytes per cubic millimeter of blood, or in the volume of packed red cells per 100 ml of blood (hematocrit). The hemoglobin concentration, hematocrit, erythrocyte count, and red cell indices of apparently healthy nonpregnant women have

been measured repeatedly with rather uniform agreement as to what represents normality. In one study, for example, the hemoglobin concentration of iron-sufficient healthy young women averaged 13.7 ± 2 g and ranged from 12.0 to 15.4 g per 100 ml of blood. During normal pregnancy, physiological changes bring about an increase in blood volume that is accompanied by a relatively smaller increase in total volume of circulating red cells and hemoglobin mass. These changes begin late in the first trimester, reach a maximum about the 34th week and diminish toward term.

If iron is readily available to the bone marrow, an average of approximately 0.5 g of iron will be utilized for augmented maternal erythropoiesis during the course of pregnancy. Iron moving to the fetus and placenta, exclusive of the maternal hemoglobin in the placenta, amounts to about 0.25 to 0.30 g. Thus, iron utilization during pregnancy with a single fetus amounts to about 0.8 g; with multiple fetuses the figure is higher. Prorated over the second half of pregnancy — the period when practically all the increases in maternal hemoglobin mass and placental transfer to the fetus take place — this amounts to nearly 6 mg of iron per day. To this must be added the 0.5 to 1.0 mg of iron that is lost through the gut, the urinary tract, and the integument each day.

The iron needed during pregnancy must be obtained from the following sources:

- *Maternal iron stores.* Iron stores of women are seldom large enough to meet the iron requirements of pregnancy — iron stores of healthy young American women have been found to average about 0.3 g.
- *Diet.* Food rarely provides enough iron to permit absorption of 6 to 7 mg daily, since no more than 10 to 20 percent of food iron is likely to be absorbed and utilized. Usual diets of pregnant women in the United States afford no more than 12–15 mg daily.
- *Supplementation with ferrous iron.* Iron supplementation during the latter part of pregnancy, in the form of ferrous salts (sulfate, fumarate, or gluconate) can be beneficial in building and protecting maternal iron stores. In general, oral preparations are preferred whenever the patient can be convinced of the necessity of systematically taking the supplement. Since usual diets in the United States are not likely to afford iron in quantities sufficient to meet the needs of pregnancy, the National Research Council report* recommends that all women receive 30 to 60 mg of iron as a daily supplement during the second and third trimesters. There is inadequate evidence that additives, such as ascorbic acid, increase either the absorption or the utilization

*Committee on Maternal Nutrition, Food and Nutrition Board, National Research Council. 1970. Maternal Nutrition and the Course of Pregnancy, National Academy of Sciences, Washington, D.C.

of iron salts. The hemoglobin concentration of pregnant women who are at or near term and who have received supplemental iron has been repeatedly found to average more than 12.0 g per 100 ml, irrespective of socioeconomic status.

There is no evidence that oral iron supplementation in the quantities indicated above during successive pregnancies produces deleterious iron overload.

Although megaloblastic anemia due to maternal folate deficiency is relatively uncommon in the United States, it does occur and must be considered in the differential diagnosis of any anemia encountered during pregnancy and the puerperium. Considerable attention has been focused on the possibility of maternal folate deficiency in the absence of anemia. This interest arose because biochemical findings indicate that folate deficiency may be common late in pregnancy, especially among poorer women, and may be implicated in several forms of pregnancy wastage. So far, attempts to reduce pregnancy wastage by means of folic acid supplementation have been unrewarding. Before attempting large-scale or nationwide programs of supplementation with folic acid early in pregnancy, or prior to pregnancy, the significance of maternal folate deficiency *per se* in pregnancy wastage in this country should be established.

Nevertheless, supplementation with folic acid is warranted, especially in instances where folate requirements are high, such as in chronic hemolytic anemia and multiple pregnancy. A daily supplement of 200 to 400 μg of folic acid should prevent deficiency in pregnant women.

RELATION OF NUTRITION TO FETAL GROWTH AND DEVELOPMENT

Animal experiments have demonstrated that alterations in maternal diet can have profound effects on size of litter, survival rates, size at birth, growth patterns, and behavior of the progeny. The severity of dietary restriction used in most animal studies is greater than is commonly encountered in human populations, although from time to time individual women may consume comparably restricted diets. The timing and duration of the dietary restriction may well also influence the results.

Because there are differences in fetal growth and development attributable to species characteristics themselves, animal studies relating to dietary change must be interpreted with caution. It has been found also that although restricting the maternal diet during gestation affects the cellular growth patterns of the progeny, different organs respond differently. Further, the data indicate that interference with cellular growth patterns may result in persistent modification and damage but that if the diet is corrected during the normal period of cell division, a deficiency in cell number may be minimized or even corrected.

Uncertainties persist as to the relevance of the results of animal studies to questions of human reproduction. In man, birth takes place at the steepest part of the growth curve of the conceptus, whereas in rodents, carnivores, and the pig, birth occurs before the growth curve reaches its maximum. Evidence indicates that the growth of different organs and tissues, as measured by cell number, varies from species to species. When the size of the young at birth is compared with the size of the mother, marked species differences are again evident. This is true also with respect to tissue components. All this underscores the need for caution in extrapolating the detailed results of animal studies to the human. Nevertheless, important basic knowledge has come, and will continue to come, from animal experimentation.

Evidence that good nutrition is important to human reproductive efficiency is derived mainly from studies of large populations. The experience in Great Britain during World War II, when pregnant women were given special priority under the food-rationing policy, was most dramatic. During this period the stillbirth rate fell from a previously rather stable figure of 38 per 1,000 live births to 28, a fall of about 25 percent during a period when many aspects of the physical environment were deteriorating. Although the relatively few small-scale feeding experiments that have been undertaken to assess the impact of diet during pregnancy on reproductive performance have provided interesting data, they have proven difficult to interpret in terms of a single variable such as nutrition.

One specific way in which diet during pregnancy affects the outcome of pregnancy is seen in the relationship between maternal weight gain and infant birth weight. A number of studies have shown a strong positive association between the total weight gain of the mother and the birth weight of the infant. Similarly, there is a strong positive association between the prepregnancy weight of the mother and the birth weight of the infant.

Evaluation of the nutritional status of pregnant women is severely handicapped because few physiological and biochemical norms have been established.

What controls the placenta's role in maternal-fetal interchange is as yet poorly understood. There is no substantial proof that placental failure *per se* limits the supply of nutrients to the fetus when the circulation on both sides is intact and the supply of nutrients is sufficient on the maternal side. Severe pathological conditions confined to the placenta are not often seen by experienced pathologists. Thus the long-held view that placental insufficiency is the cause of abnormal development or growth retardation of the fetus must be questioned. Other factors in the maternal organism may be more important.

Traditionally, birth weight has been used as an important index of the quality of fetal development and the welfare of the newborn. Whether retardation of physical growth *in utero* is followed by retardation of later growth and development is open to question. Despite great interest, there has been little

investigation of the mental development of children whose growth *in utero* had been retarded.

Although widely used, data on birth weights for gestational age provide little information on growth and development of specific organ systems such as the brain and other neural tissue. One must be cautious in drawing conclusions from studies in which birth weight for gestational age is the only criterion used to estimate impact of maternal nutrition on normal fetal growth and development.

RELATION OF NUTRITION TO PREGNANCY IN ADOLESCENCE

The occurrence of pregnancy during adolescence presents both physical and psychological risks. Girls are at increased risk if pregnancy occurs before their own growth has been completed. The majority of girls attain physical maturity by 17 years of age, and pregnancy after this age has not been found to present special biological hazards. Thus, the course and outcome of pregnancy of girls 17 to 20 years of age resemble those of mature young women (20 to 24 years of age), whereas there is a sharp increase in infant mortality for each year of age under 17.

In the United States, as in a number of western countries, there has been a decline in the age of menarche during the past century. The mean age of menarche is currently about 13 years.

Sexual maturation occurs in an orderly sequence and is closely related to growth and skeletal maturation, although the timing and character of growth differ greatly among individuals. In early maturers, menarche is coincident with the peak velocity of adolescent growth and at a time when skeletal maturation is less advanced than in late maturers. The girl who matures early may also be capable of conceiving earlier than her average- and late-maturing sisters and before her skeletal maturation, including pelvic capacity, is complete.

The psychological impact of pregnancy on the adolescent girl may well be more detrimental to her lifetime well-being and that of her child than are the effects of biological immaturity. Society, because of its punitive attitudes towards early pregnancy, especially if it occurs out of wedlock, is prone to withhold the understanding and support that are so important under these circumstances. Restrictive practices may force the young pregnant girl to discontinue her education, may make it difficult for her to obtain medical care, and in many states may even prevent her from getting married. These social and psychological difficulties are superimposed on the emotional adaptations and problems characteristic of adolescence.

The magnitude of the problem of pregnancy in adolescence may be gauged by considering statistical data relating to the trends and numbers of live births, birth weights, and mortality rates. Thus, in the United States, live births to mothers 17 years of age and under have been increasing, both in absolute numbers and as a percentage of all live births. Of the 196,372 live births to girls of this age group in 1965, more than 29,000 were born to mothers 15 years of age and under, over 56,000 to mothers 16 years of age and some 110,000 to mothers of 17 years.

Young teen-age mothers have a disproportionate number of babies weighing less than 2,500 g at birth. In contrast to an overall U.S. value of 8.3 percent for all live births in this category in 1965, the percentage for nonwhite mothers under 15 years of age was 21; for white mothers of the same age it was 13. Median birth weights are also lower for infants of young mothers.

Neonatal, postneonatal, and infant mortality rates are much higher for infants born to young mothers. These rates are greatest among young girls who have repeated pregnancies.

Prior to age 17, nutrient requirements reflect the special demands of growth and maturation, although individual requirements vary widely because of variations in the time and rate of maturation. Calorie requirements during adolescence parallel the growth curve. Since each individual has a unique pattern of development, dietary allowances must meet her individual needs at different stages of growth. It must be stressed that an adequate diet, with special reference to calories, protein, and calcium, is critical for growth. The young adolescent tolerates caloric restriction poorly, and pregnancy imposes additional anabolic needs for calories and nutrients. The impact of a pregnancy occurring during adolescent growth upon the achievement of potential body stature remains to be determined.

Such evidence as there is on the nutritional status and food habits of adolescent girls, pregnant or nonpregnant, suggests that dietary habits are often bizarre and that intakes of iron, calcium, vitamin A, and ascorbic acid tend to be particularly inadequate. It is estimated that some 10 to 12 percent of adolescents entering pregnancy are obese and a somewhat smaller proportion underweight.

RELATION OF NUTRITION TO THE TOXEMIAS OF PREGNANCY

The concept has persisted for years that nutrition is related in some way to the occurrence and course of toxemias of pregnancy, but little is known of the relative importance of the many etiological factors considered important.

Toxemia has been called the disease of theories; measures for prevention and treatment, including dietary procedures, have thus remained largely empirical. The study of toxemia of pregnancy has been handicapped by lack of accepted criteria for diagnosis and the absence of a suitable laboratory animal model.

A variety of symptom complexes continue to be included under the generic term "toxemia." The toxemias considered here were those that could be divided into "pre-eclampsia" and "eclampsia." The former is defined as an acute hypertensive disorder appearing after about the 20th week of pregnancy and accompanied by edema of hand and face and/or proteinuria; the latter is defined as being closely related to pre-eclampsia and, in most cases, its end result.

In the United States, there has been a decline in the maternal mortality rate due to acute toxemia from 52.2 per 100,000 live births in 1940 to 6.2 in 1965. Mortality rates show wide variation among individual states, ranging from one third or less of the national average in some states to four or five times the national average in others. The most striking association of these differences is with per capita income; the lower a state's per capita income, the higher the maternal mortality from toxemia, and vice versa. This same relation appears to hold with respect to incidence of the disease.

The relative importance of nutrition in the etiology and course of toxemia during pregnancy has been the subject of controversy for many years. Despite the dearth of specific evidence, opinions about diet have had a powerful influence on medical practice. Greatest interest has centered on the intake of calories, protein, and salt.

The concept that limiting weight gain during pregnancy by caloric restriction protects against toxemia derived from the observed reduction in the incidence of eclampsia in Europe during World War I. Because the war brought about a scarcity of food, pregnant women gained less, and it was concluded that the restricted diet was protective. During the 1920's and 1930's, caloric restriction intended to limit weight gain during pregnancy was widely advocated in the United States as a means of preventing toxemia and other complications. The practice found its way into textbooks of obstetrics and has been widely adopted by the medical profession, despite the fact that it has been subjected to little scientific scrutiny.

That caloric restrictions may not necessarily be beneficial is suggested by recent studies on a large group of women in a single university hospital who gained in excess of 30 pounds during pregnancy. Only 9 percent of these women developed toxemia. Confusion has in part resulted from failure to distinguish between weight gained as a result of edema and that due to deposition of fat. There is no evidence that women with large total weight gain due to excessive accumulation of fat are more likely to develop toxemia than women with lesser accumulation.

The quantity of protein consumed has been held by some to influence both the development of toxemia and the effectiveness of measures designed to prevent it. For example, it has been widely suspected that changes in diet in the United States, particularly in protein intake, may have contributed to the decreased national incidence of this complication. Although the proportion of total calories furnished by protein in the average diet in the United States has remained fairly constant at 11 to 13 percent, an increasing proportion has come from animal sources. Evidence bearing on the influence of levels of protein intake of individual women is insufficient to allow valid conclusions concerning the influence of dietary protein levels *per se* on the development of toxemia or on its prevention.

Since edema is one of the characteristic features of toxemia, routine limitation of salt intake during pregnancy to avoid or reduce edema has gained wide acceptance in practice. Diuretics are also commonly prescribed to accomplish the same goal, often in conjunction with salt restriction. Recent experimental studies on pregnant rats demonstrated deleterious effects of salt depletion. The safety of routine salt restriction must be questioned, as must the use of diuretics in prenatal care.

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3 *Implications for Dietary Management during Pregnancy*

Knowledge of the influences that specific nutrients have on the outcome of pregnancy is limited. Particular emphasis is given here to those dietary principles and practices that have immediate implications for current health services, public health, and nutrition practices.

An average weight gain during pregnancy of 24 lb (range 20–25 lb) is commensurate with a better than average course and outcome of pregnancy. This would be a gain of 1.5 to 3.0 lb during the first trimester and a gain of 0.8 lb per week during the remainder of pregnancy. There is no scientific justification for routine limitations of weight gain to lesser amounts. (See Appendix A for a chart indicating expected gain during the course of pregnancy and Appendix B for a table of standard weight for age and height.)

The pattern of weight gain is of greater importance than the total amount a sudden, sharp increase after about the 20th week of pregnancy may indicate water retention and the possible onset of pre-eclampsia. There is no evidence that the total amount of gain during pregnancy has, *per se*, any causal relationship to pre-eclampsia.

Severe caloric restriction, which has been very commonly recommended, is potentially harmful to the developing fetus and to the mother and almost inevitably restricts other nutrients essential for growth processes. Weight-reduction regimes, if needed, should be instituted only after pregnancy has terminated.

The young adolescent (i.e., under 17 years of age) poses special problems during pregnancy. Her own growth requires an adequate diet, with particular reference to calories, protein and calcium, and she tolerates caloric deprivation poorly. Therefore, when the nutritional demands of pregnancy are superimposed on those of adolescence, there should be no stringent caloric restriction. Even for the obese young adolescent, a modest weight gain should be permitted

during pregnancy, and any attempt to reduce maternal weight by caloric restriction or drugs should be postponed until after delivery. The standardized diets commonly used in prenatal clinics are especially unsuited to the special nutritional needs of the young adolescent.

Special attention should be paid to the dietary intake and food habits of women who enter pregnancy in a poor nutritional state. Young adolescents, women who have been on slimming regimens, and those of low socioeconomic status are particularly vulnerable to the metabolic demands of pregnancy. When modification of the customary diet is indicated during pregnancy, it should be undertaken in accordance with the principles of good nutrition. The planning or assessment of diets should be guided by the Recommended Dietary Allowances of the National Research Council (Appendix C).

The widespread practice of routinely restricting salt intake and at the same time prescribing diuretics is of doubtful value in preventing pre-eclampsia and is potentially dangerous. The routine use of diuretics without specific clinical indications is unwise.

Vitamin and mineral supplements should not be routinely instituted as a means for correcting poor food habits. In considering the wisdom of recommending them, the relative cost, as compared to enhancing the nutrient intake with foods, should be taken into account, especially in caring for pregnant women with inadequate incomes. Except for iron and folic acid, the routine supplementation of diets of pregnant women with vitamin and mineral preparations is of uncertain value. When supplementation is judged necessary, the quantities of nutrients supplied should approximate the daily amounts suggested in the Recommended Dietary Allowances (Appendix C).

In view of the apparent widespread incidence of nutritional anemia and the increased iron requirements of pregnancy, iron supplementation is needed during the second and third trimesters in amounts of 30 to 60 mg per day.

A daily supplement of 0.2 to 0.4 mg of folate during pregnancy should be sufficient to prevent folic acid deficiency.

In areas where the soil and water are deficient in iodine, the use of iodized salt should be encouraged.

4 *Recommendations*

Nutrition has an important role in reproductive performance. Epidemiological data strongly suggest that good preparation for pregnancy is based on good health background and good nutritional status. To be well nourished from childhood and to maintain good diet during pregnancy would help to ensure safe, healthy pregnancies and healthy babies.

To reach such an objective on a national scale has implications for policies that affect the availability of food, especially for families with inadequate food budgets; for public health and nutrition services and educational programs at the federal, state, and local levels of government; for nutrition education through schools and public communication channels; and for the nutrition education of those in professions concerned with maternity care.

General

As a result of deliberations on the issues considered in the comprehensive report, the following recommendations evolved:

1. There is need for emphasis on a single standard of high-quality maternity care, including nutrition, for all pregnant women.
2. It should be borne in mind by all officials responsible for planning and implementing food programs, especially for families with inadequate budgets, that their physiological needs place infants, children, adolescents, and pregnant women in top priority.
3. The curricula in medical schools should be greatly strengthened to provide solid, scientific education in nutrition and its relation to health. Medical

students should also be made aware of the knowledge and skills of professional nutritionists and dietitians so that as physicians they may better utilize the services of these persons.

4. The American College of Obstetricians and Gynecologists would be well advised to establish a Committee on Nutrition. National and state boards of medical examiners and the American Board of Obstetrics and Gynecology should include in their qualifying examinations questions on nutrition as it relates to the course and outcome of pregnancy.

5. There should be many more qualified nutrition personnel in community health services that serve mothers and children, to act as consultants and devise ways of increasing direct services to individuals. These services should include the training of auxiliary personnel who could then assist families on food budgeting and purchasing, meal preparation, and family living.

6. Persons responsible for planning the curricula of elementary and secondary schools should provide for teaching basic facts of nutrition and should encourage children and young people to develop good eating habits and to appreciate the value of a good diet.

7. Public health agencies and the health professions should assume greater responsibility for disseminating sound nutrition information, thus minimizing the influence of food faddists and charlatans.

8. While the team approach to comprehensive maternity care is generally appropriate, when pregnant adolescents are involved, there should be at least one professional person on the team who is well versed in their special needs and problems and can communicate effectively with them.

9. There must be no barriers to impede or prevent a young girl from obtaining prenatal care and family-planning guidance—all attitudes, practices, regulations, and laws that discourage teen-agers from utilizing existing medical services and obtaining information and advice about pregnancy should be examined and, where possible, changed.

10. School personnel should be helped in their efforts to bridge the gap between the school health and guidance programs and the maternity care facilities in the community.

11. Provision should be made for pregnant adolescents to continue their education and to receive instruction in personal and family living, nutrition, and child care.

Research Emphases

The overall aim should be to provide rational bases for medical, public health, and nutrition policies and practices. Research has been too much centered on problems and pathology of pregnancy and on clinic populations in which the

incidence of complications tends to be high; more emphasis should be placed on the study of the normal physiological adjustments that take place during pregnancy. Accordingly, it is recommended that support be sought from private foundations and government agencies to establish and maintain one or more multidisciplinary research and training centers for the study of the biology of human reproduction. The research most needed requires continuing, long-term investigations carried out by teams of trained investigators working in well-equipped institutions, in close affiliation with obstetrical facilities, with both out-patient and in-patient services, and with opportunities to study in depth the physiological changes that take place throughout the reproductive cycle in women of varying levels of health and reproductive performance. Only from research of this kind can come definitive answers to questions about specific relationships between the nutritional status and diet of the mother during pregnancy and the course and outcome of pregnancy. Such centers should also afford opportunities for the training of personnel for research, teaching, and service.

Because many effects of diet on human reproduction can be detected only by observations that extend over a long period of time and because others may require examination of large populations, there is need for epidemiological studies to assess the influences of geographic, social, and economic factors, including food availability, food habits, and the availability and quality of medical care. There should be close cooperation between epidemiologists, laboratory investigators, and clinical research workers.

New techniques should be developed to provide more precise information on the effects of undernutrition and malnutrition during gestation.

As for research with experimental animals, greater use should be made of primates, but if their full potential value is to be realized, breeding colonies of the best-suited species should be established to ensure an adequate supply of animals of known genetic background and health history.

In the following listing of research areas that need emphasis, no priorities are implied. What can be undertaken at a given institution will depend in large measure on the special interests of individual staff members and on the available money and personnel resources.

The Pregnant Woman

- Physiological and biochemical norms, established on the basis of studies of healthy women experiencing a healthy pregnancy
- Sodium requirements in pregnancy
- The importance of individual differences in physiological adaptations during pregnancy to its course and outcome

- Hormonal changes in pregnancy in relation to the supply of nutrients to the fetus
- Changes in the absorption and retention of nutrients during pregnancy
- The mechanism for mobilizing calcium from the skeleton and from the diet for transport to the fetus; studies on the role of dietary calcium during pregnancy
- Changes that occur in the metabolism of protein during pregnancy and factors affecting these changes
- The relationship between maternal blood sugar levels and carbohydrate metabolism of the fetus
- The effects of caloric restriction during pregnancy on the growth and neurological development of the fetus
- Circulatory factors in the mother that affect the transfer of nutrients to the fetus; data on blood pressure levels of normal women prior to pregnancy, possibly from measurements that could be included in the routine health examination of high school and college girls
- The relation of blood pressure levels to the outcome of pregnancy for both mother and infant
- The relationship between toxemia and the amount and kind of protein consumed, over both short and long periods
- Effects of oral contraceptives on the nutritional status of women and their preparation for pregnancy
- Special problems and nutrient requirements of multiple pregnancy
- Longitudinal studies of girls from all socioeconomic groups, beginning at age eight and continuing to the end of the growth period to provide data on:

  - relation of patterns of postmenarchal growth to fertility
  - effects of pregnancy on postmenarchal growth
  - the impact of early pregnancy on adult stature
  - length of the anovulatory period in early- and late-maturing girls
  - differences between early and late maturers as to hazards encountered in pregnancy
  - metabolic effects of the imposition of pregnancy on the growth process of the young girl and the cumulative effects of these on nutrient requirements
  - effects of the mother's biological immaturity on the fetus
  - effects of oral contraceptives on postmenarchal growth and on induction of metabolic disorders
  - nutritional requirements at different stages of adolescent growth and development
  - criteria and methods for assessing the nutritional status of adolescents
  - influence of the long-term health and nutritional status, and of dietary intakes during pregnancy, of teen-age mothers on the course and outcome of pregnancy

–the psychological impact of early pregnancy on the young girl – causation of temporary or permanent developmental arrest, interference with her ability to become a competent mother, differences in kind from those seen in mature women

- The relation of maternal hematological status to the course and outcome of pregnancy
- Factors that modify the absorption of iron and its subsequent utilization during pregnancy
- Effects of nutrients supplied by the diet or by supplementation on hematological status
- Effects of preconceptual and interconceptual care on hematological status

The Fetus and Placenta

- Mechanisms for transporting nutrients across the placenta, including placental clearance and turnover rates, and factors controlling these mechanisms
- Level of nutrients in maternal blood needed to promote optimal fetal growth
- Relation of endocrine functions of the placenta to the supply of nutrients to the fetus
- Factors influencing the transport of nutrients across the placenta in multiple pregnancies
- Improved methods to study the circulation in the placenta
- Re-examination of the concept of placental insufficiency
- Role of maternal infection during pregnancy to more clearly differentiate the effects *in utero* of poor nutrition and infectious agents
- Determination of fetal-uterine relationships at specific times during gestation by such new techniques as sonar scanning

The Newborn

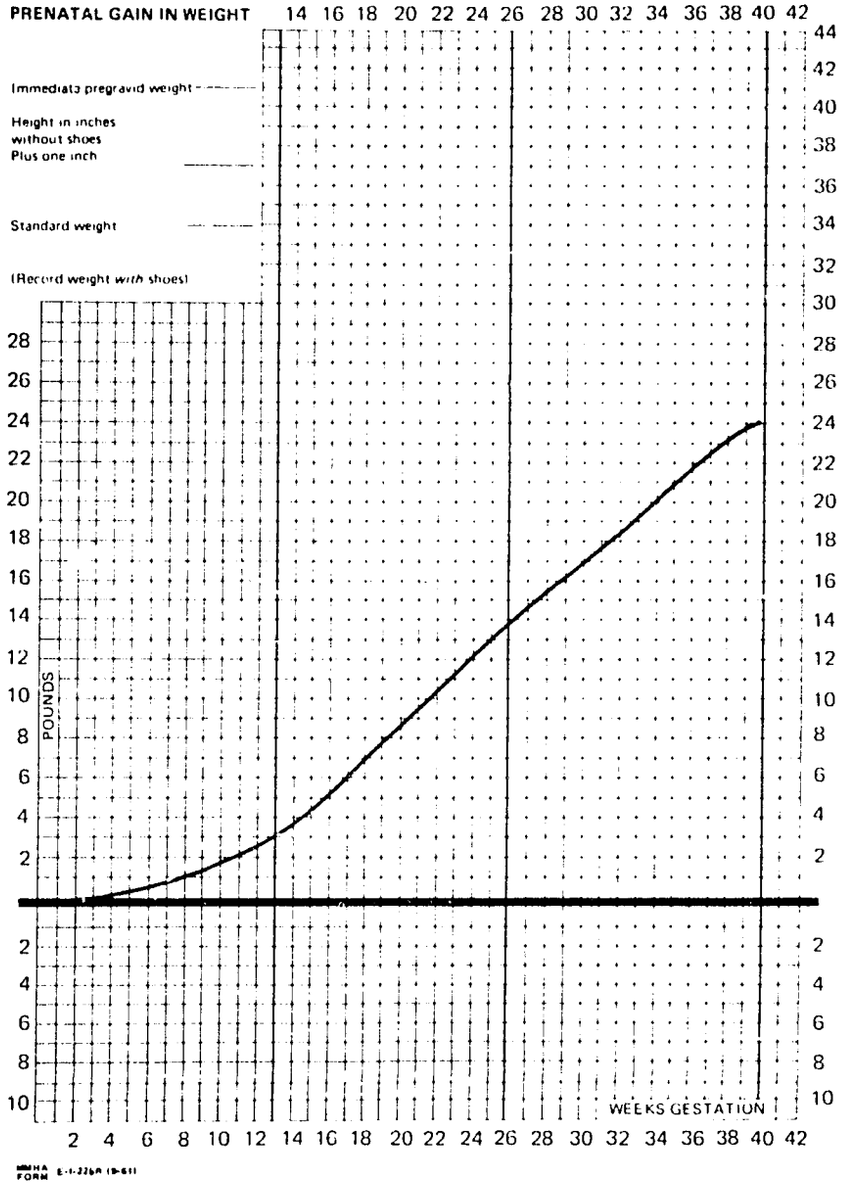
- Comparative studies of body composition of newborns having different characteristics, i.e., normal infants, infants with low birth weight for gestation age, and those prematurely born
- The effects of maternal ketonuria on the neurological development of the offspring
- The physical and intellectual development of infants and children of very young mothers in comparison to the children of older mothers with the same social, economic, and ethnic characteristics
- Longitudinal studies in appropriate populations covering the period from early pregnancy, through birth, to middle childhood, to assess the full impact

of maternal undernutrition and malnutrition on the later growth and development of children

Epidemiological and Field Studies

- The effects of rapid changes in the socioeconomic milieu (e.g., the increasing numbers of women employed outside the home, the increasing range and availability of "convenience foods," the movement of families to new environments) on the kinds and quantities of foods purchased and on the nutrient intake
- Changes in social patterns that may indicate altered needs for medical, public health and nutrition, or other services
- Studies of a population of women before, during, and after the pregnancy period to clarify the relation between the incidence of the toxemias of pregnancy and various specific factors in the home and community environment socioeconomic status, nutritional status, race, dietary and other health habits, availability and utilization of medical care
- Controlled studies in a population having a high incidence of toxemia to elucidate the role of sodium. (The studies should concentrate on primigravidas and should deal with groups large enough to lend statistical significance to data on pre-eclampsia. Information should be obtained on the amounts of sodium ingested, retained, and excreted, and determinations made of blood volume and plasma levels of sodium, potassium, and related hormones. Total body water should be measured and, if feasible, muscle biopsies done to determine how sodium content might be affected by dietary sodium restriction.)
- The occurrence of teen-age pregnancies in various socioeconomic groupings and in different geographical areas
- Collection of natality and mortality statistics, reported by single years of age for girls under 20
- The role of dietary practices and nutrition throughout life on changes in the age of menarche
- Studies, on a recurrent or continuing basis, of groups of women with best and with poorest reproductive performance, to define the most important risk factors, to include an evaluation of past nutritional history as well as dietary intake during pregnancy
- Studies of pregnancy outcome for groups of women with and without specific interventions that affect nutrient intake: supplementary foods, pharmaceutical supplements, education in nutrition
- Studies to determine educational methods to instill eating habits that will promote a desirable nutritional status (to be undertaken in elementary and secondary schools as well as in clinics and other settings where health services are provided for children and adolescents, with particular concern for the relationship of socioeconomic status and cultural and ethnic backgrounds to the development of food habits)

APPENDIX A GAIN IN WEIGHT GRID



Pattern of normal prenatal gain in weight. Source: U.S. Department of Health, Education, and Welfare, Social and Rehabilitation Service, Children's Bureau. (Reprinted with permission from *Clinical Obstetrics*, 1953, J. B. Lippincott and Co.)

APPENDIX B TABLE OF STANDARD WEIGHT FOR HEIGHT[a]

Height without Shoes, Plus 1 Inch	Standard Weight
4'10"	104
4'11"	107
5' 0"	110
5' 1"	113
5' 2"	116
5' 3"	118
5' 4"	123
5' 5"	128
5' 6"	132
5' 7"	136
5' 8"	140
5' 9"	144
5'10"	148
5'11"	152
6' 0"	156

[a]The above weights were taken from Metropolitan Life Insurance Company, Actuarial Tables, 1959, and adjusted to comply with instructions appearing on the Gain in Weight Grid, namely: height in inches without shoes plus 1 inch to establish a standard for heels. Patients should be weighed with shoes as normally worn. The table above is for medium body build and, except for extreme body build deviations, these figures should be used.

For example, a patient whose height, measured without shoes, is 5 feet 4 inches would have one inch added; therefore, her standard weight for height would be 128 pounds.

Ranges are not acceptable in estimating standard weight since this is an objective observation and represents the midpoint. This midpoint must be used for recording purposes.

For patients under age 25, one pound should be deducted for each year.

APPENDIX C RECOMMENDED DAILY DIETARY ALLOWANCES FOR GIRLS AND WOMEN AT VARIOUS AGES, WITH ADDED ALLOWANCES FOR PREGNANCY

	Recommended Daily Allowances for Nonpregnant Women					Recommended Daily Allowances Added for Pregnancy
	12-14[a] years old	14-16[b] years old	16-18[c] years old	18-22[d] years old	22-35[d] years old	
Calories (kcal)	2,300	2,400	2,300	2,000	2,000	200
Protein (g)	50	55	55	55	55	10
Vitamin A (IU)	5,000	5,000	5,000	5,000	5,000	1,000
Vitamin D (IU)	400	400	400	400		0
Vitamin E (IU)	20	25	25	25	25	5
Ascorbic acid (mg)	45	50	50	55	55	10
Folacin (mg)	0.4	0.4	0.4	0.4	0.4	0.4[e]
Niacin (mg equiv.)	15	16	15	13	13	2
Riboflavin (mg)	1.4	1.4	1.5	1.5	1.5	0.3
Thiamin (mg)	1.2	1.2	1.2	1.0	1.0	0.1
Vitamin B_6 (mg)	1.6	1.8	2.0	2.0	2.0	0.5
Vitamin B_{12} (μg)	5	5	5	5	5	3
Calcium (g)	1.3	1.3	1.3	0.8	0.8	0.4
Phosphorus (g)	1.3	1.3	1.3	0.8	0.8	0.4
Iodine (μg)	115	120	115	100	100	25
Iron (mg)	18	18	18	18	18	[f]
Magnesium (mg)	350	350	350	350	300	150

[a]Body size, 44 kg, height, 154 cm.
[b]Body size, 52 kg; height, 157 cm.
[c]Body size, 54 kg; height, 160 cm.
[d]Body size, 58 kg; height, 163 cm.
[e]The diet may be supplemented with 0.2-0.4 mg of folacin daily.
[f]It is recommended that the diet be supplemented with 30-60 mg of iron per day.

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